UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

April 27, 1988

Docket No. 50-508

MEMORANDUM FOR: The Record

FROM: Guy S. Vissing, Project Manager
Standardization and Non-Power
Reactor Project Directorate
Division of Reactor Projects III,
IV, V and Special Projects

SUBJECT: SUMMARY OF MEETING OF THE STAFF WITH WASHINGTON PUBLIC POWER SUPPLY SYSTEM CONCERNING GEOSCIENCE ISSUES FOR WNP-3 (WPPSS LETTER DATED 11/20/87), APRIL 5, 1988

Introduction

A meeting of the staff with representatives of Washington Public Power Supply System (WPPSS or the Supply System) was held at the offices of NRC in Rockville, Maryland, on April 5, 1988. The purpose of the meeting was to discuss the Supply System's response to the staff's questions Q230.3, Q230.4 and Q230.5. The Supply System transmitted the responses to the staff's questions by letter dated November 20, 1987. Many of the viewgraphs were of the figures in the November 20, 1987 letter. Enclosure 2 provides the viewgraphs which were presented at the meeting. Enclosure 1 provides the attendance list for this meeting.

Discussion

Historical earthquake data appears to support the belief that the subducting Juan de Fuca plate is arched in a northernly direction beneath Pudget Sound and the direction of the maxim dip varies from east-southeast at latitude 47 degrees N to east-northeast at latitude 49 degrees N. This data includes data taken from an extensive network of University of Washington seismograph stations located in the area after 1970. Analysis of the data subsequent to 1970 provided vertical and horizontal error bars of epicenters of earthquakes in the region. Larger magnitude (4.5 and greater at depths of 30km and greater) earthquakes appear to occur at or east of the point of flexure of the dip in the subducting plate. WPPSS postulates that one likely mechanism for the localization of the larger earthquakes in the vicinity of the flexure is the concentration of tensional stresses at the bend of the plate. If this is correct, then the slab or plate flexure area may mark the western boundary of the larger inter-slab earthquakes.

WPPSS in estimating the maximum magnitude of random earthquakes assumes that the maximum is about one-half magnitude unit larger than the observed magnitude. Using this method, WPPSS estimates the maximum earthquake to be 5-1/2. Considering both the historical record and the results of detailed geological investigations in the site region, the maximum magnitude possible for a "random" event in the site vicinity is estimated to be about 5-1/2 to 6 by WPPSS. The staff has not, as yet, reached any conclusion on this issue.

Response spectra for the site were computed from accelerograms recorded during earthquakes of magnitude 5.0 ± 0.5 at epicentral distances of about 25km or less. As the plant is founded on rock, only recordings located on rock were used. Statistical analysis of the data set was performed. The SSE design spectrum was found to be well above the computed statistical response spectra for the maximum historical event that has occurred within the site area.

The maximum earthquake on the Olympia Lineament has been estimated by WPPSS to have a magnitude of 7.5 and to be located at a distance of 35km from the site. Site-specific spectra were estimated by conducting a statistical analysis of the responses spectra earthquakes in the western region scaled to magnitude 7.5 and distance 35km. On the basis of these analyses the SSE spectrum at the site appears to be adequate in relationship to ground motions from the postulated maximum event on the Olympia Lineament.

Conclusions And Staff Comments

The information presented at this meeting was, in general, well prepared, appeared to use the latest methodology and was responsive to the questions. The basis for defining the Coast Range tectonic province as being between 44 and 47.3 degrees north latitude and the east-west extent of this proposed tectonic province needs to be provided. The use of the maximum historical earthquake plus one-half magnitude unit to estimate the maximum magnitude random earthquake needs to be justified. The basis for assigning a maximum magnitude 7.5 earthquake to the Olympia Lineament is needed. The ground motion estimates made for the various earthquakes appear to be reasonable. However, the staff will need to confirm the assumptions and calculations. WPPSS has made a reasonable argument for the existence of the flexture in the subducting plate. The staff will review this issue and assess its implications.

The possibility of a field trip by the NRC staff members to the site vicinity was discussed and the date was left open.

Guy S. Vissing

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Enclosures: As stated

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Original Signed By:

Guy S. Vissing, Project Manager
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Office of Nuclear Reactor Regulation

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DATE	:04/18/88	:04/27/88	:04/26/88	:	:	:	:

OFFICIAL RECORD COPY *See previous concurrence historical record and the results of detailed geological investigations in the site region, the maximum magnitude possible for a "random" event in the site vicinity is estimated to be about 5-1/2 to 6.

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with comments marked up

P	:PDSNP	:ESGB	:	:	:	:
	:LRubenstein	:GBagchi	:	:	:	:
/88	:04/ /88	:04/26/88	:	:	:	:

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ENCLOSURE 1

ATTENDANCE LIST
FOR
MEETING WITH WPPSS
CONCERNING WNP-3 GEOSCIENCE ISSUES
APRIL 5, 1988

Name	Orangization
Guy S. Vissing	NRC/NRR/PDSNP
Doug Coleman	Supply System
Dave Bosi	Supply System
Bob Crosson	Univ. of Washington
Bob Youngs	Geomatix Consultants
Kevin Coppersmith	Geomatrix Consultants
Bill Kiel	Supply System
R. L. Rothman	NRC/NRR
Dick McMullen	NRC/RES
Leon Reiter	NRC/NRR

WNP-3 GEOSCIENCES PROGRAM
SCHEDULE FOR REVIEW

SUBMITTAL

- Crustal Earthquakes

Response to Questions 230.3, 230.4 and 230.5	November 1987

- Seismic Hazard

Response to Question 230.6	February 1988

MEETING

- Crustal Earthquakes	March 1988

SUBMITTAL

- Evaluation of Subduction Zone Earthquakes

Response to Questions 230.1 and 230.2	April 1988

MEETINGS

- Seismic Hazard	May 1988
- Attenuation and Ground Motion Modeling	July 1988
- Evaluation of Subduction Zone Earthquakes	August 1988
- Open Items	September 1988

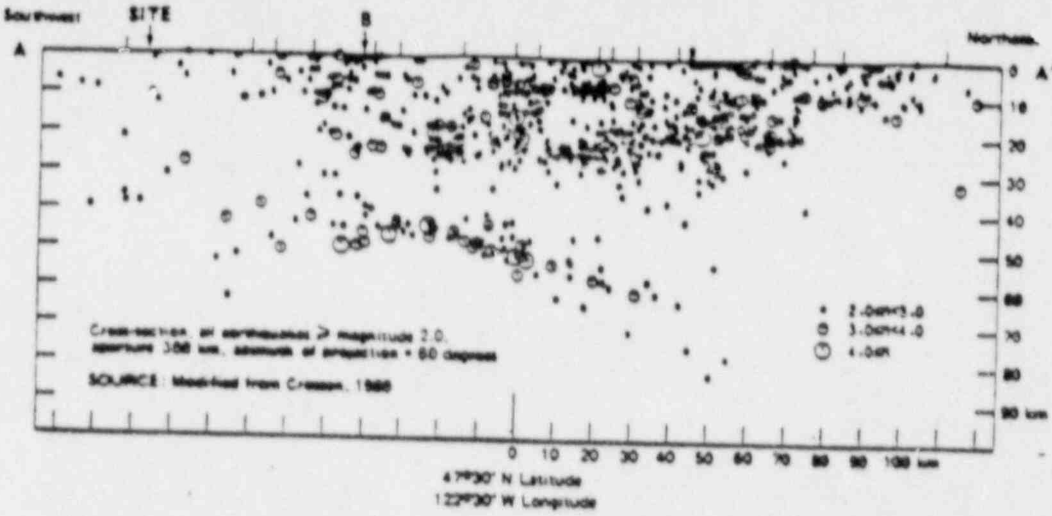
COMPLETE ISSUE REVIEW **November 1988**

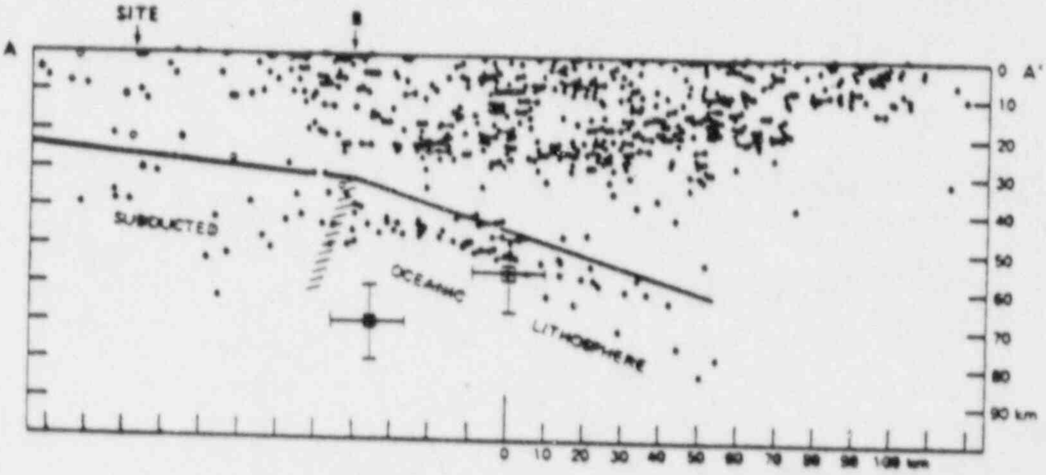
Question 230.3a

Attention is called to FSAR Figure 2.5-31. No location errors are specified for most of the earthquakes plotted thereon, especially for those occurring in a region which projects to the southwest of Olympia on section AA' and particularly for depth of focus. Referring to Crosson (1972), Figure 6, the site and most of the area in which these earthquakes occur is off-scale and the location errors are likely to be large. Several factors influence the accuracy in depth of focus, most important of which is station coverage which changed greatly during the time interval covered. The applicant is therefore asked to provide a number of diagrams similar to Crosson's Figure 6 for periods which reflect significant changes in network coverage and showing error bars that indicate the accuracy of hypocentral locations.

Question 230.3b

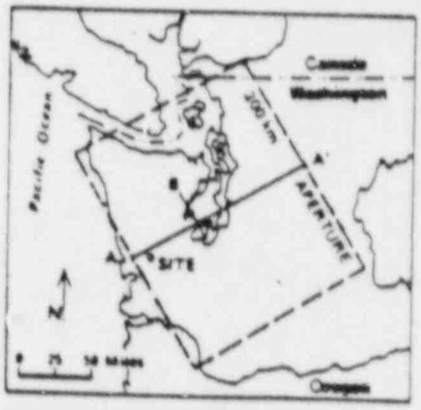
Figure 2.5-36C shows seismicity (for example in the vicinity of Mt. St. Helens) that does not appear to have been plotted in the sections shown in Figure 2.5-31. Yet Figure 2.5-31 states that earthquakes within 150 km of a line striking N60°E through the site have been included on the section. Two questions arise: (1) what earthquakes (if any) have been omitted from the section (Figure 2.5-31), and (2) why is the aperture for the section so wide since a width of 300 km results in earthquakes in the Willamette depression being projected to points west of the site into what may be an entirely different tectonic province?





EXPLANATION

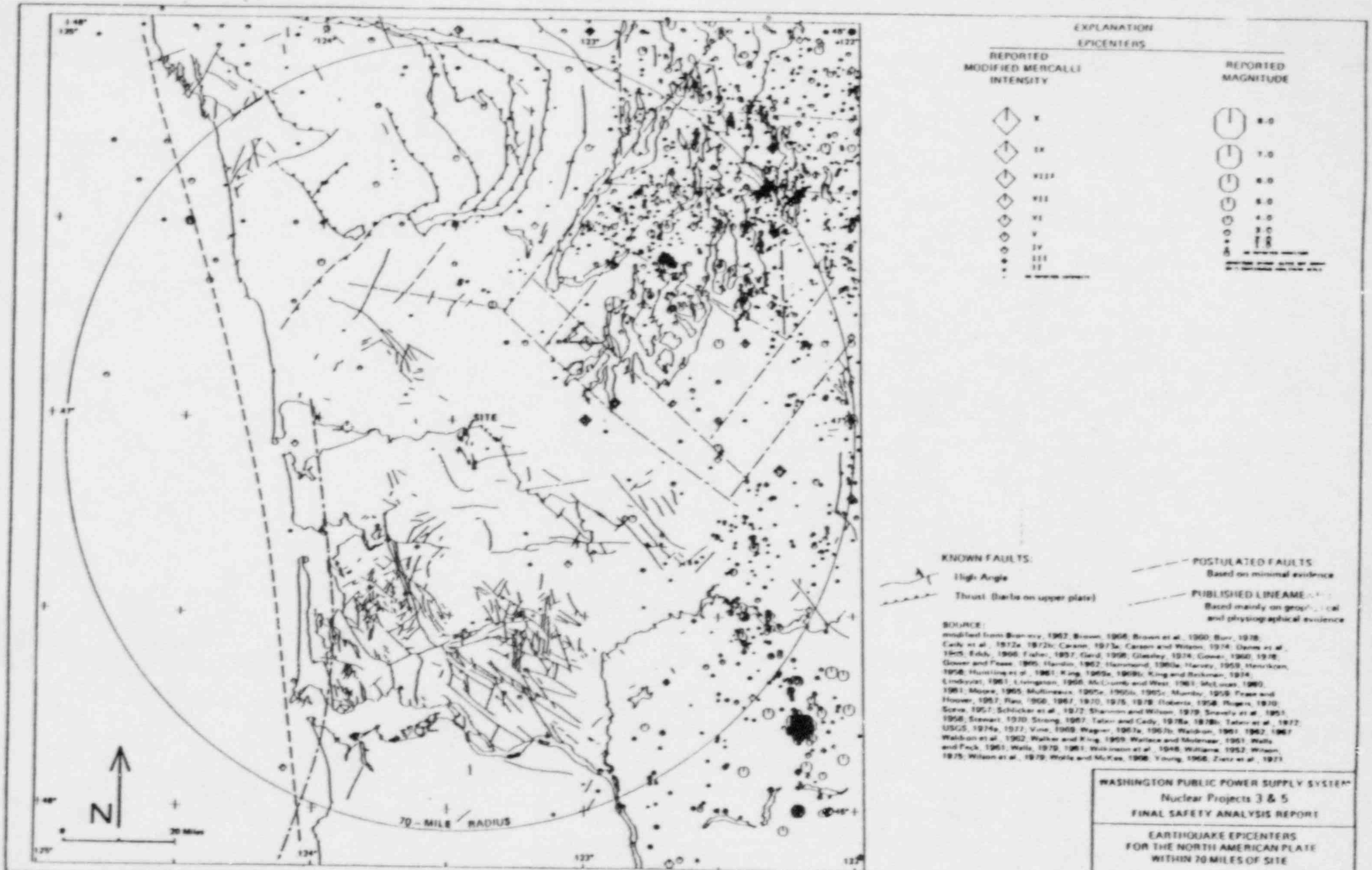
- Hypocenters 1970–1978 from Crosson, 1980
- Hypocenters July–September 1973 from WPPSS, 1974, Appendix 2.5G
- ■ Hypocenters of magnitude 7.1, 1949 earthquake from Appendix 2.5H
- □ Hypocenter of magnitude 6.5, 1965 earthquake from Appendix 2.5H
- Approximate location of province boundary between shallow and deep portions of the subducted Juan de Fuca plate (see Subsection 2.5.1.1.4.2.2.9)
- B Surface projection of province boundary



WASHINGTON PUBLIC POWER SUPPLY SYSTEM
Nuclear Projects 3 & 5
FINAL SAFETY ANALYSIS REPORT

HYPOCENTERS PROJECTED ONTO PROFILE A–A'

Figure 2.5-31



WASHINGTON PUBLIC POWER SUPPLY SYSTEM
Nuclear Projects 3 & 5
FINAL SAFETY ANALYSIS REPORT

EARTHQUAKE EPICENTERS FOR THE NORTH AMERICAN PLATE WITHIN 70 MILES OF SITE

Figure 2.5-36c

Important to Update Figure 2.5-31

- 1970-1980 catalog has been re-evaluated by U of W staff

- Additional data from 1981-1986

- Greater detail on geometry of subducting Juan de Fuca plate
  - Crosson and Owens (1987)
  - Baker and Langston (1987)
  - Baker and Weaver (1988)

Replotted Cross Sections

Include horizontal and vertical [illegible]

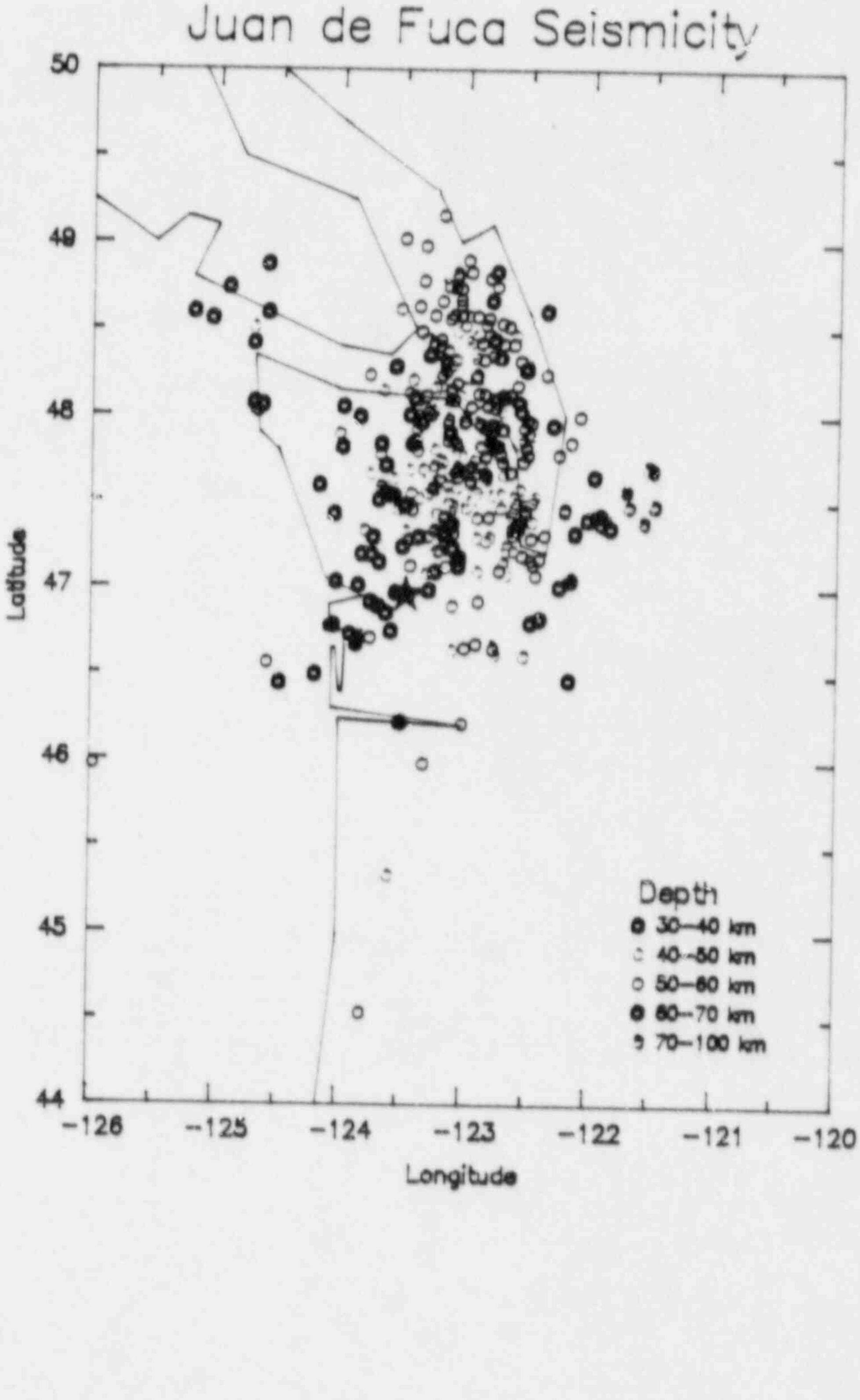
[illegible]

30-km aperture [illegible]

[illegible]

[illegible]

Figure 230.3a-1


Juan de Fuca Seismicity
Latitude
Longitude
50
49
48
47
46
45
44
-126
-125
-124
-123
-122
-121
-120
Depth
30-40 km
40-50 km
50-60 km
60-70 km
70-100 km

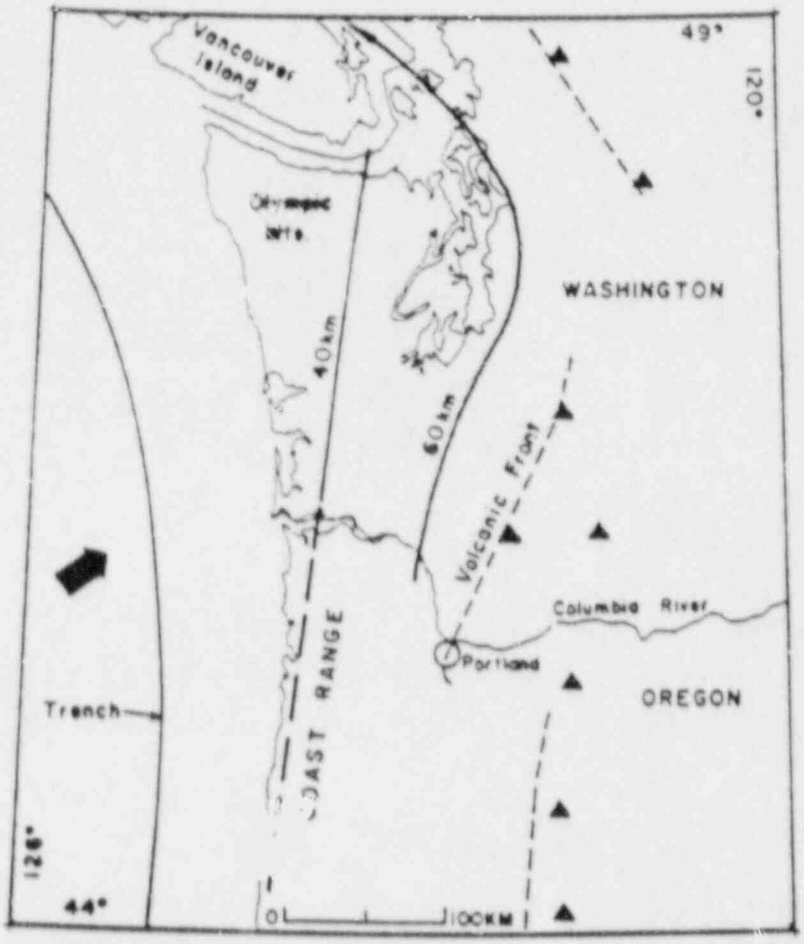


FIG. 5. Summary of plate geometry beneath Washington and northern Oregon. The 40- and 60-km depth contours are taken from the westward extent of the 30 to 40 km and westward extent of the 50- to 60-km distributions, shown in Figure 2, respectively. The volcanic front is the westward extent of late Cenozoic volcanism taken from the map by Luedke and Smith (1982). Bold arrow offshore shows the direction of convergence between the Juan de Fuca and North American Plates.

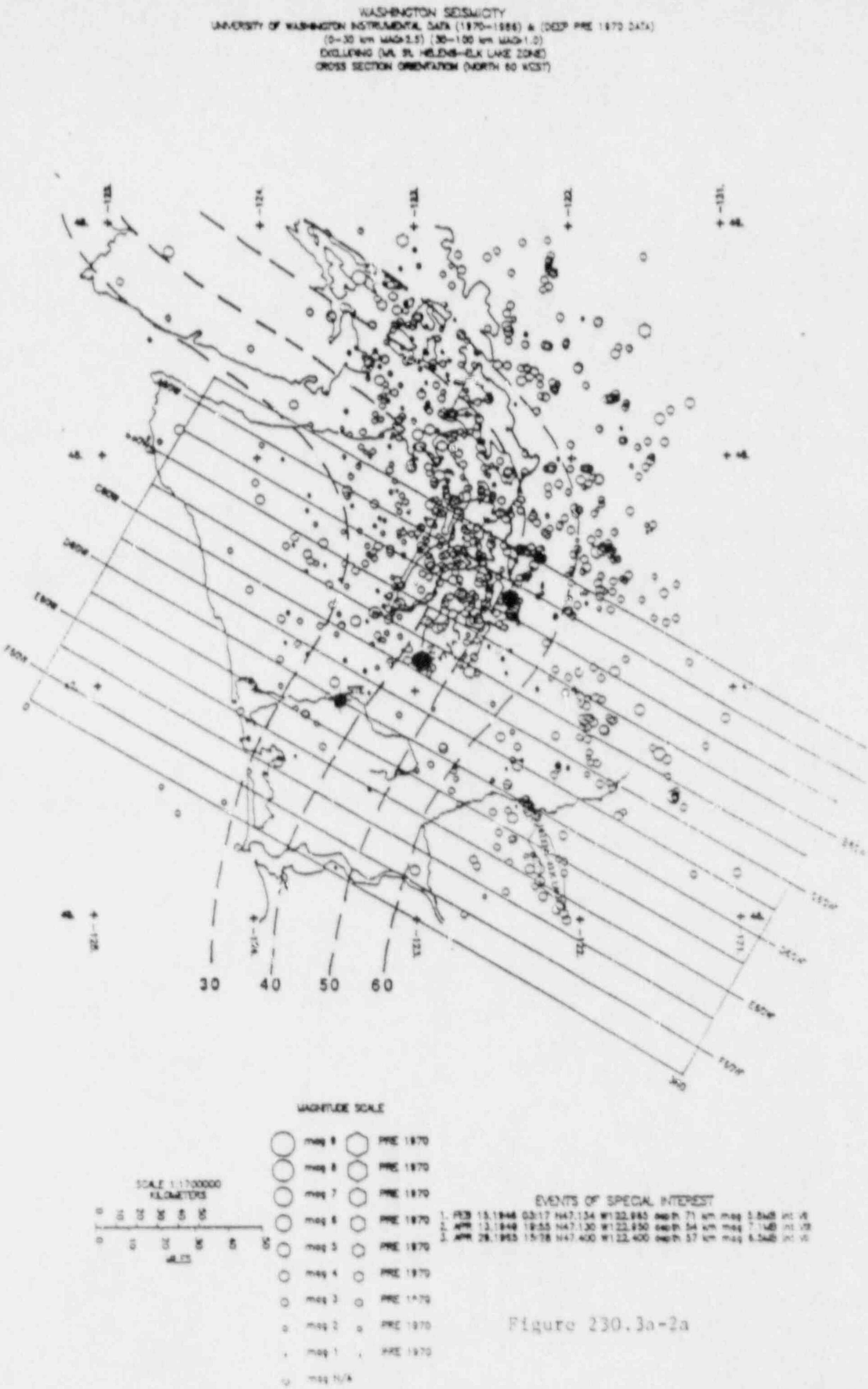
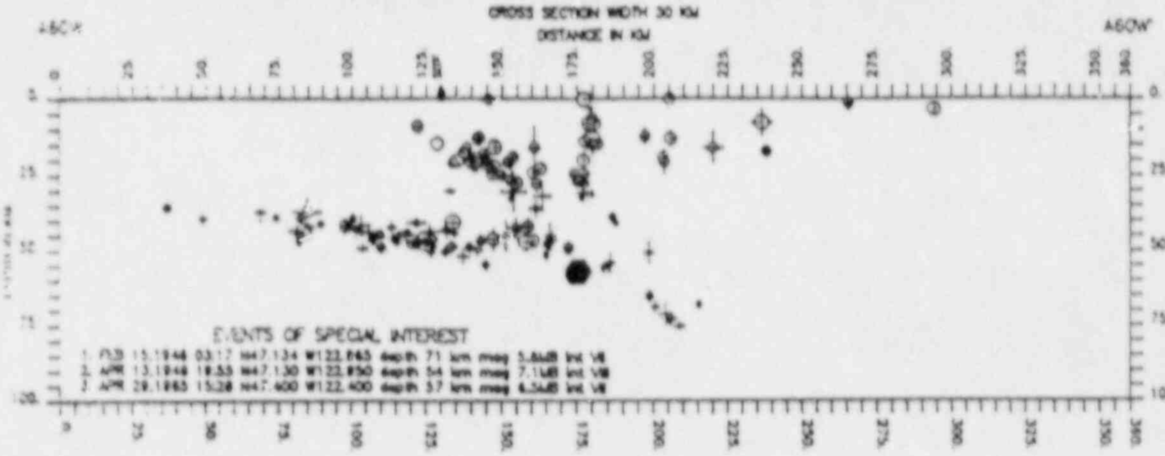


Figure 230.3a-2a

UNIVERSITY OF WA INSTRUMENTAL DATA (1970–1986) & (DEEP PRE 1970 DATA)



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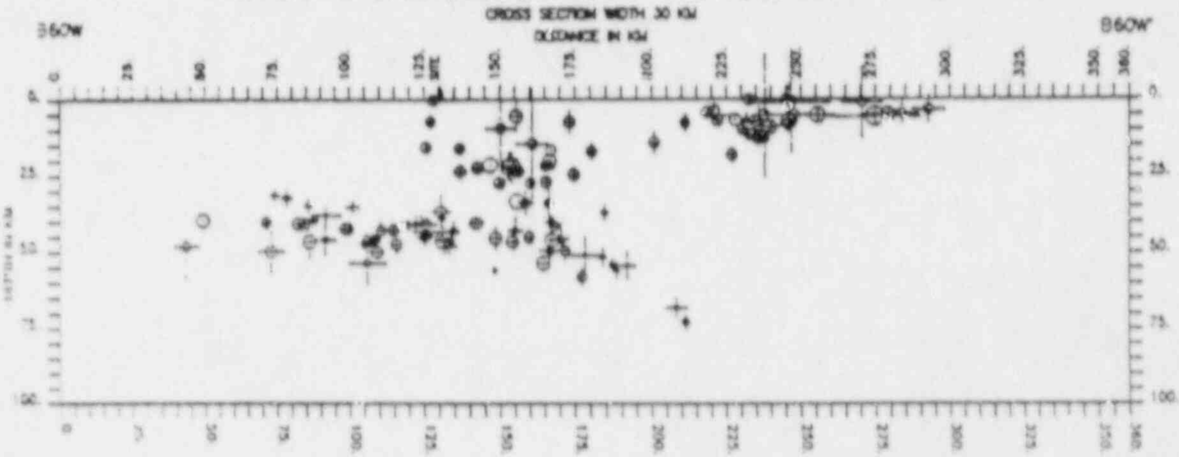


UNIVERSITY OF WA INSTRUMENTAL DATA (1970–1986) & (DEEP PRE 1970 DATA)

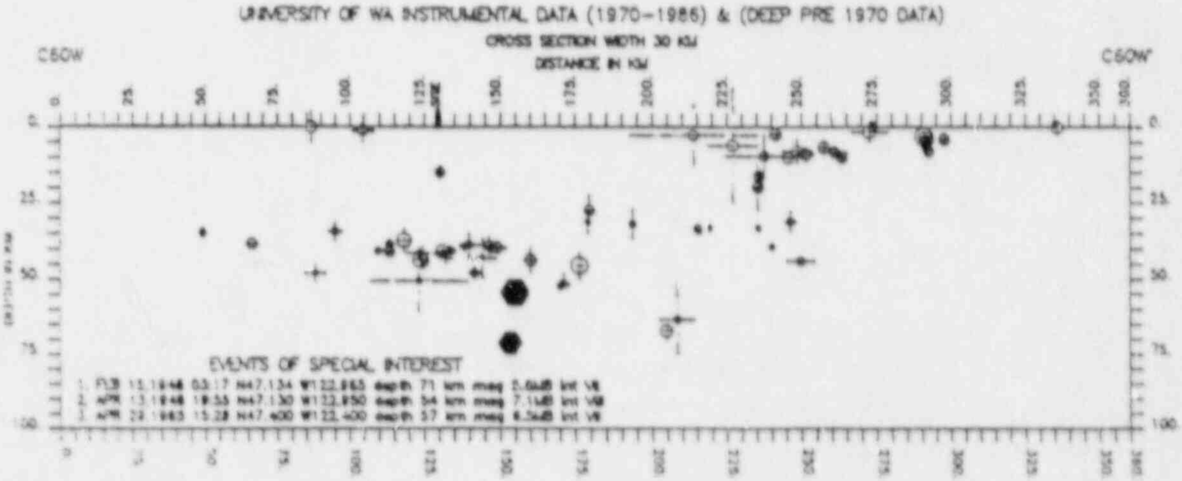
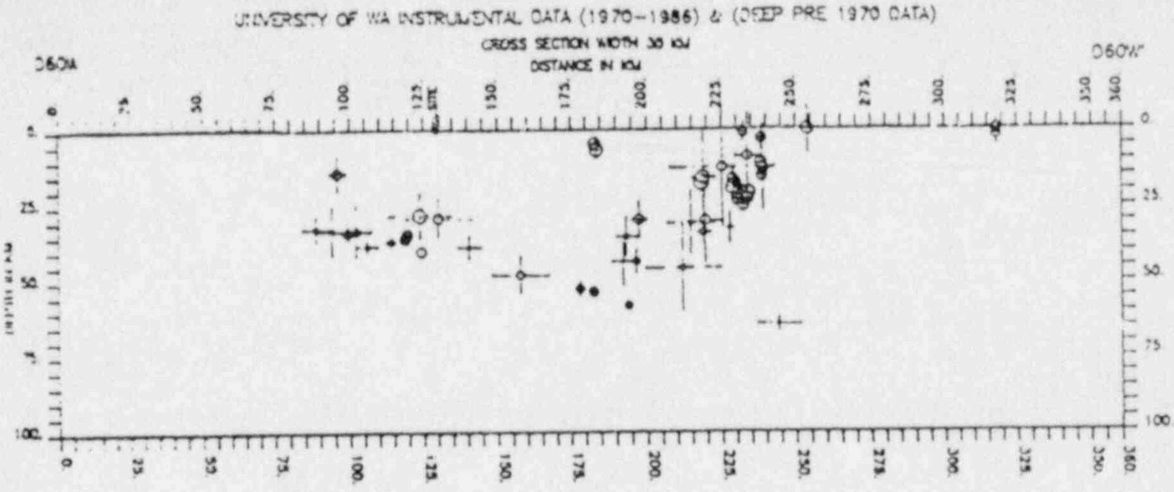
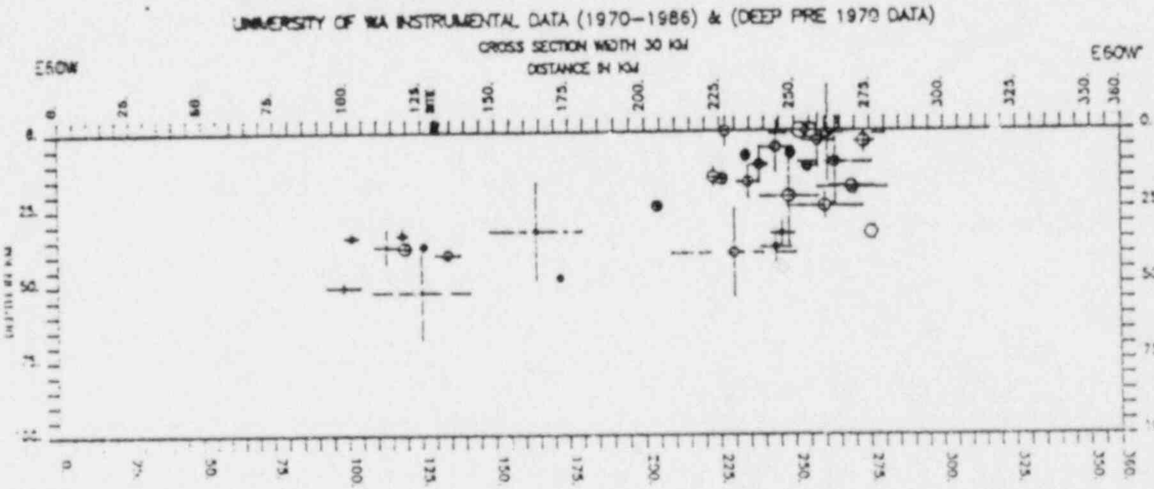


Figure 230.3a-2b





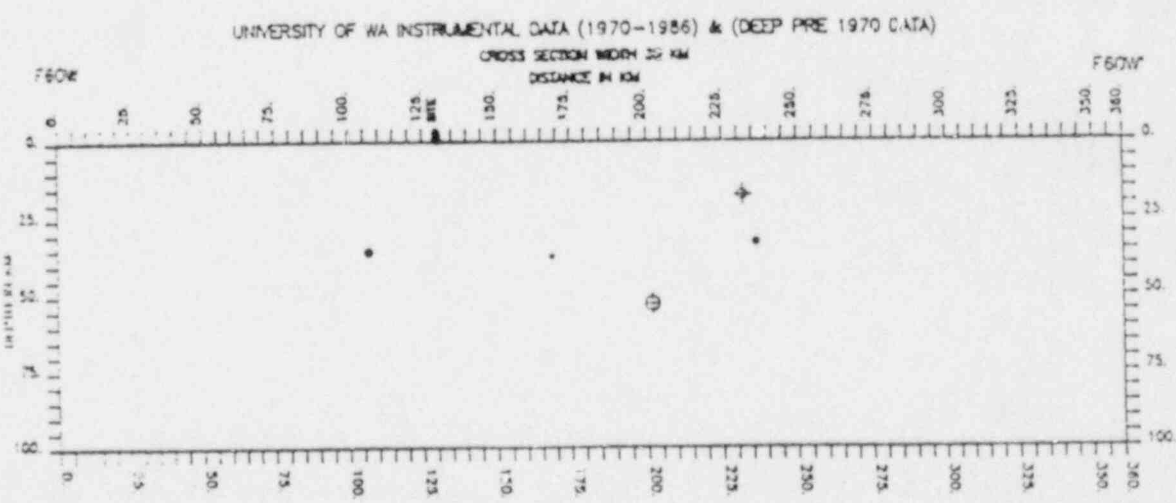
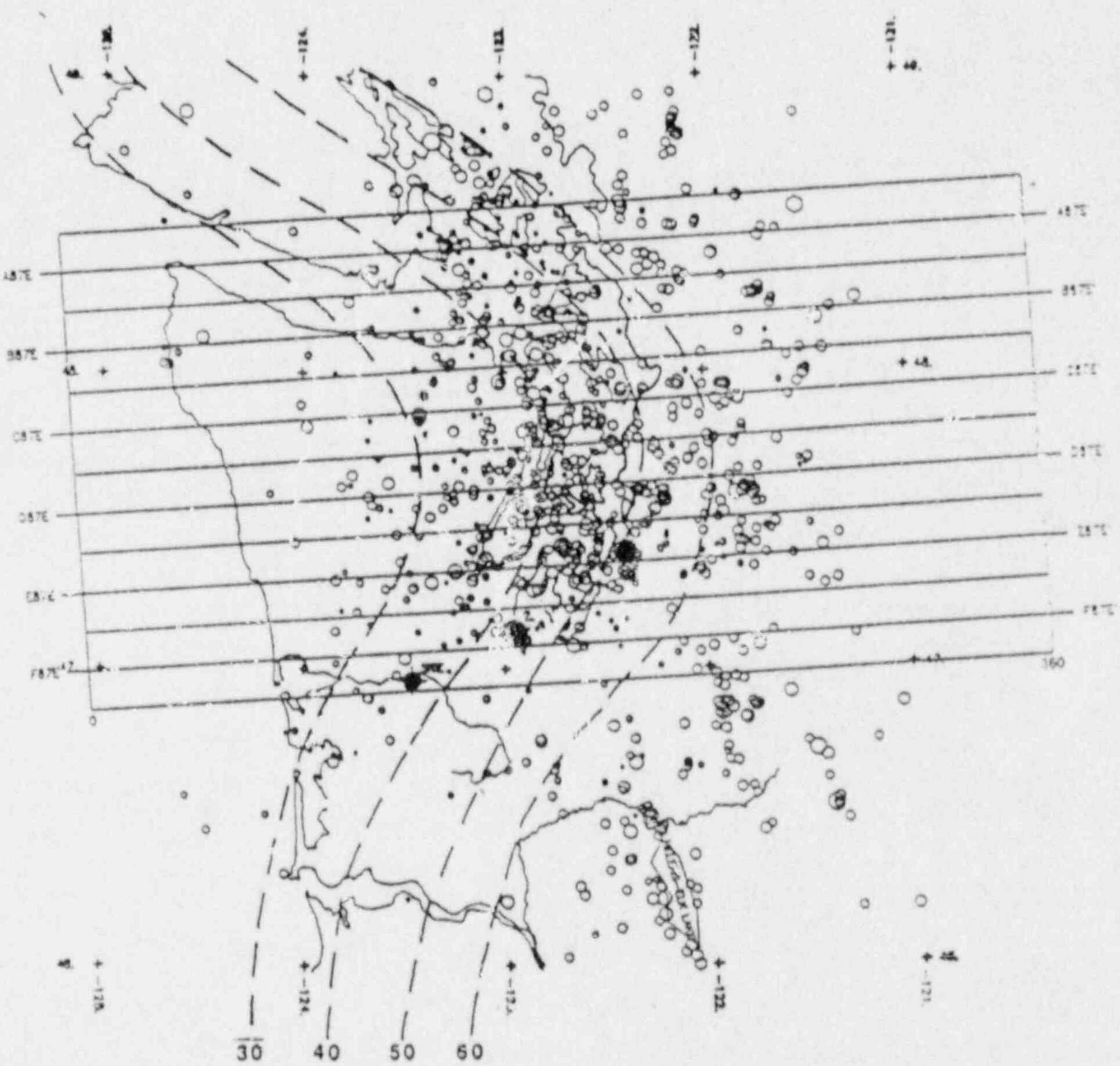
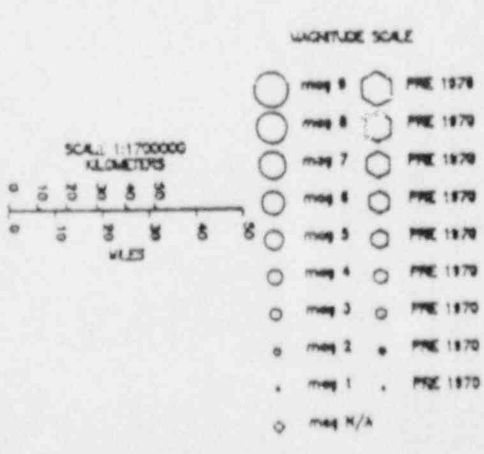


Figure 230.3a-2c

WASHINGTON SEISMICITY
UNIVERSITY OF WASHINGTON INSTRUMENTAL DATA (1970-1986) & (DEEP PRE 1970 DATA)
(0-30 km MAG>2.5) (30-100 km MAG>1.0)
EXCLUDING (Mt. St. HELENS-ELK LAKE ZONE)
CROSS SECTION ORIENTATION (NORTH 87 EAST)

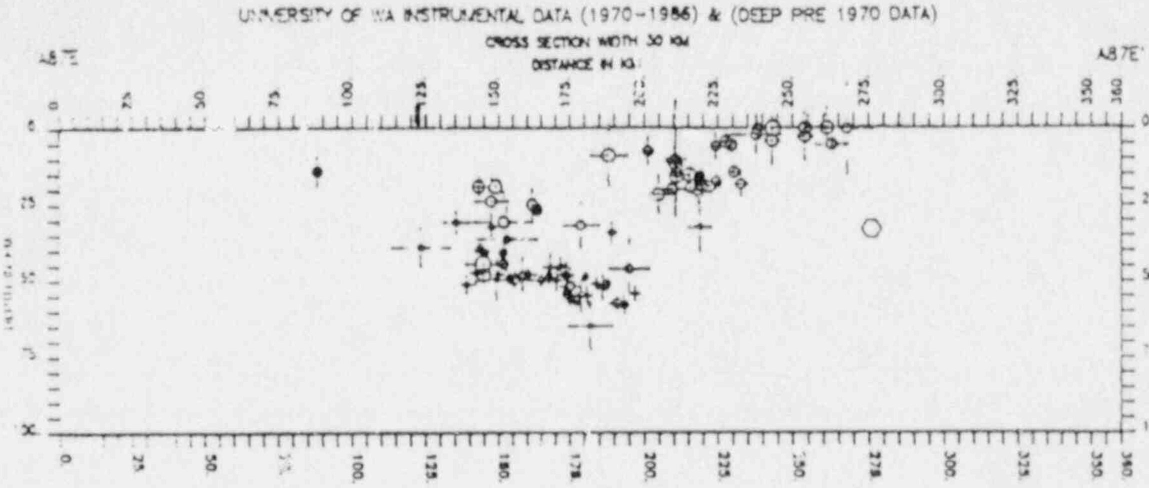


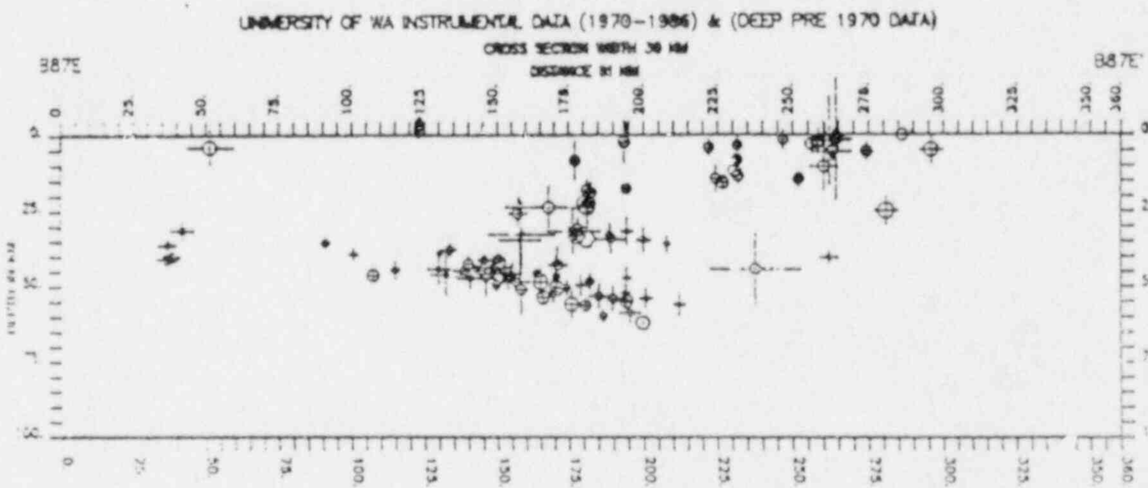


EVENTS OF SPECIAL INTEREST

1. FEB 15,1946 03:17 N47.134 W122.953 depth 71 km mag 5.8MB Int VII
2. APR 13,1949 19:55 N47.130 W122.950 depth 54 km mag 7.1MS Int VIII
3. APR 29,1965 15:28 N47.400 W122.400 depth 57 km mag 6.5MB Int VII

Figure 230.3a-3a





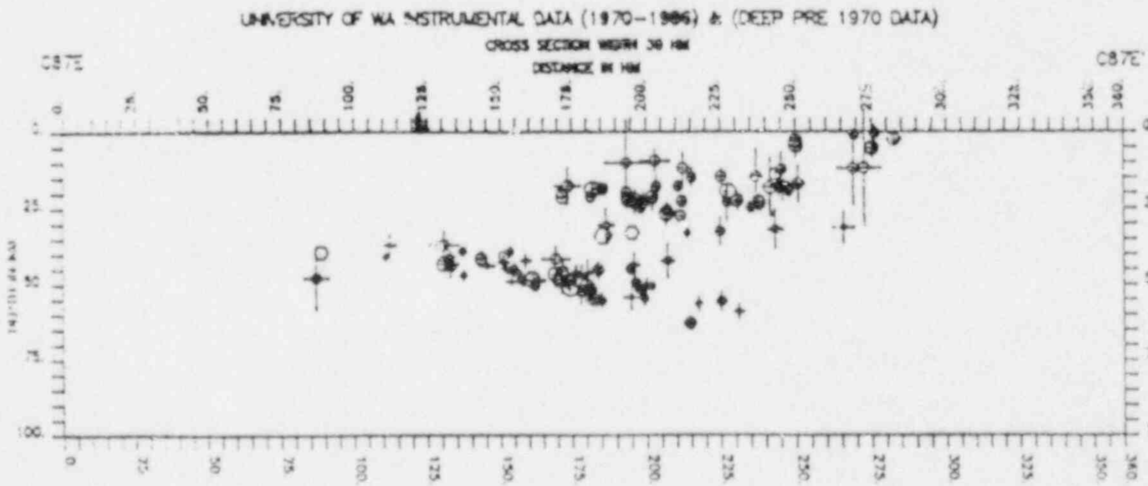
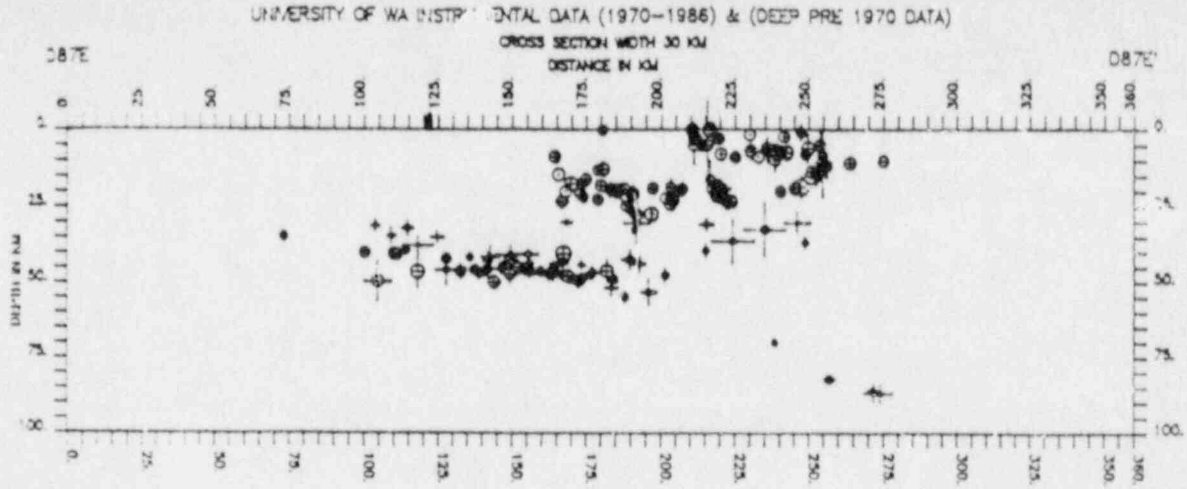
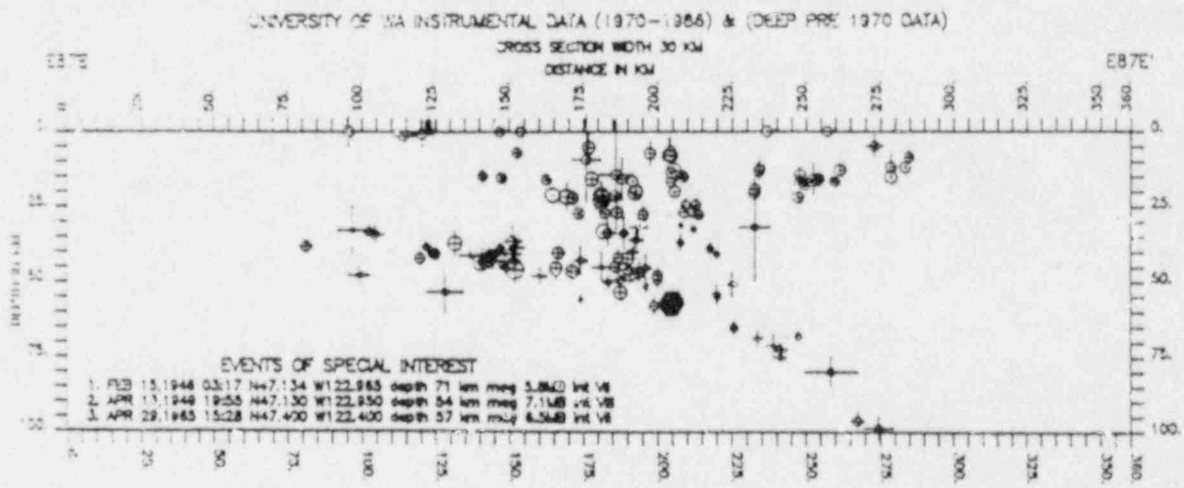


Figure 230.3a-3b





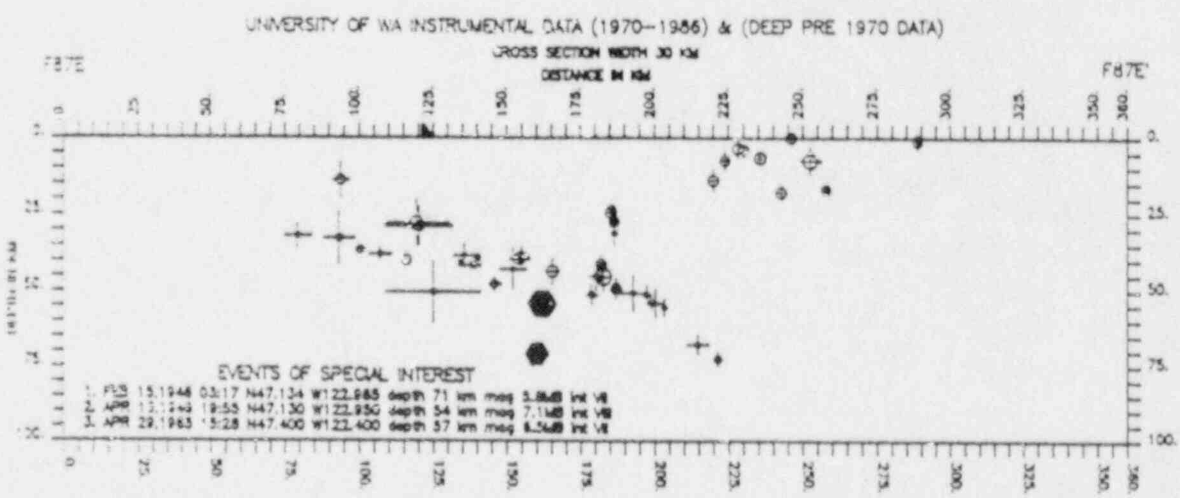


Figure 230.3a-3c

WASHINGTON SEISMICITY
UNIVERSITY OF WASHINGTON INSTRUMENTAL DATA (1970–1986) & (DEEP PRE 1970 DATA)
(0–30 km MAG>2.5) (30–100 km MAG>1.0)
EXCLUDING (Mt. St. HELENS–ELK LAKE ZONE)
CROSS SECTION ORIENTATION (NORTH 39 EAST)

Figure 230.3a-4a

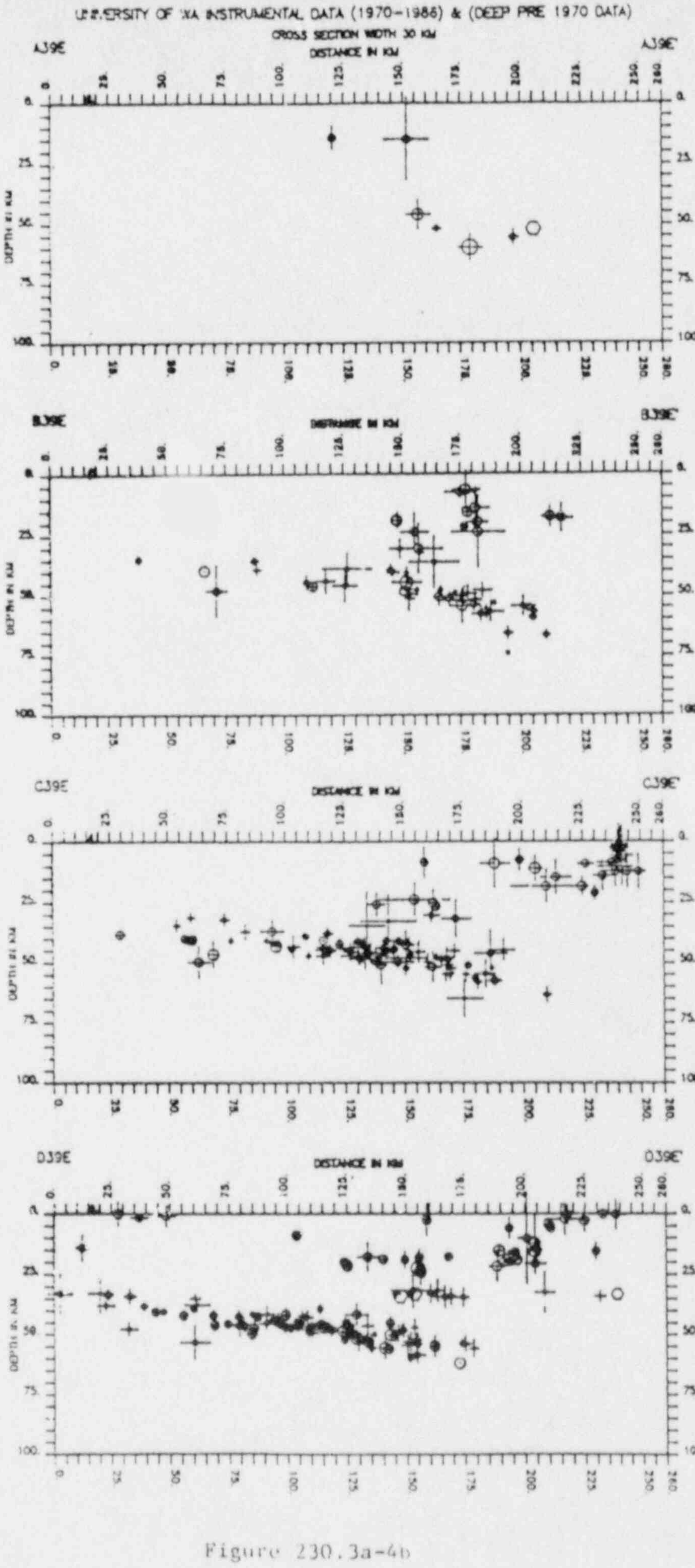


Figure 230.3a-4b

Crosson (1972, Fig 6) presents idealized estimates of location error

For dense arrays
idealized error $\ll$ reported error

Present contours of reported error averaged for 1/4° cells
1970-1979 & 1980-1986 time periods
<30km & >30 km depth ranges

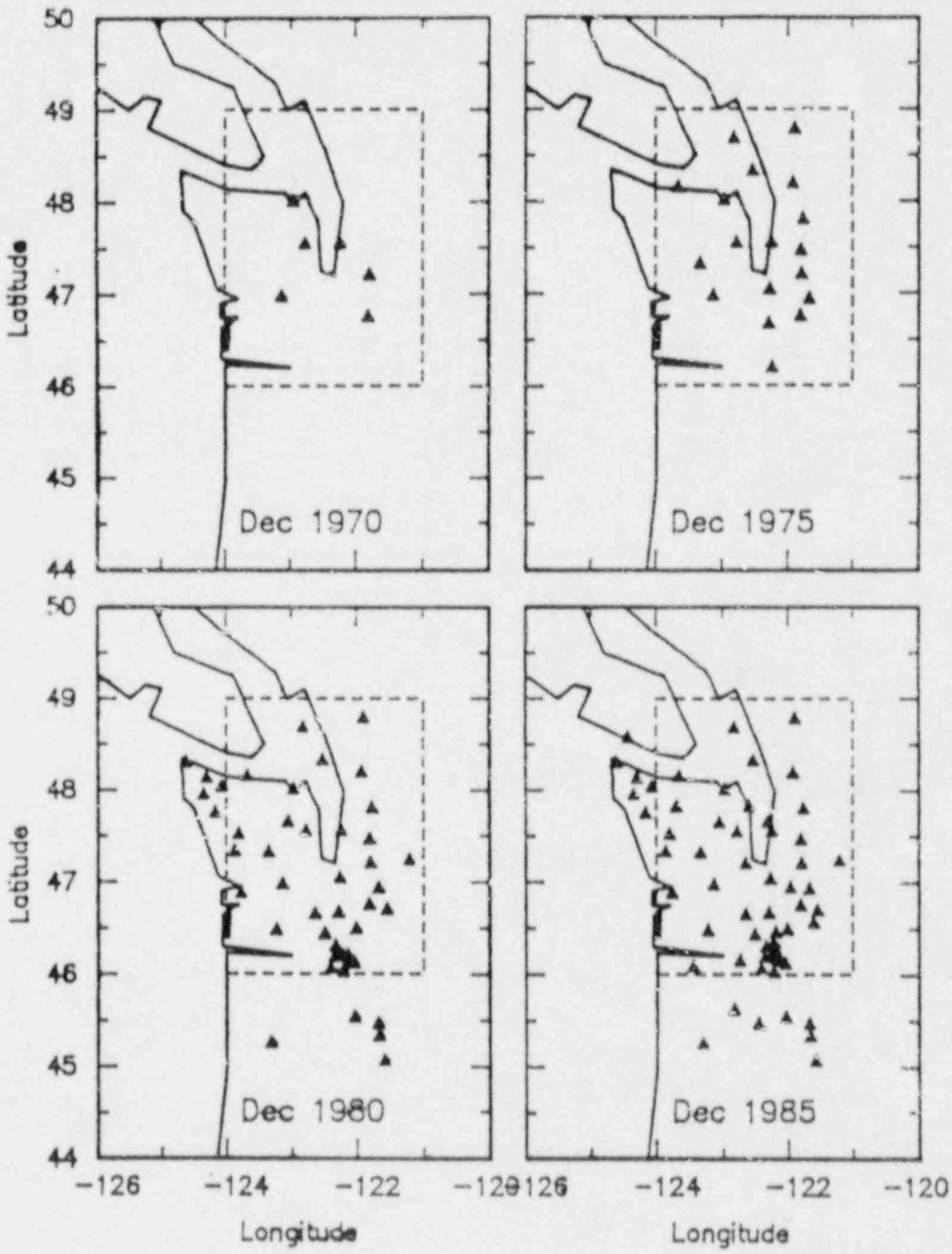


Figure 230.3a-5

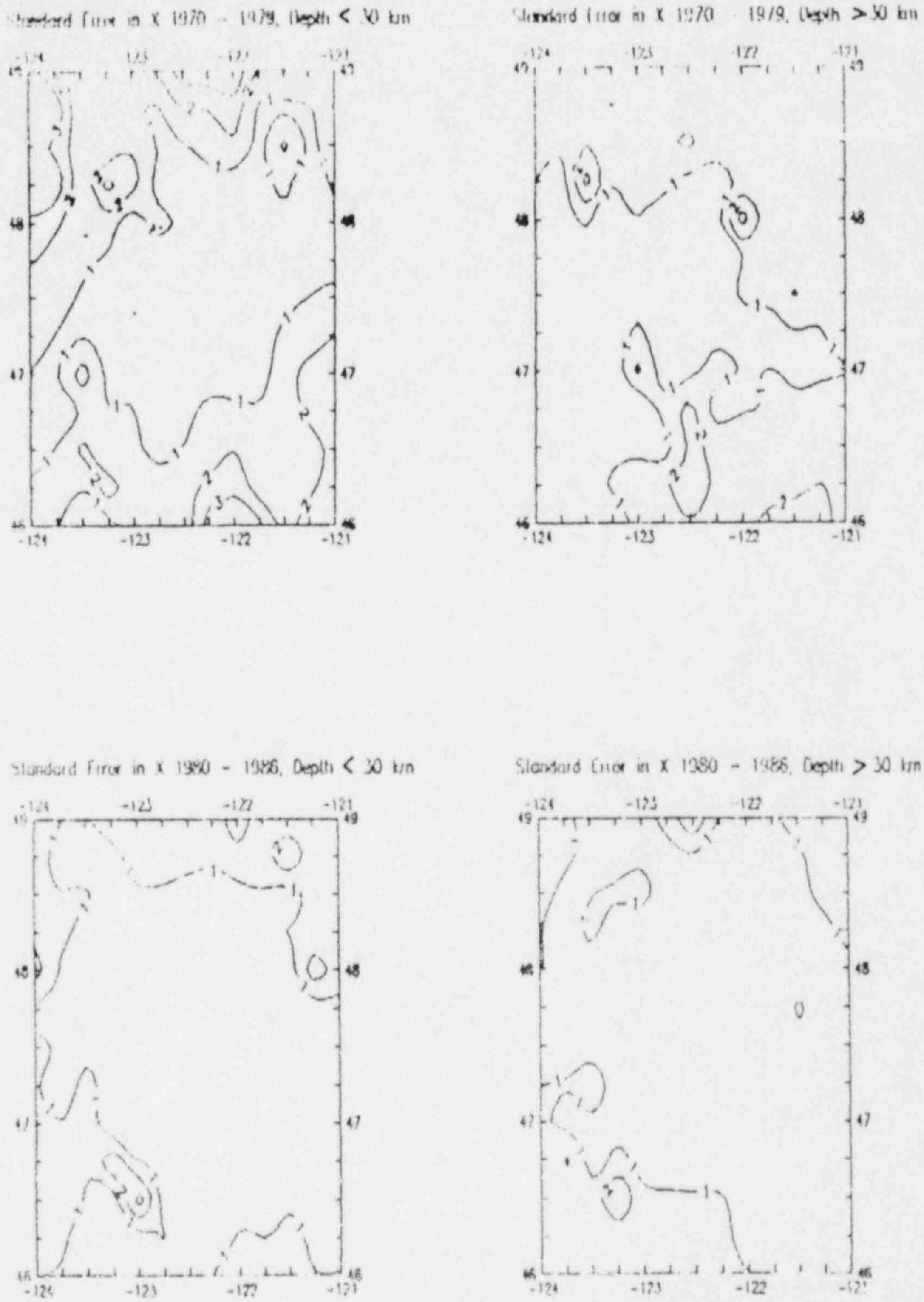


Figure 230.3a-6

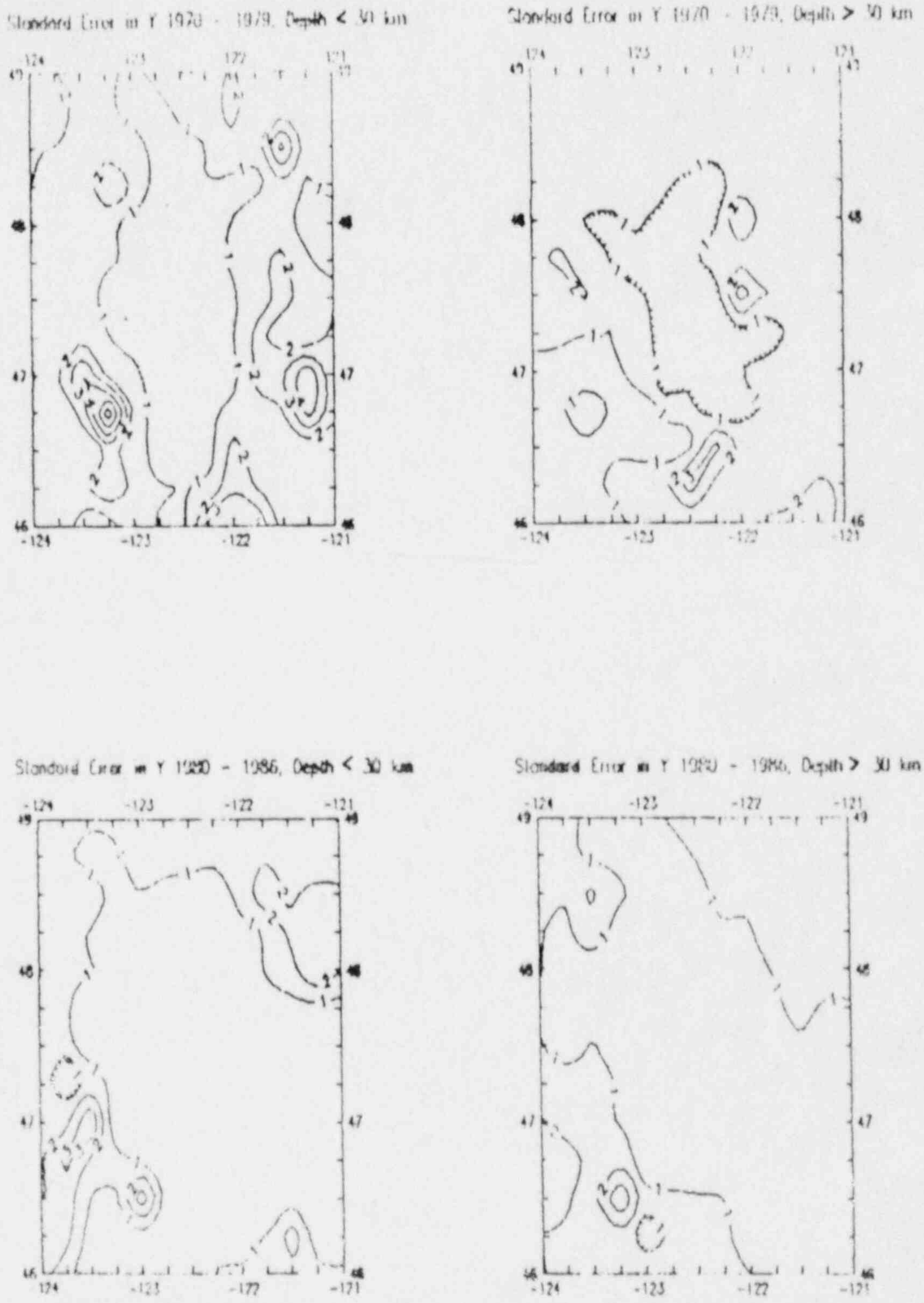


Figure 230.3a-7

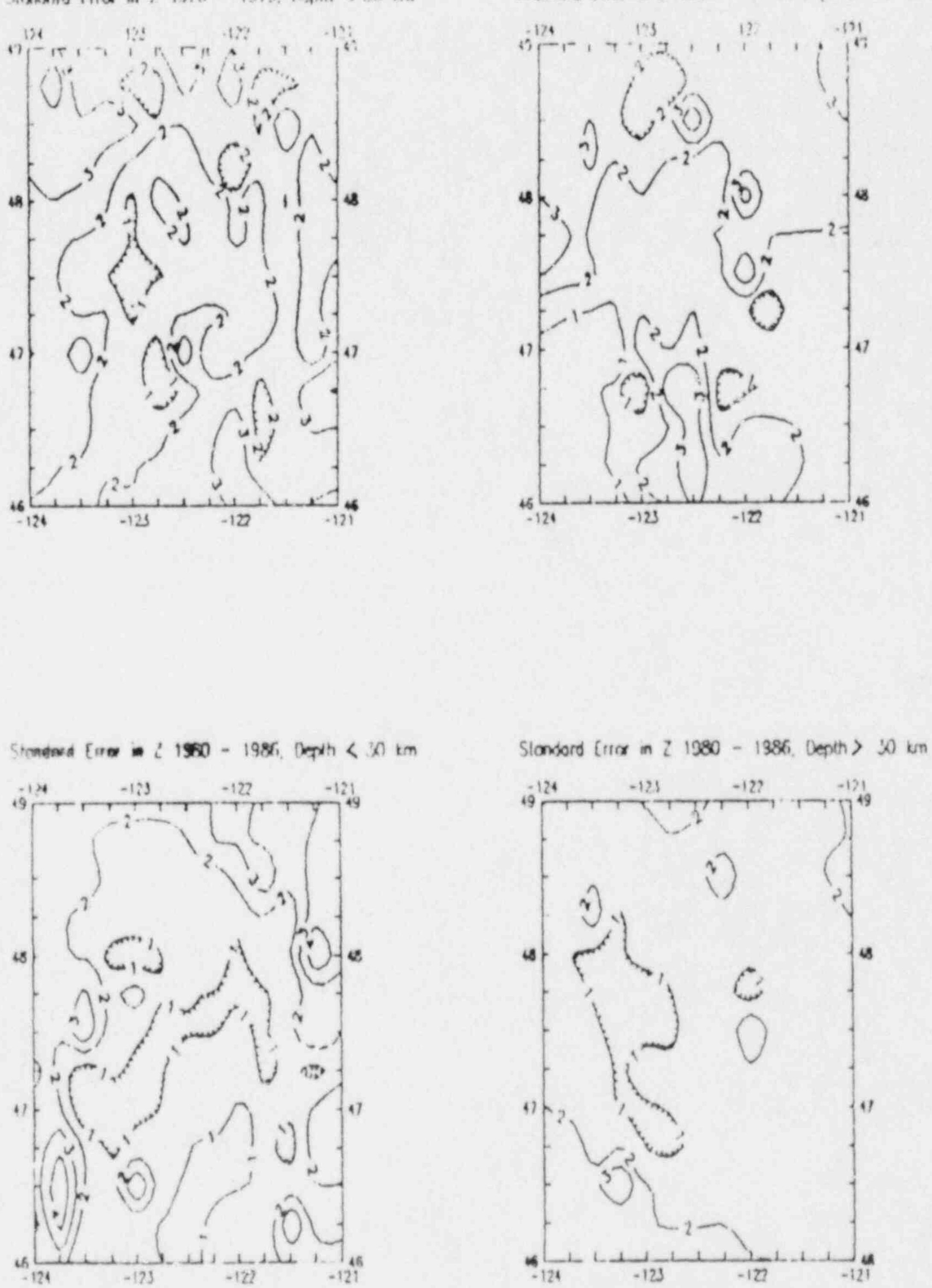


Figure 230.3a-8

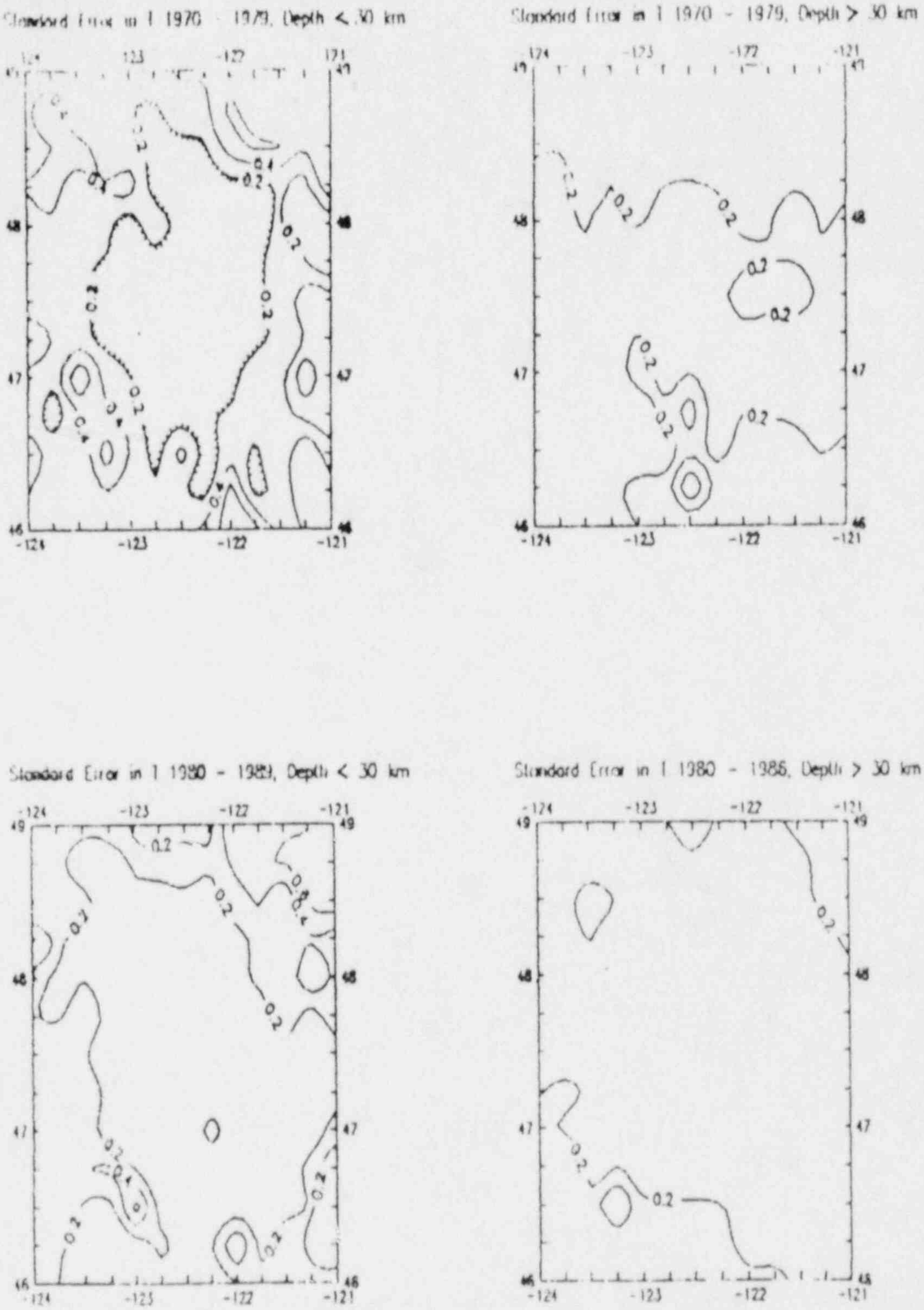


Figure 230.3a-9

Question 230.3c

Expand your explanation of the decrease in seismicity on the sections through the site west of point B in Figure 2.5-31.

- "Decrease in seismicity" → size of largest events in the slab relative to the downdip flexure

- All observed larger events have occurred at or to east of flexure

- Consistent with observations at other subduction zones

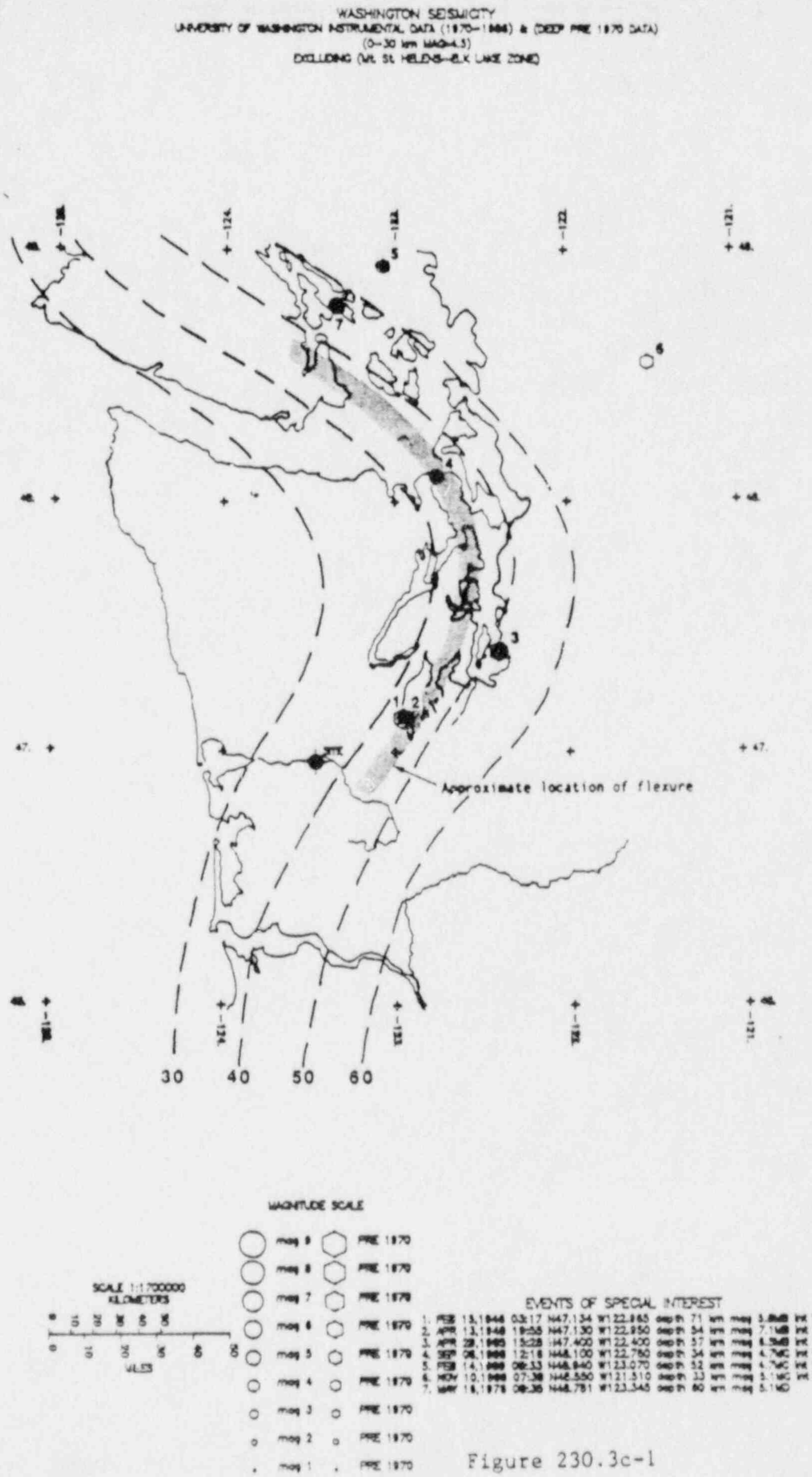


Figure 230.3c-1

Question 230.3d

The geometry and location of the flexure in the subducting plate is assumed to be the western boundary to down-dip tension earthquakes. Therefore, its position is critical. Clarify your reasoning for locating the position of the flexure.

- Reasoning for flexure: hypocentral distribution, magmatic generation depths

- 1965, 1949 events show downdip tension

- Small earthquakes observed to west of flexure; t-axes very generally downdip

- Slab-pull stresses expected within slab; stress localization likely at the flexure.

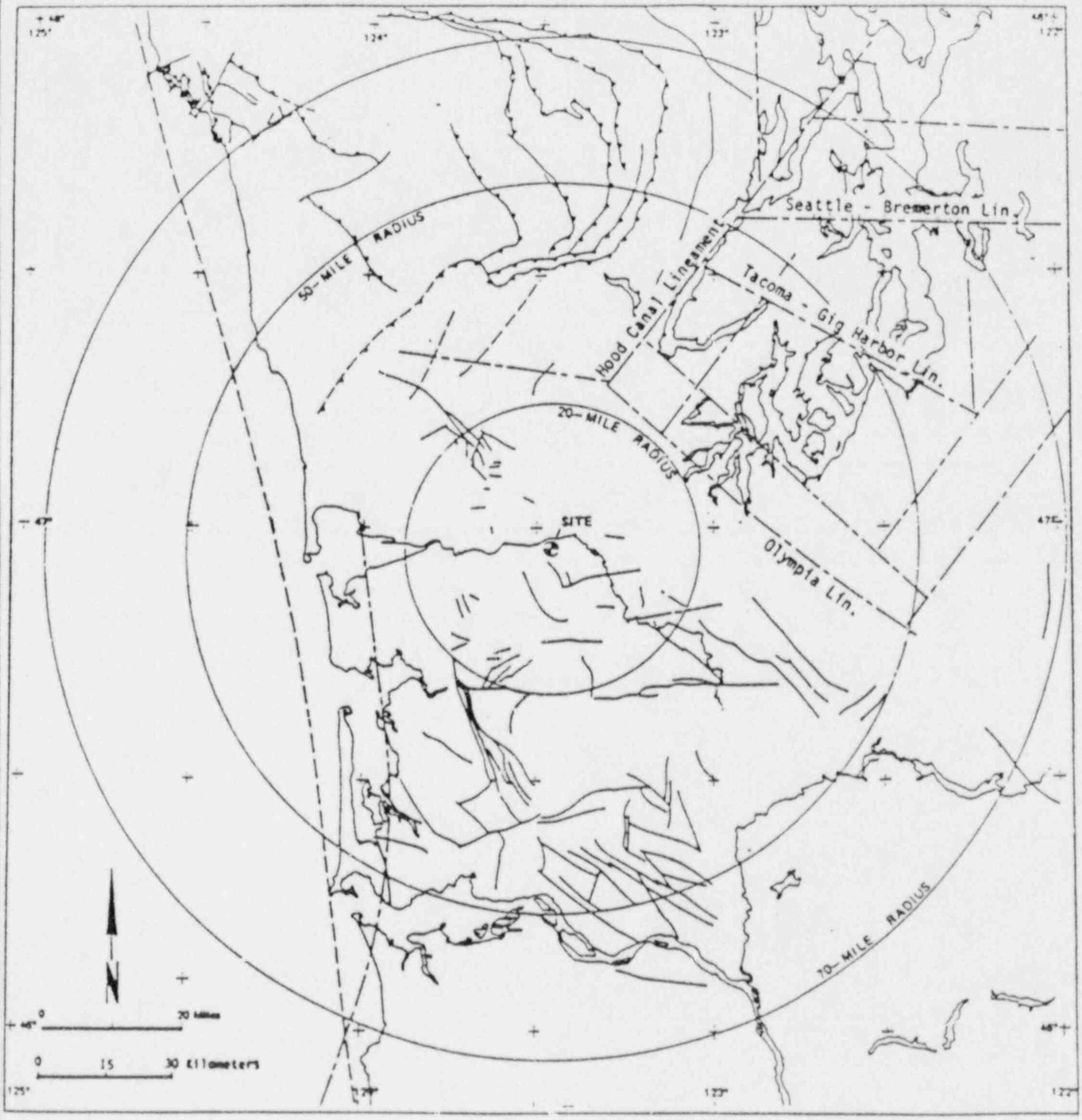
BOUGUER GRAVITY MAP OF
SITE AND OLYMPIA LINEAMENT

Figure 2

SOURCE: WPPSS, (1982), Figure 2.5.0-4

SIGNIFICANT FAULTS AND LINEMENTS WITHIN 70 MILES OF SITE

Figure 1



KNOWN FAULTS

High Angle

Thrust (barbs on upper plate)

POSTULATED FAULTS
Based on minimal evidence

PUBLISHED LINEAMENTS
Based mainly on geophysical and physiographic evidence

SOURCE: WPPSS, 1982

Question 230.3e

The Puget Sound earthquake of February 15, 1946, is a large earthquake with uncertain depth (Rasmussen, Millard, and Smith, 1974). If this event was relocated at a shallower depth or farther to the west, it may significantly alter the applicant's conclusions about the earthquake potential of the subduction interface or the overriding plate. The International Seismological Summary for 1946 (1954) lists over 40 observations for this earthquake. The observations range in distance from as close as Seattle to as far as Lome in the Ivory Coast. Despite the existence of these data, the applicant chose not to do a computer relocation (FSAR p. 2.5-120). We request that the applicant relocate this earthquake using the published I.S.C. data and establish the relationship of this earthquake to the Juan de Fuca-North American plate interface.

Relocation of 1946 earthquake

used Program TELES (B.3dt) &
Jeffreys-Bullen earth model
ISS data (42 stations)

4 Analysis Cases

1) data with residuals ≤ 30 sec (36 stations)

2) data with residuals ≤ 15 sec (34 stations)

3) data with residuals ≤ 10 sec + Washington State data (34 stations)

4) only data with residuals ≤ 10 sec (33 stations)

In addition depth determined using pP-P times & U of W velocity model

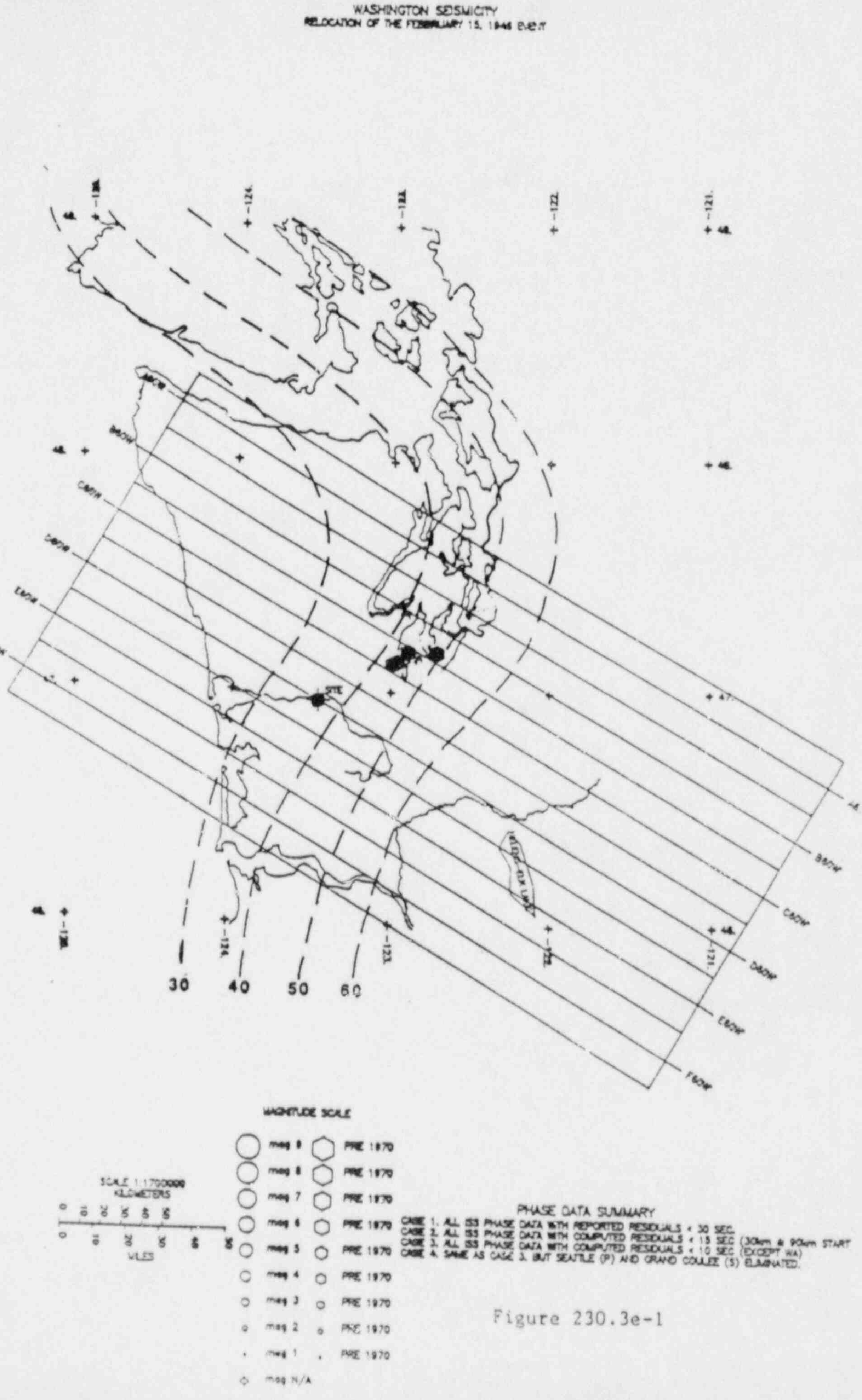


Figure 230.3e-1

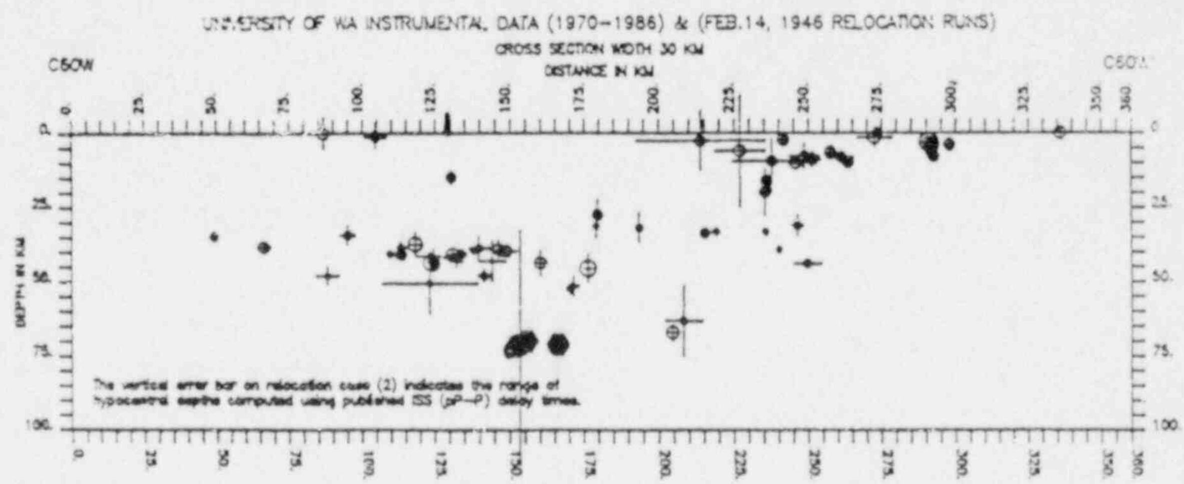


Figure 230.3e-2

Question 230.4a

Estimate the maximum magnitude possible for a "random earthquake" in the shallow crust within a 32-km radius around the site.

- "Maximum magnitude possible" evaluated based on historical seismicity and geological data.

- Maximum historical (5) plus ½ magnitude unit = 5½

- Geological data : age and amount of fault and fold deformation

  - Inferred deep fault blocks (e.g. S. Puget Sound) not present

  - Mapped faults in site locality (within 40KM) are not capable

  - Faults and folds genetically related to Tertiary deformation that ceased by early Pleistocene

  - Undiscovered surface faults precluded by stratigraphic and structural relationships
    - intraformational contacts
    - Astoria - Lincoln Creek contact (low angle)
    - geophysical lineaments, remote sensing lineaments
    - late Quaternary surfaces and deposits

  - Late Quaternary surfaces preclude fault or fold deformation, within resolution

Thickening of fault zones: A mechanism of melange formation in accreting sediments

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ABSTRACT

Sediments accreted at subduction zones undergo stratal disruption and form a type of melange. The thickness of the disrupted zones grows with progressive deformation. This suggests that initial fault surfaces are abandoned and deformation propagates into adjacent undeformed sediment. Factors causing the abandonment of fault surfaces during continuing deformation include (1) strengthening owing to porosity loss during consolidation, (2) localized drops in fluid pressure on fault surfaces that act as dewatering conduits, and (3) reorientation of fault surfaces. The disruptive processes occurring in accretionary prisms result principally from the deformation of a consolidating sediment mass.

INTRODUCTION

Stratigraphically disrupted sedimentary sequences represent one type of melange (Raymond, 1984; Cowan, 1985). Studies of modern accretionary prisms (Lundberg and Moore, 1986; Cowan et al., 1984), evidence from ancient accretionary complexes (Bachman, 1982; Byrne, 1984; Moore and Wheeler, 1978), sedimentary facies relations (Underwood, 1984), and theoretical arguments (Cloos, 1984) all suggest that this type of melange forms during the offscraping and underthrusting of deep-sea sediments (Fig. 1). The disrupted strata constitute broad shear zones that range in thickness from tens of metres in modern examples (e.g., Cowan et al., 1984) to kilometres in ancient melanges (e.g., Moore and Wheeler, 1978). Evidently, shear zones thicken during evolution of the accreted material. Stratal disruption developing in partially consolidated sediments, as opposed to low-porosity, lithified rocks, is obvious in drill cores from modern accretionary prisms and is inferred from textural studies of ancient accretionary complexes (e.g., Cowan, 1982; Byrne, 1984). Substantial disruption along fault zones in modern accretionary prisms is accompanied by significant cumulative displacements as documented by both seismic data and drilling (e.g., Biju-Duval et al., 1984). These disruptive processes are occurring at effective confining stresses that probably do not exceed 100 MPa (1 kbar). Enormous strain is possible during underthrusting, and this strain no doubt contributes to the ubiquity of stratigraphic disruption and melange formation. We argue, however, that the partially consoli-

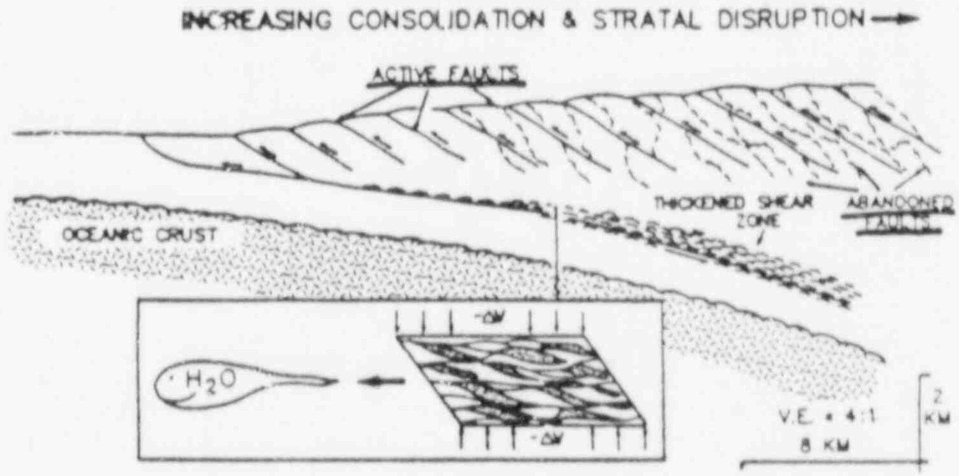


Figure 1. Cross section of accretionary prism showing progressive stratal disruption during offscraping and underthrusting. Details of fault abandonment in offscraped sediment and thickened fault zones after Cowan et al. (1984) and Moore et al. (1987). Inset: Detail of disruption showing volume decrease ($-\Delta V$) and dewatering (fish) associated with deformation, causing consequent increase in sediment strength.

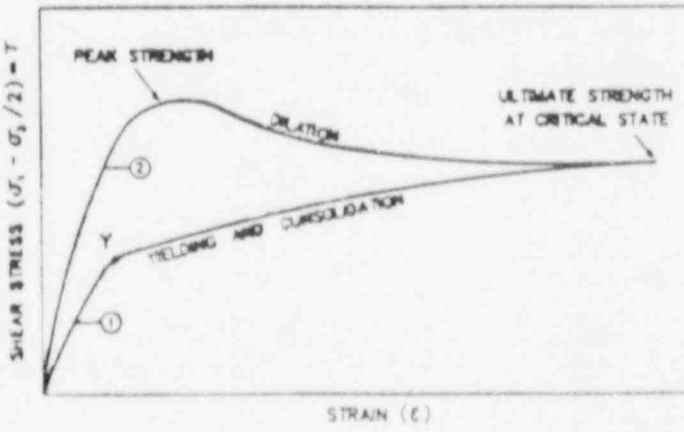
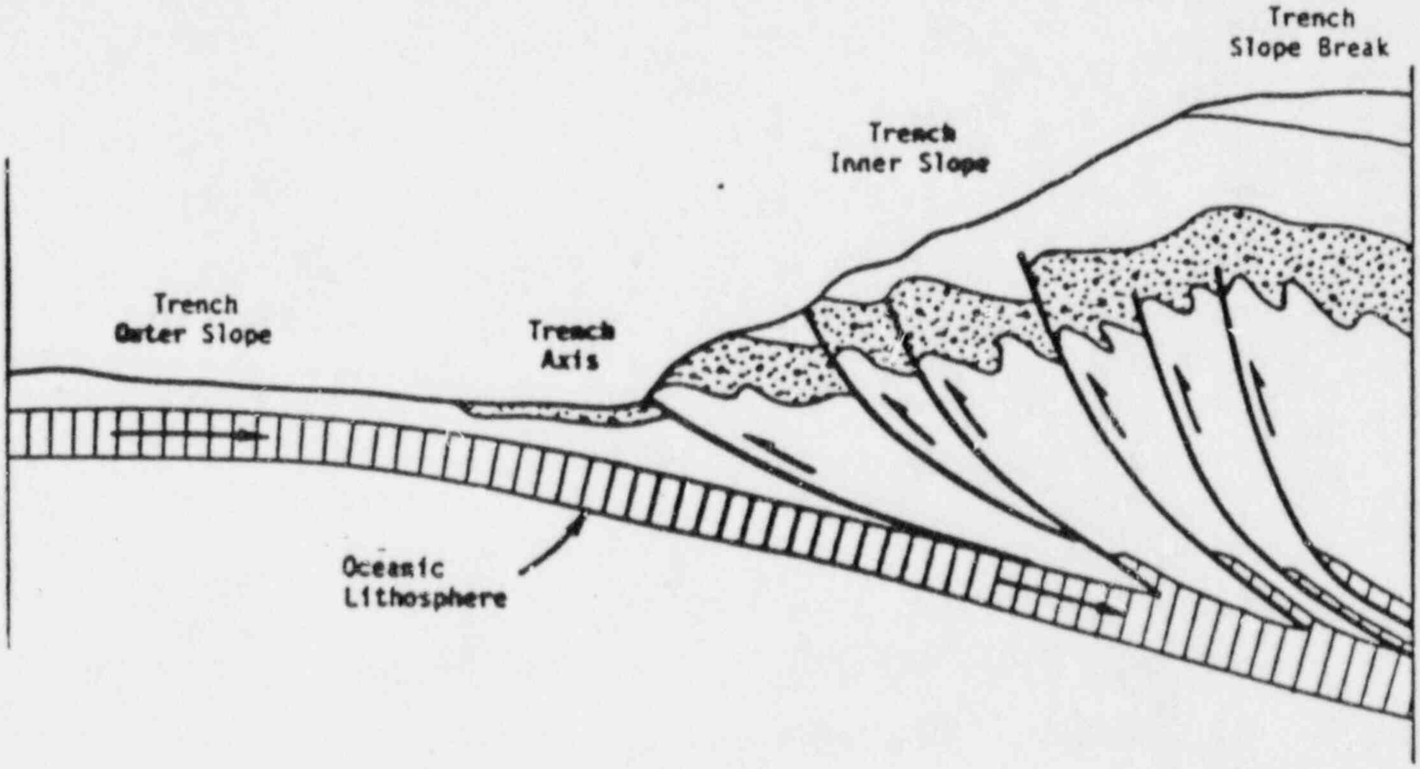


Figure 2. Generalized stress-strain curves for deformation of muddy sediment at low confining pressures. Sediments subject to fabric collapse (curve 1) yield, consolidate, and strain harden (e.g., Crawford, 1959; Bjerrum and Landva, 1966; Crooks and Graham, 1976). Conversely, muddy sediments deformed at confining stresses less than those of consolidation (curve 2) may increase in volume during deformation and show peak strength followed by lower residual strength (after Roscoe et al., 1958; Dunn et al., [illegible]). Irrespective of initial consolidation state, same sediment tends to converge on same ultimate strength at its critical state, a unique set of shear stress, normal effective stress, and porosity conditions. Strain hardening (similar to curve 1) is also shown during drained deformation of San Andreas fault gouge (Morrow et al., 1982; Chu, 1984) and dry cataclasis of sand and siltstone (Borg et al., 1960; Hoshino et al., 1972) at higher confining pressures. In each case, strengthening appears to be due to porosity reduction. Conversely, classical experiments on sandstone and shale more typically resemble curve 2 with initially higher peak strength followed by lower ultimate strength (e.g., Handin et al., 1963; Hoshino et al., 1972).

SCHEMATIC CROSS-SECTION OF TRENCH SLOPE ACCRETIONARY MODEL

Figure 5



NOTE:
Modified from Seely et al., 1974

Resolution : trenches → cm
detailed mapping → 1 m
reconn mapping → 5 m

- Given antiquity of deposits, only very small amounts of cumulative slip would escape detection:

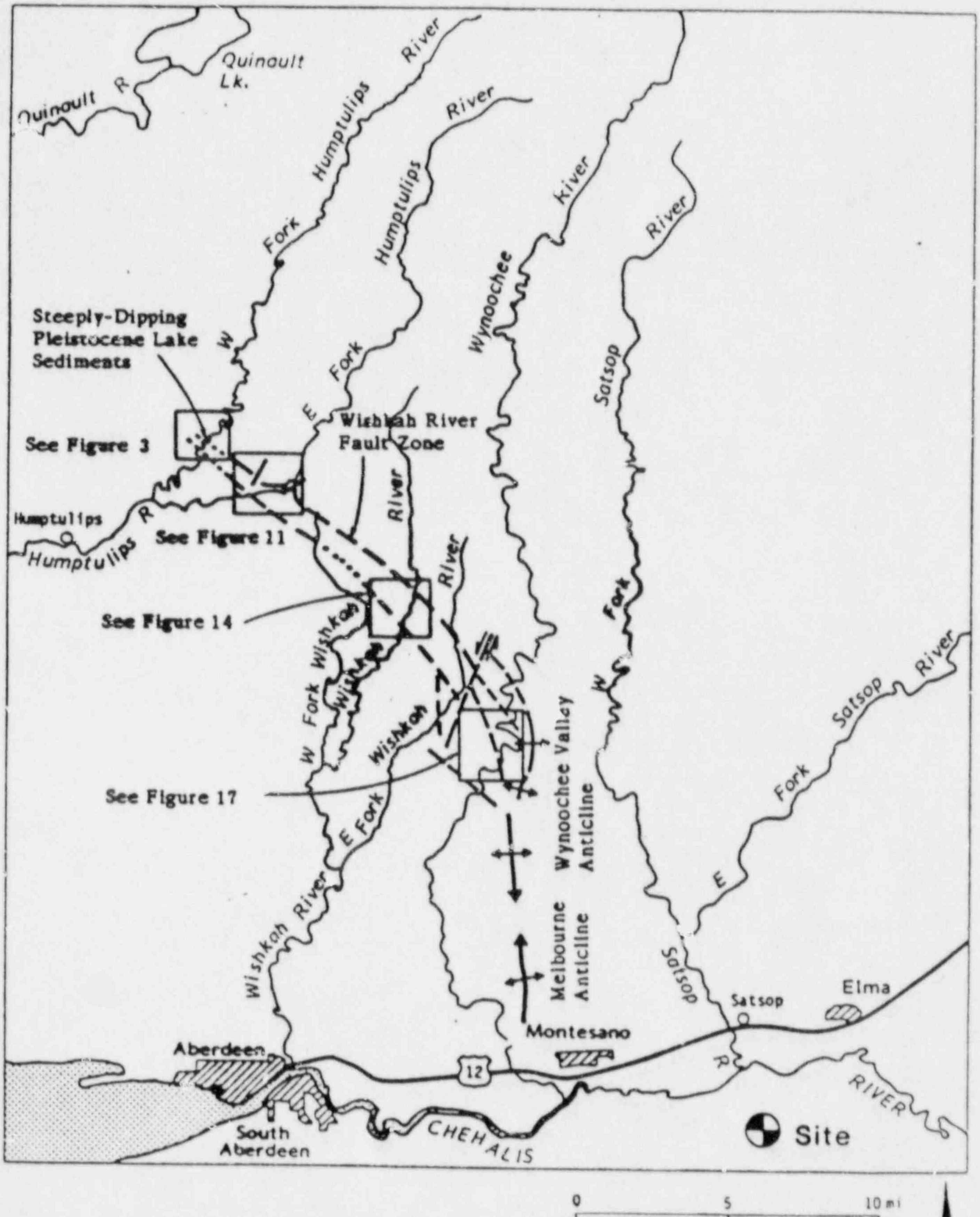
1 m / 300,000 yr	5 m / 800,000 yr
0.25 m / 75,000 yr	1 m / 60,000 yr
0.03 m / 10,000 yr	0.16 m / 10,000 yr

For imaginable recurrence intervals, displacements per event would be cm. → ~ M 6

- Given historical seismicity and maximum deformation allowed by geologic data, maximum possible magnitude for random event → 5½ - 6.

LOCATION MAP

Figure 1



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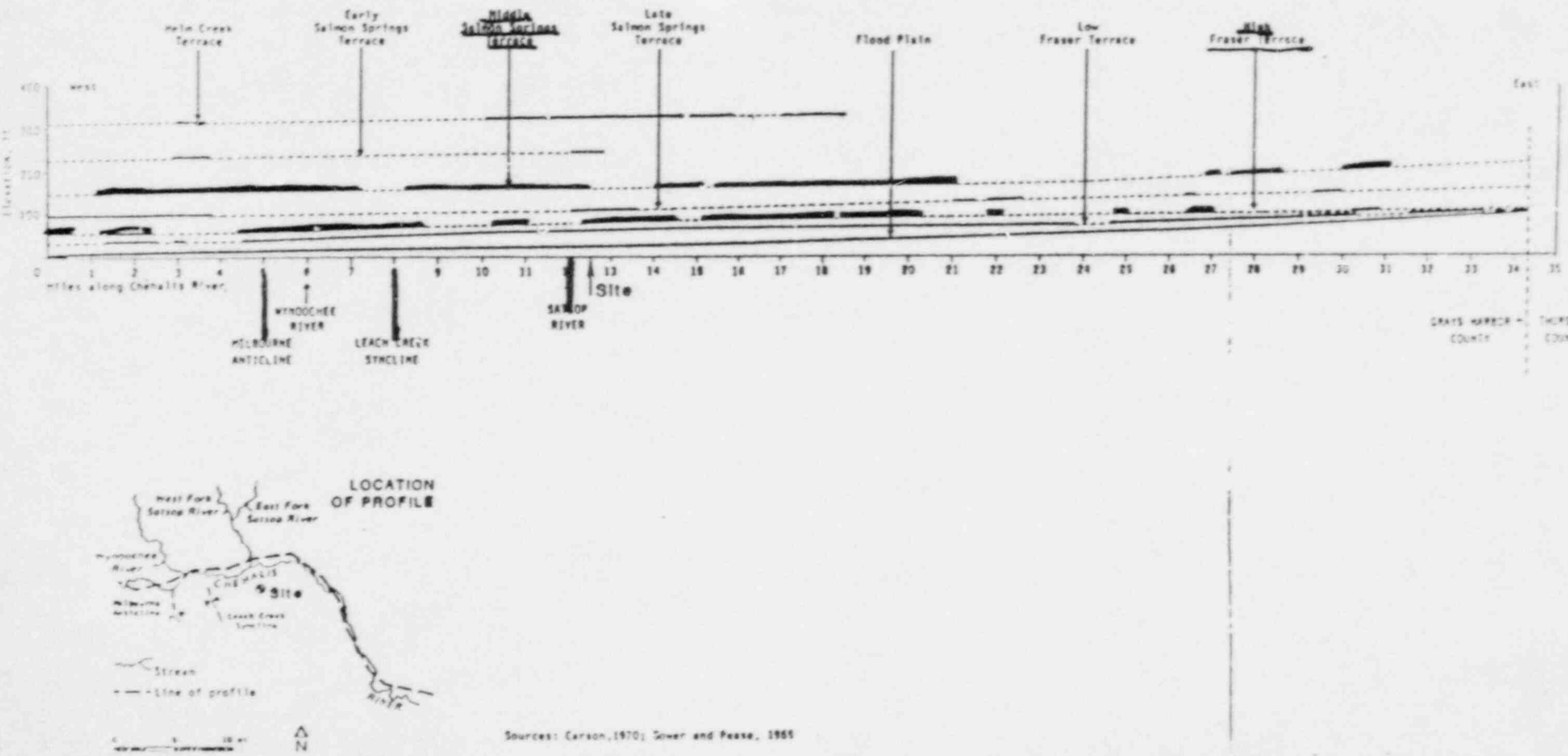
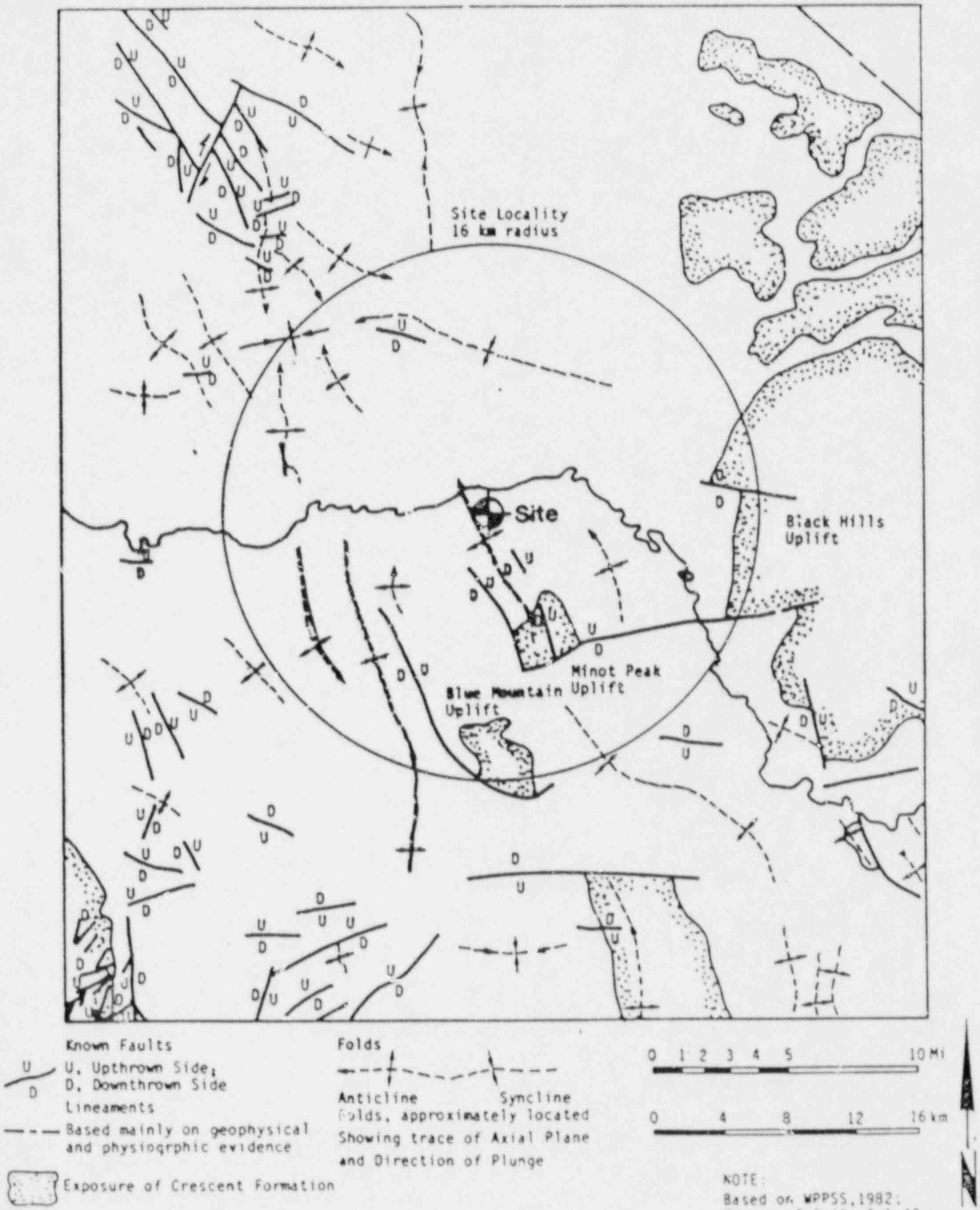
CHEHALIS RIVER
TERRACE PROFILES

Figure 23



Sources: Carson, 1970; Gower and Pease, 1965

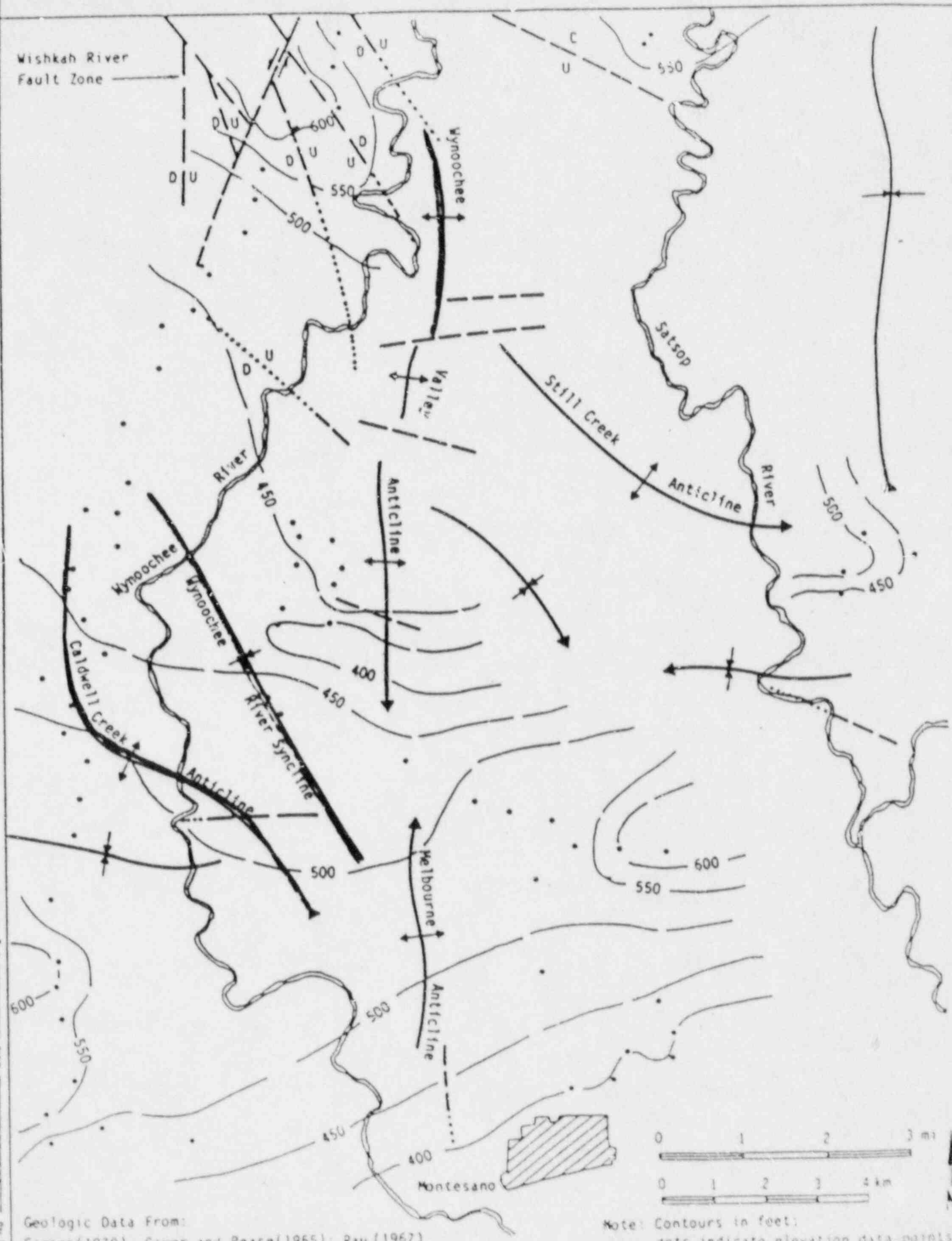
GEOLOGIC STRUCTURE OF SITE LOCALITY AND VICINITY Figure 1



NOTE:
Based on WPPSS, 1982:
Figures 2.5-40, 2.5-42

CONTOUR MAP OF THE ELEVATION OF THE TOP OF THE WEDEKIND CREEK FORMATION

Figure 22



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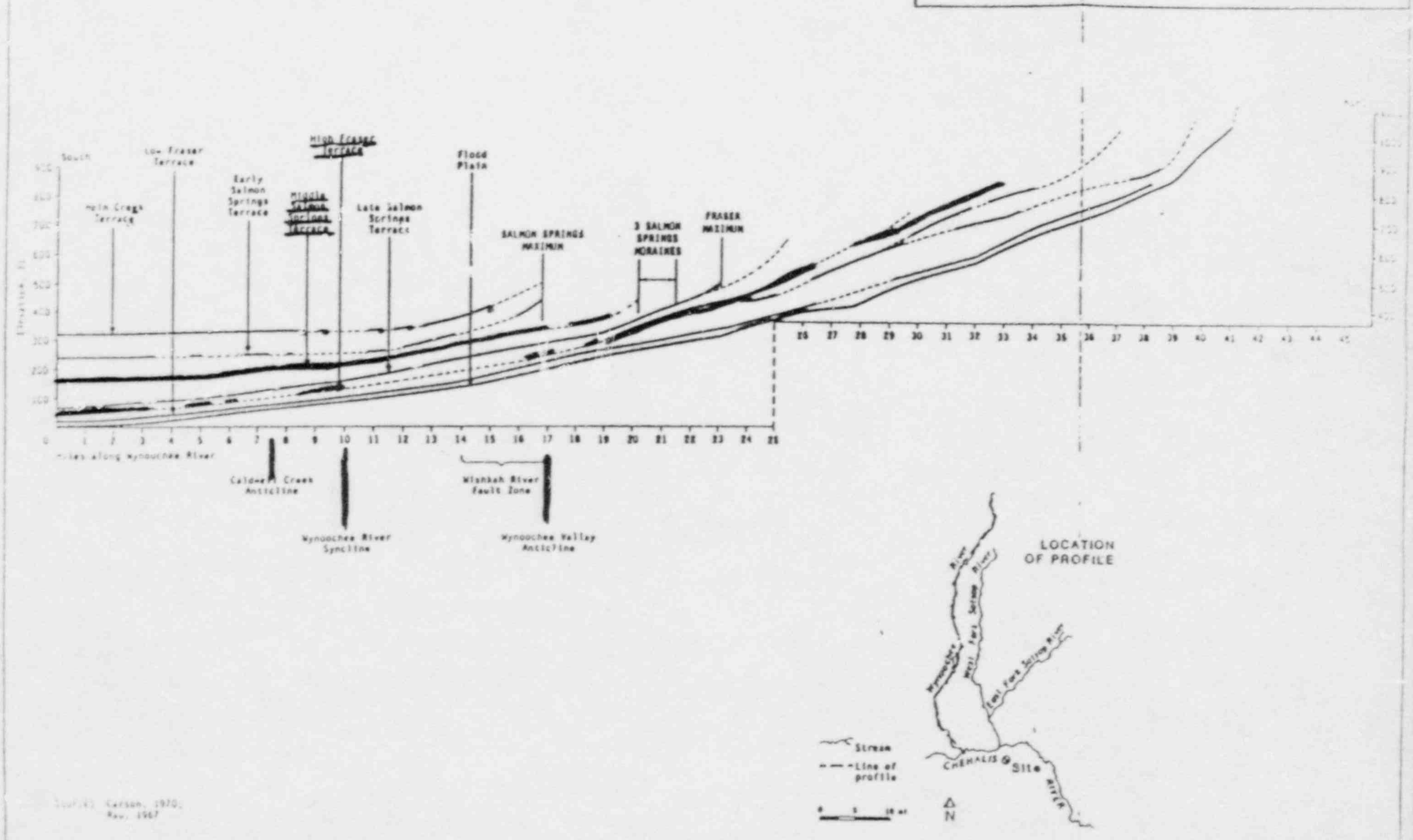
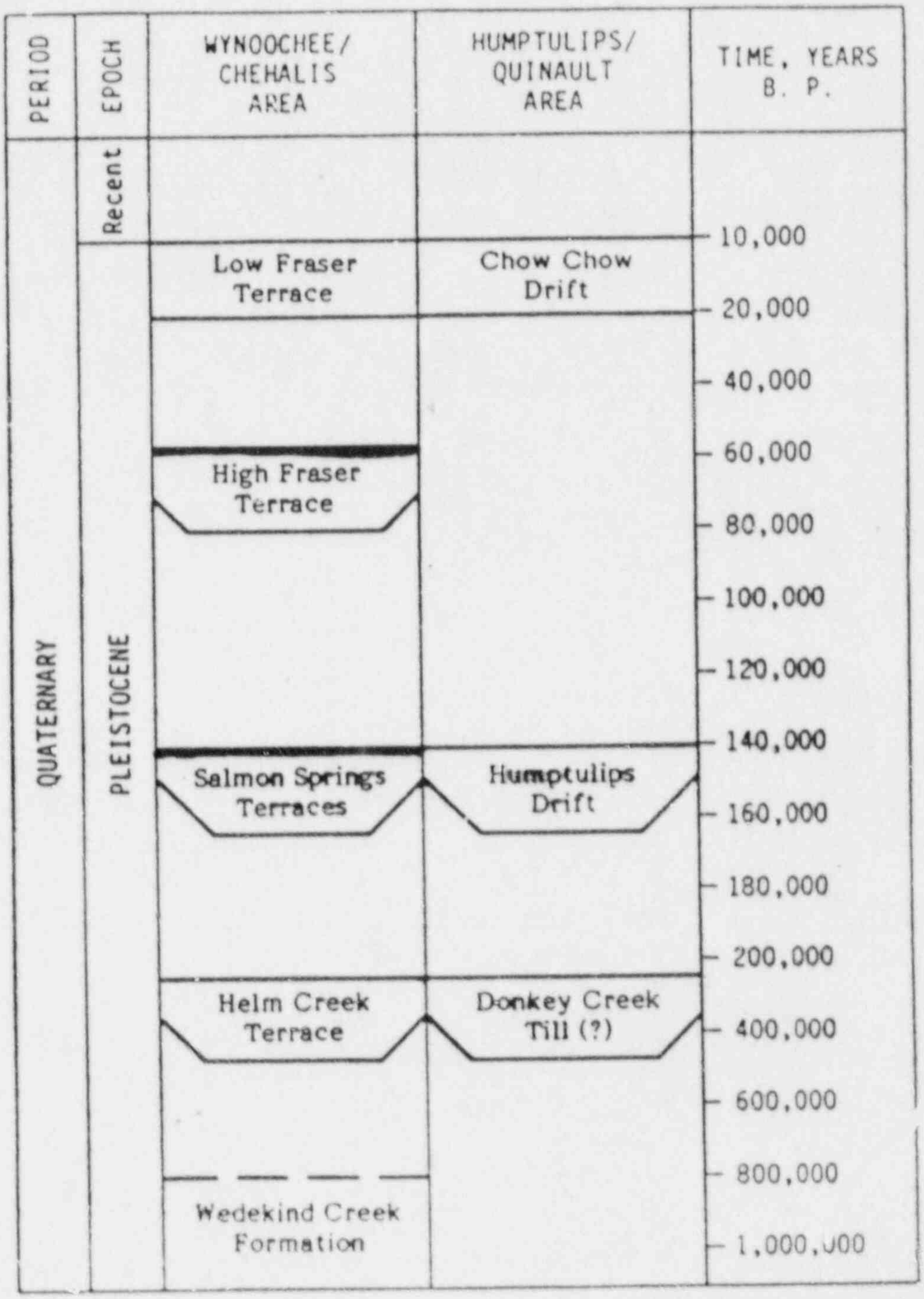


WYNOOCHEE RIVER TERRACE PROFILES

Figure 16

QUATERNARY CORRELATION CHART

Figure 2



SOURCES: WPPSS, 1982;
McCrumb and West, 1981;
Coleman and Pierce, 1981;
Carson, 1970;
Moore, 1965

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Question 230.4b

Inasmuch as the 17 March 1904 earthquake has not been associated with a structure at any of its various hypothetical locations (pp. 2.5-127, 128, FSAR), shown why the size of this earthquake should not be considered the size of the "random earthquake".

Question 230.4c

With respect to the 17 March 1904 earthquake, provide all references not in the public sector for the intensities shown in Figure 2.6-90, as well as for any other locations for which information is available which could be used to assess intensity. Provide the documentation for the relocation of the earthquake to "south of Port Townsend" and the assignment of a smaller size (both attributed to the Pacific Science Center, Victoria, B.C., as "Milne, 1981, private communication" and "Rogers, 1981, private communication").

Location and Size of 1904 Earthquake

- Early locations rounded off to nearest 1° or ½°

- Location developed by Rogers (1983) consistent with isoseismals presented in FSAR Fig 2.5-90
  These are based on felt reports in Townley & Allen & local newspapers

- Rogers' location & isoseismals suggest event located on western edge of Puget Sound seismic zone

- Rogers' estimate of M_L 5.3 based on Toppozada (1975)
  $M_L = -1.88 + 1.53 \log_{10}$ (felt area)
  & felt area of 20,000 mi^2 reported by Rasmussen (1967)

  Felt area shown in Fig 2.5-90 (40,000 mi^2) yields M_L 5.7

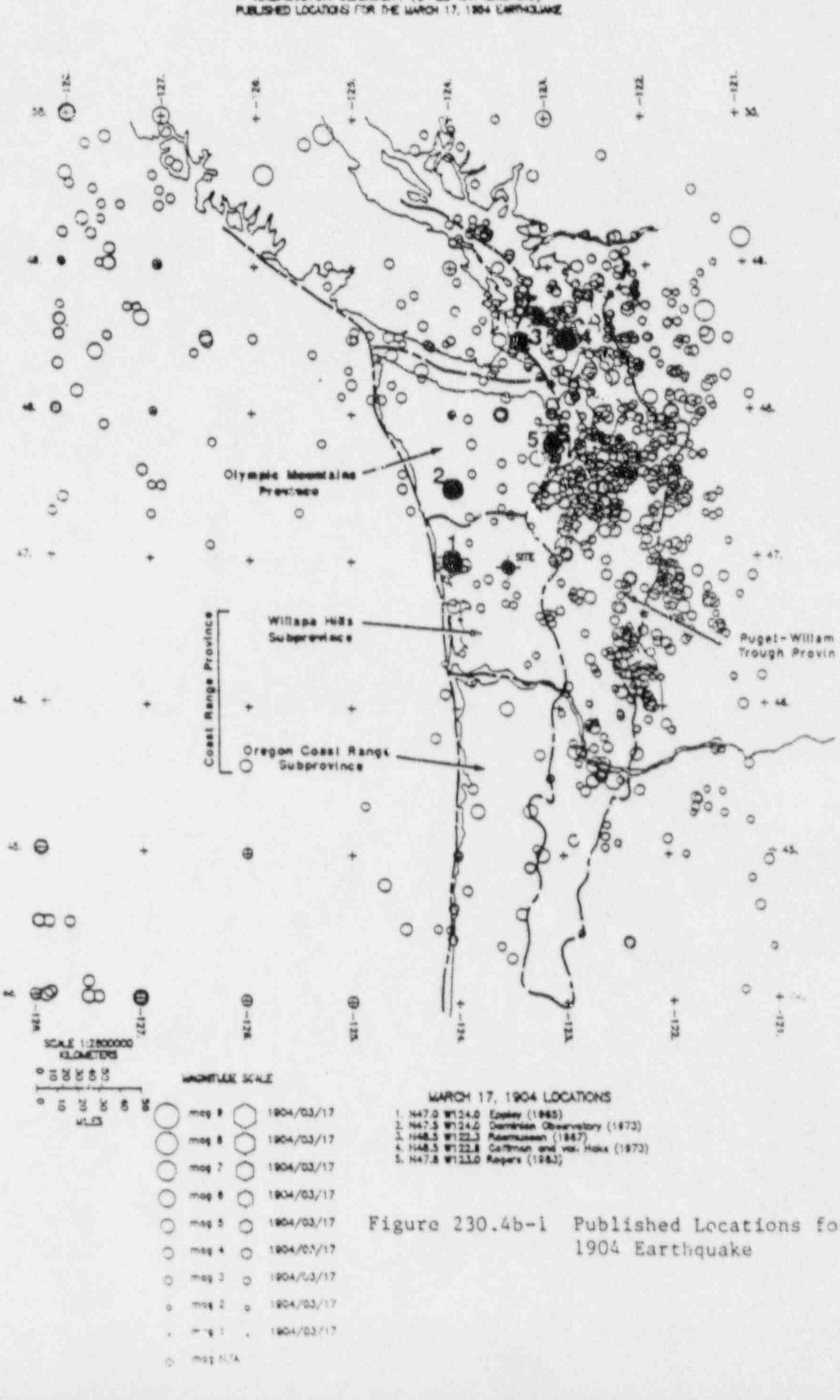


Figure 230.4b-i Published Locations for 1904 Earthquake

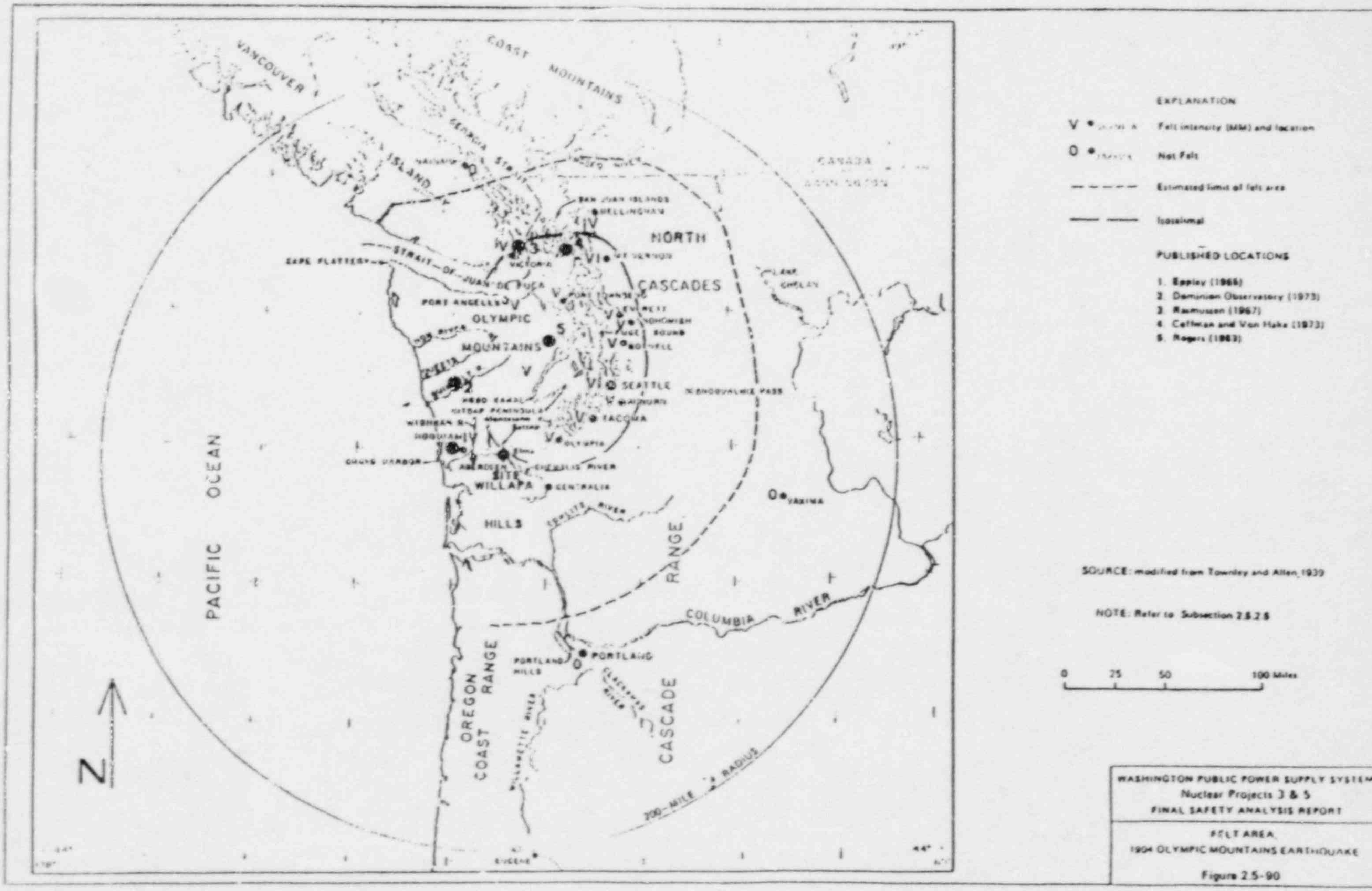


Figure 230.4b-2 Isoseismal Map for 1904 Earthquake

Question 230.4d

Identify the maximum historical earthquake, not associated with known geologic structure, in the tectonic province of the site. Following Appendix A to 10CFR100, assume this earthquake can occur in the vicinity of the site, estimate the resulting ground motion, and assess the adequacy of the SSE spectrum for this occurrence.

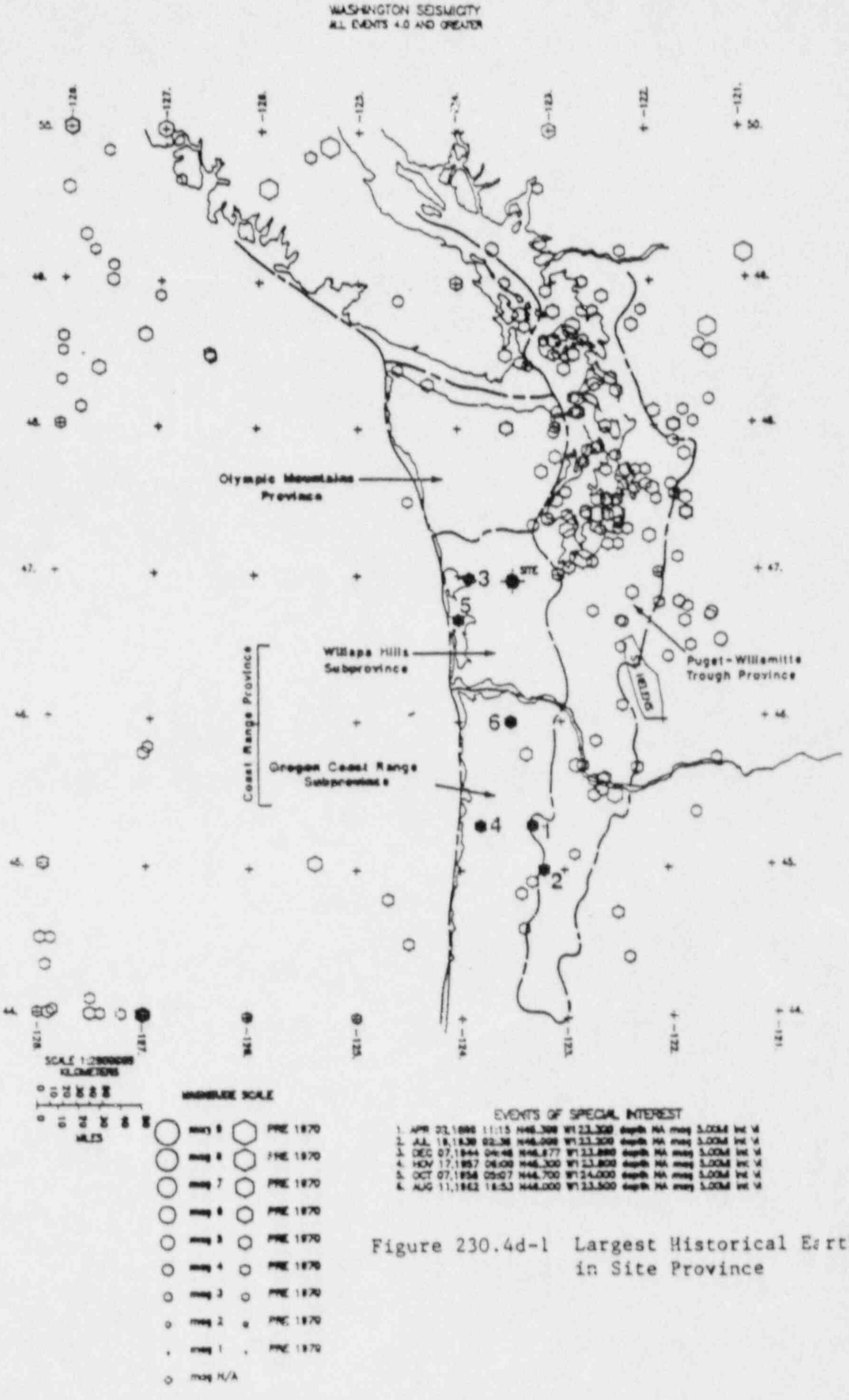


Figure 230.4d-1 Largest Historical Earthquakes in Site Province

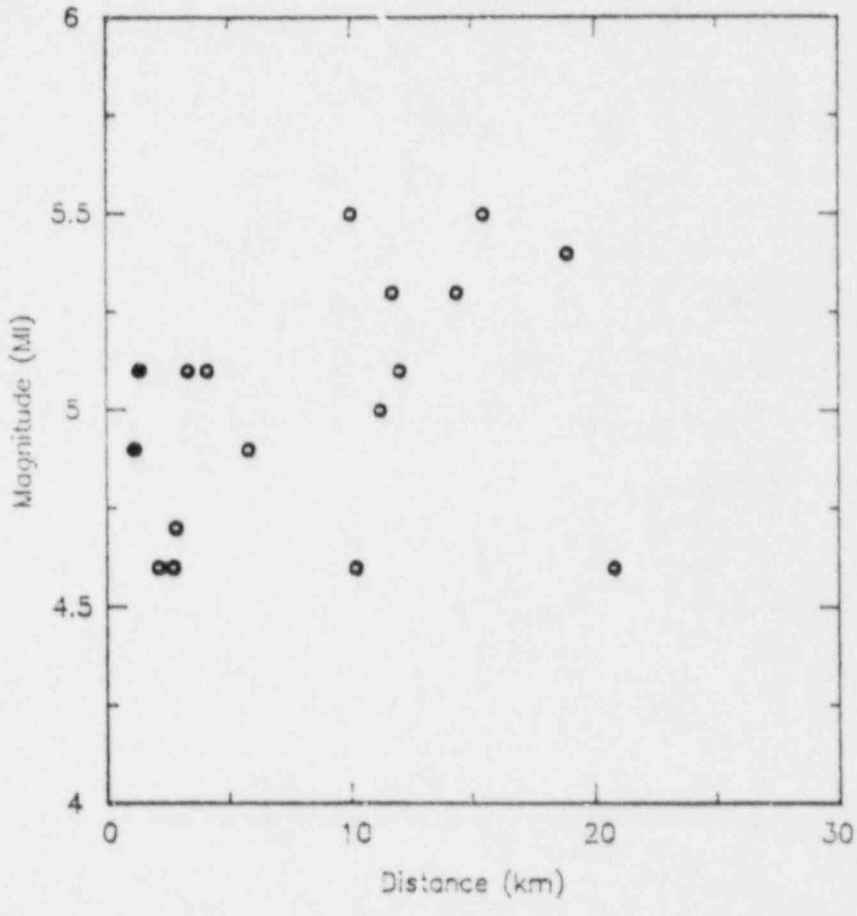


Figure 230.4d-2 Scattergram of Available Recordings

Table 230.4d-1. RECORDS USED IN STATISTICAL ANALYSIS

Earthquake Name	Date	Fault Type	Ml	Station No	Epic Dist (km)	Comp	PGA (g)
Helena, Montana (A)	11/28/35	Normal	5.0	2229	6.4	N00E	0.076
Helena, Montana (A)	11/28/35	Normal	5.0	2229	6.4	N90E	0.088
San Francisco, CA	3/22/57	StrikeSlip	5.3	1117	11.7	N10E	0.105
San Francisco, CA	3/22/57	StrikeSlip	5.3	1117	11.7	S80E	0.127
Lytle Creek, CA	9/12/70	Reverse	5.4	111	18.9	S85E	0.086
Lytle Creek, CA	9/12/70	Reverse	5.4	111	18.9	S05W	0.057
Oroville, CA (AA)	8/3/75	Normal	4.6	1543	2.7	S00E	0.255
Oroville, CA (AA)	8/3/75	Normal	4.6	1543	2.7	N90E	0.140
Oroville, CA (AF)	8/6/75	Normal	4.7	1543	2.8	S00E	0.470
Oroville, CA (AF)	8/6/75	Normal	4.7	1543	2.8	N90E	0.229
Oroville, CA (AK)	8/8/75	Normal	4.9	1551	5.8	S55E	0.077
Oroville, CA (AK)	8/8/75	Normal	4.9	1551	5.8	N35E	0.109
Oroville, CA (AK)	8/8/75	Normal	4.9	1543	1.1	S00E	0.274
Oroville, CA (AK)	8/8/75	Normal	4.9	1543	1.1	N90E	0.116
Oroville, CA (AU)	9/27/75	Normal	4.6	1495	10.2	N90W	0.155
Oroville, CA (AU)	9/27/75	Normal	4.6	1495	10.2	S00E	0.075
Oroville, CA (AU)	9/27/75	Normal	4.6	1543	2.1	S00E	0.163
Oroville, CA (AU)	9/27/75	Normal	4.6	1543	2.1	N90E	0.203
Oroville, CA (AU)	9/27/75	Normal	4.6	1552	20.8	N20W	0.067
Oroville, CA (AU)	9/27/75	Normal	4.6	1552	20.8	S70W	0.050
Friuli Seq,Italy	09/11/76	Reverse	5.5	8019	10.0	NORT	0.039
Friuli Seq,Italy	09/11/76	Reverse	5.5	8019	10.0	EAST	0.034
Friuli Seq,Italy	09/11/76	Reverse	5.5	8022	15.5	NORT	0.042
Friuli Seq,Italy	09/11/76	Reverse	5.5	8022	15.5	EAST	0.071
Coalinga, CA AS03	05/09/83	Reverse	5.1	46	4.1	N90E	0.353
Coalinga, CA AS03	05/09/83	Reverse	5.1	46	4.1	N00E	0.302
Coalinga, CA AS03	05/09/83	Reverse	5.1	61	3.3	N00E	0.114
Coalinga, CA AS03	05/09/83	Reverse	5.1	61	3.3	N90W	0.152
Coalinga, CA AS03	05/09/83	Reverse	5.1	65	1.3	N00E	0.177
Coalinga, CA AS03	05/09/83	Reverse	5.1	65	1.3	N90W	0.240
Coalinga, CA AS10	07/09/83	Reverse	5.3	46	14.4	N90E	0.074
Coalinga, CA AS10	07/09/83	Reverse	5.3	46	14.4	N00E	0.056
Coalinga, CA AS13	07/21/83	Reverse	5.0	46	11.2	N90E	0.031
Coalinga, CA AS13	07/21/83	Reverse	5.0	46	11.2	N00E	0.045
Coalinga, CA AS14	07/25/83	Reverse	5.1	46	12.0	N90E	0.201
Coalinga, CA AS14	07/25/83	Reverse	5.1	46	12.0	N00E	0.178

Table 230.4d-2. ROCK STRONG-MOTION RECORDING STATIONS

Stn.* No.*	Station Name	Station Description Instrument Housing (Ref.)	Subsurface Conditions (Ref.)
46	CDMG COALINGA: SKUNK HOLLOW	Free-field (07)	Pliocene Marine (06)
61	USGS COALINGA: SKUNK HOLLOW	Concrete Oil-pump Pad (07)	Pliocene Marine (06)
65	USGS COALINGA: OIL FIELDS FIRE STATION	Concrete Hose-rack Pad (07)	Pliocene Marine (06)
111	CEDAR SPRINGS: MILLER CANYON, ALLEN RANCH, CDWR	1-Story Bldg. Part Bsmt (01)	Quartz Diorite (02), Granodiorite (08)
1117	SF: GOLDEN GATE PARK	Instrument Shelter (01)	Franciscan Chert and Shale (02)
1495	CDMG8 CDMG TEMP STAT 8 AT OROVILLE CA	1-Story Bldg. Ground (01)	Greenstone (01)
1543	DWR DEPT WATER RESC TEMP STAT OROVILLE	1-Story Bldg. Ground (01)	Greenstone (01)
1551	CDMG6 CDMG TEMP STAT 6 AT OROVILLE CA	1-Story Bldg. Ground (01)	Greenstone (01)
1552	CDMG9 CDMG TEMP STAT 9 AT OROVILLE CA	1-Story Bldg. Ground (01)	Greenstone (01)
2229	HELENA, MT: FEDERAL BUILDING, PARK & CLARK	4-Story Bldg. Bsmt (01)	Limestone (02)
8019	SOMPLAGO D. ITALY	Undergound (23)	Rock
8022	S. ROCCO, ITALY	Free-field (23)	Rock (23)
46T03	COALINGA: SULPHUR BATHS	Free-field (21)	Pliocene Marine (06)
46T06	OILFIELDS: SKUNK HOLLOW	Free-field (21)	Pliocene Marine (06)

NOTE: (1) Number in parentheses within station name for CDMG Stations is the USGS Station Number.
These stations are now part of the CDMG California Strong Motion Instrumentation Program.

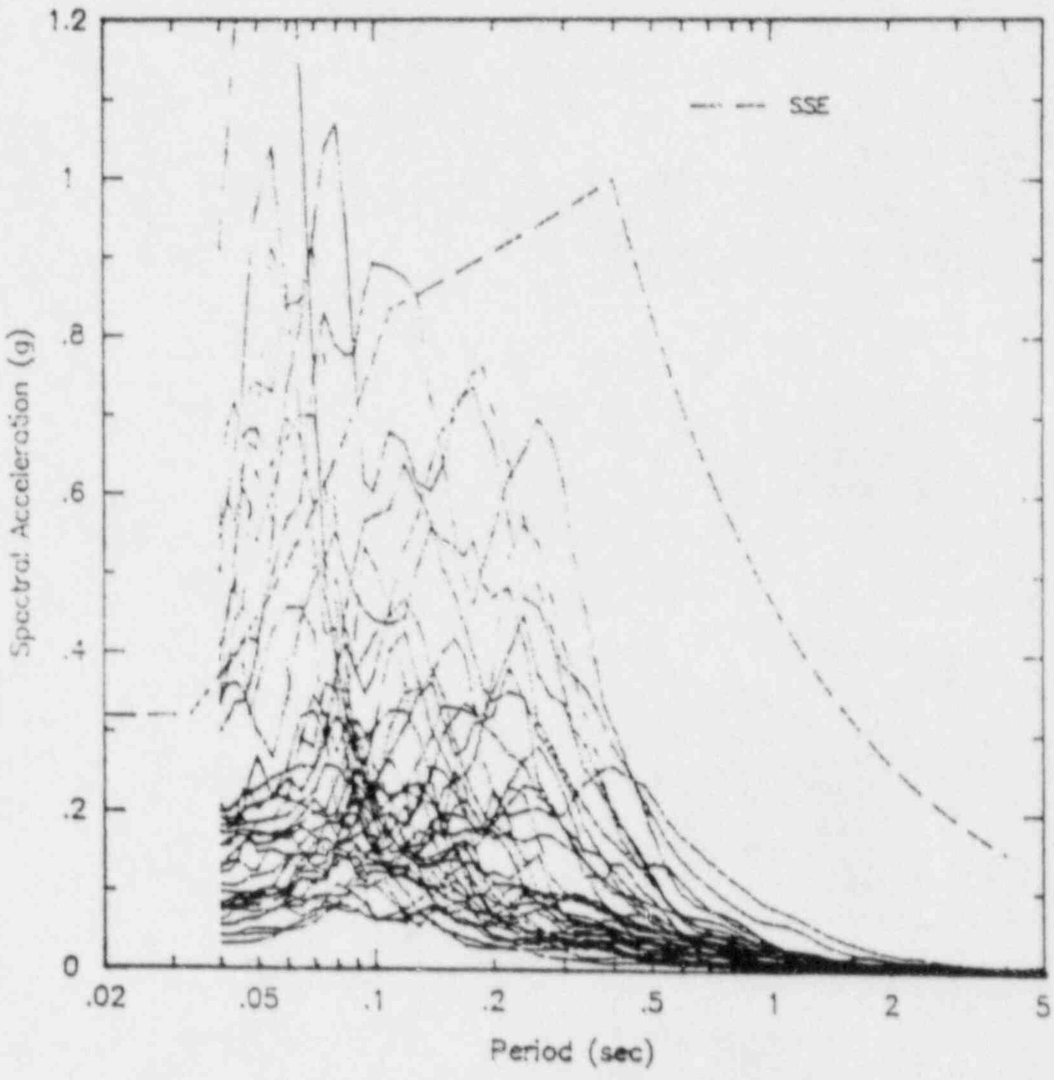


Figure 230.4d-3 Plot of Individual Response Spectra in Data Set

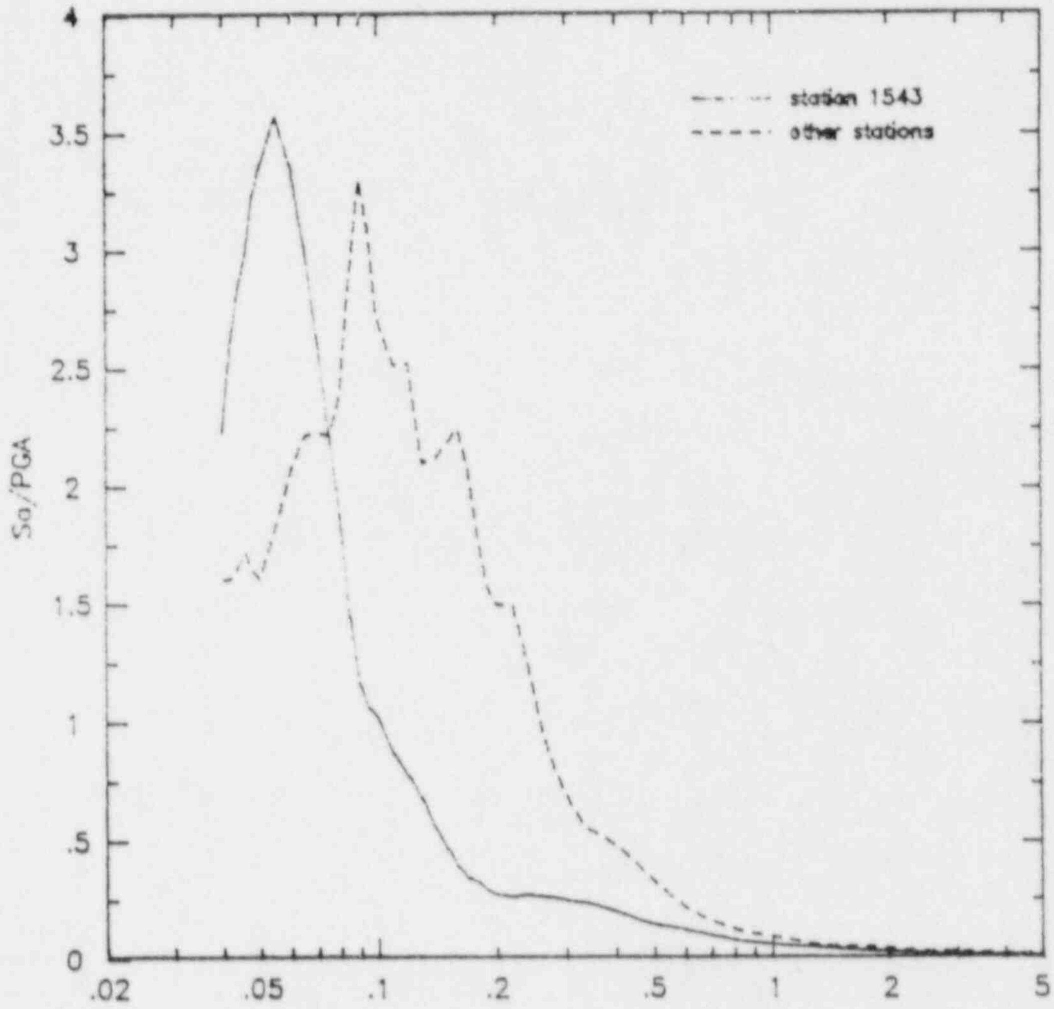


Figure 230.4d-4 Comparison of Median Spectral Shapes for Rock Recordings at Oroville Station DWR and Other Oroville Rock Sites

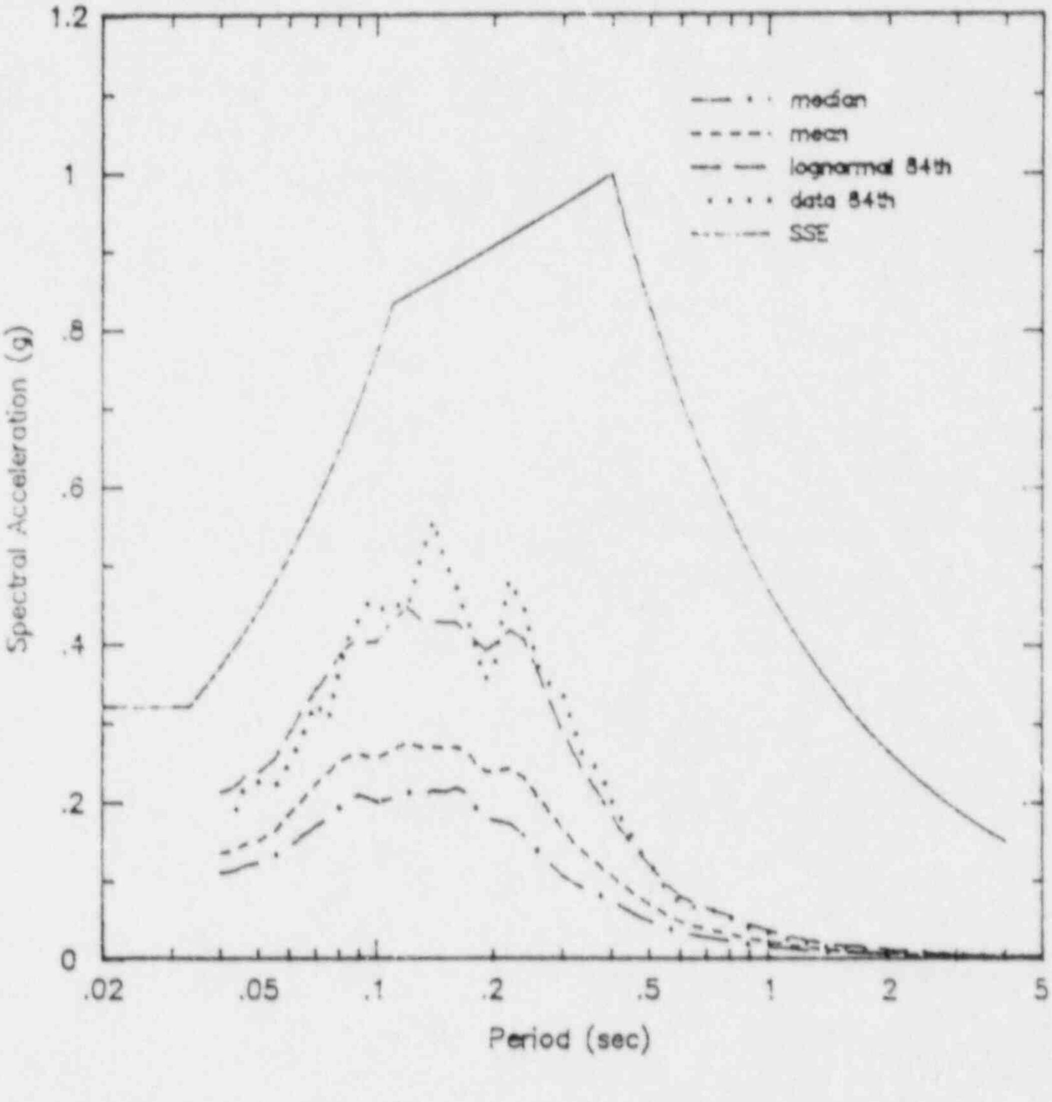


Figure 230.4d-5 Results of Statistical Analysis of Site-Specific Data Set

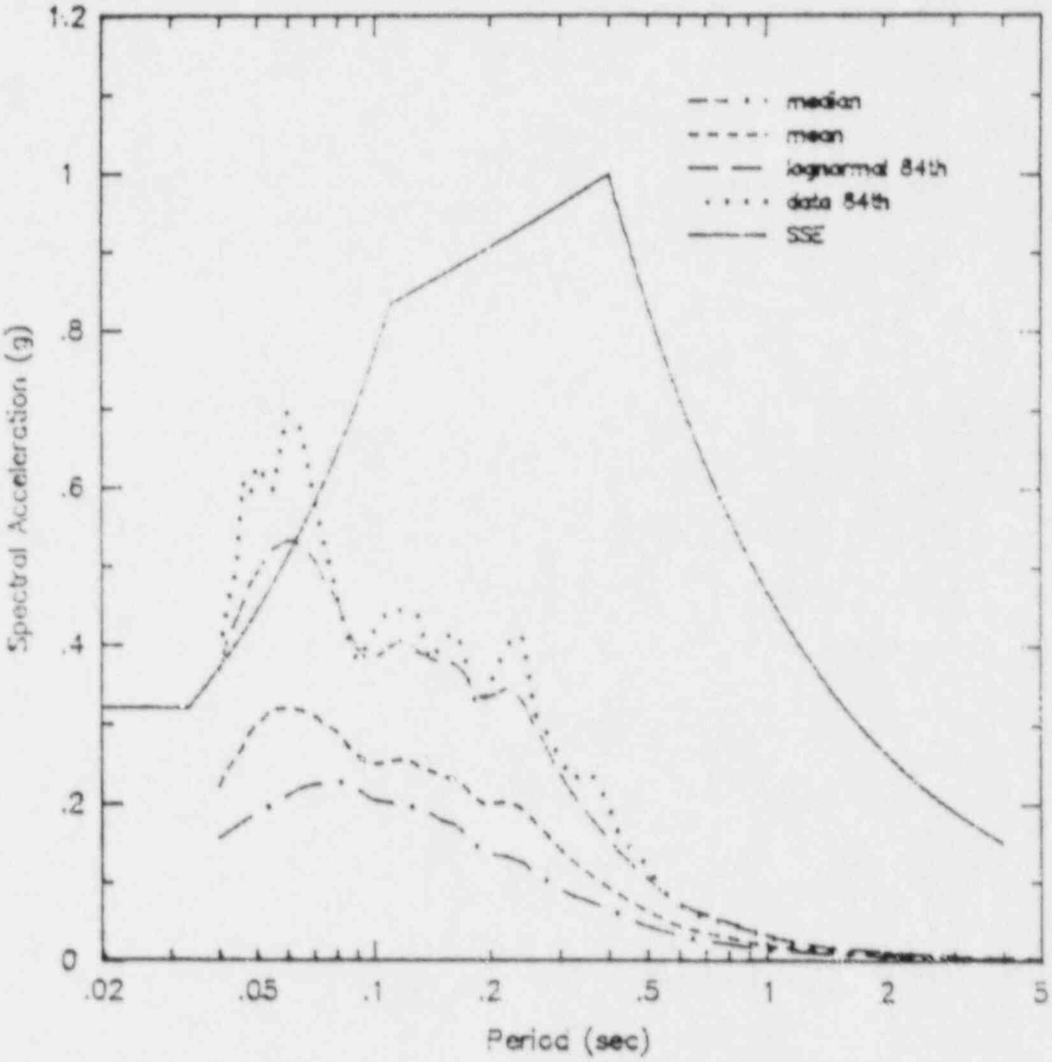


Figure 230.4d-6 Effect of Including DWR Recordings on Statistical Spectra

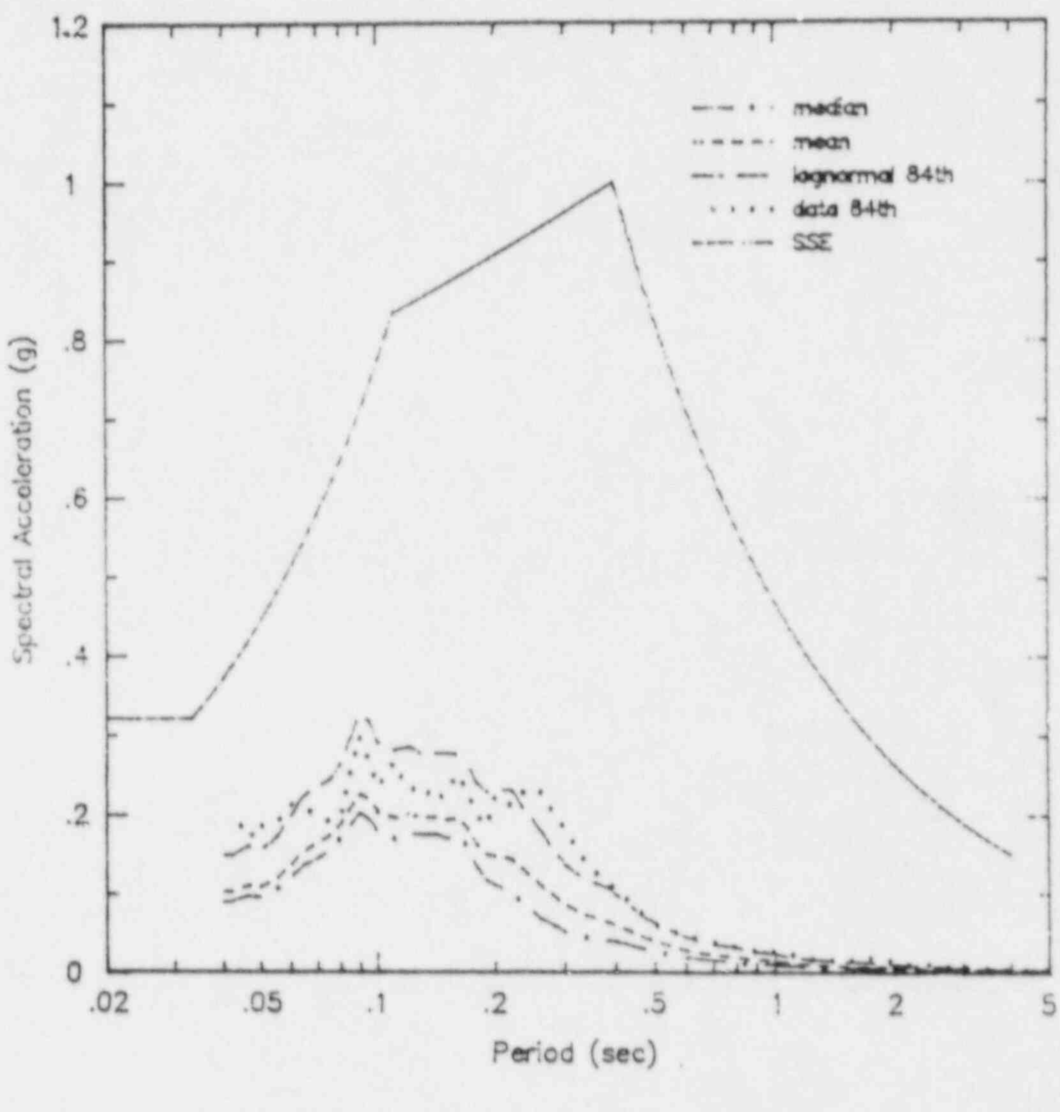


Figure 230.4d-7 Results of Weighted Statistical Analysis of Site-Specific Data Set

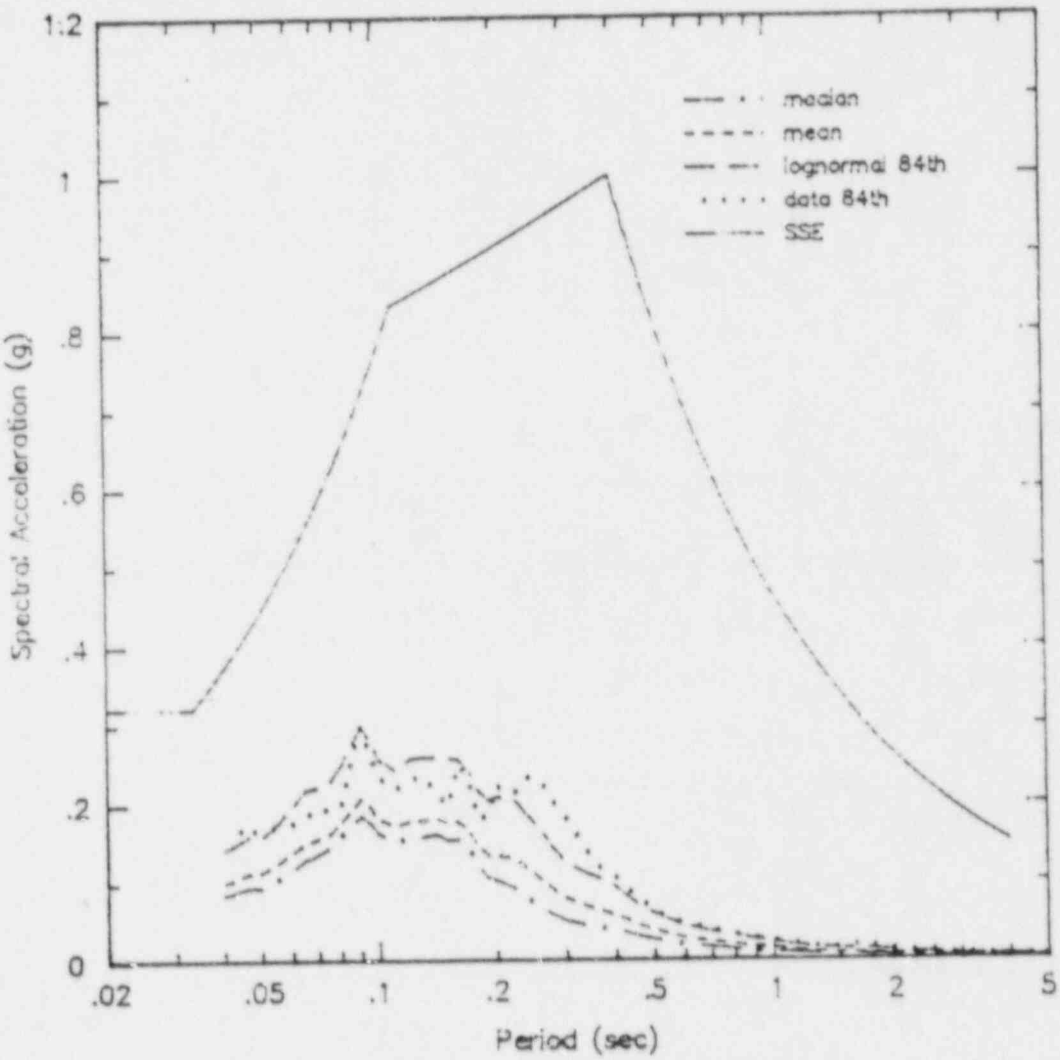


Figure 230.4d-8 Effect of Including DWR Recordings on Weighted Statistical Spectra

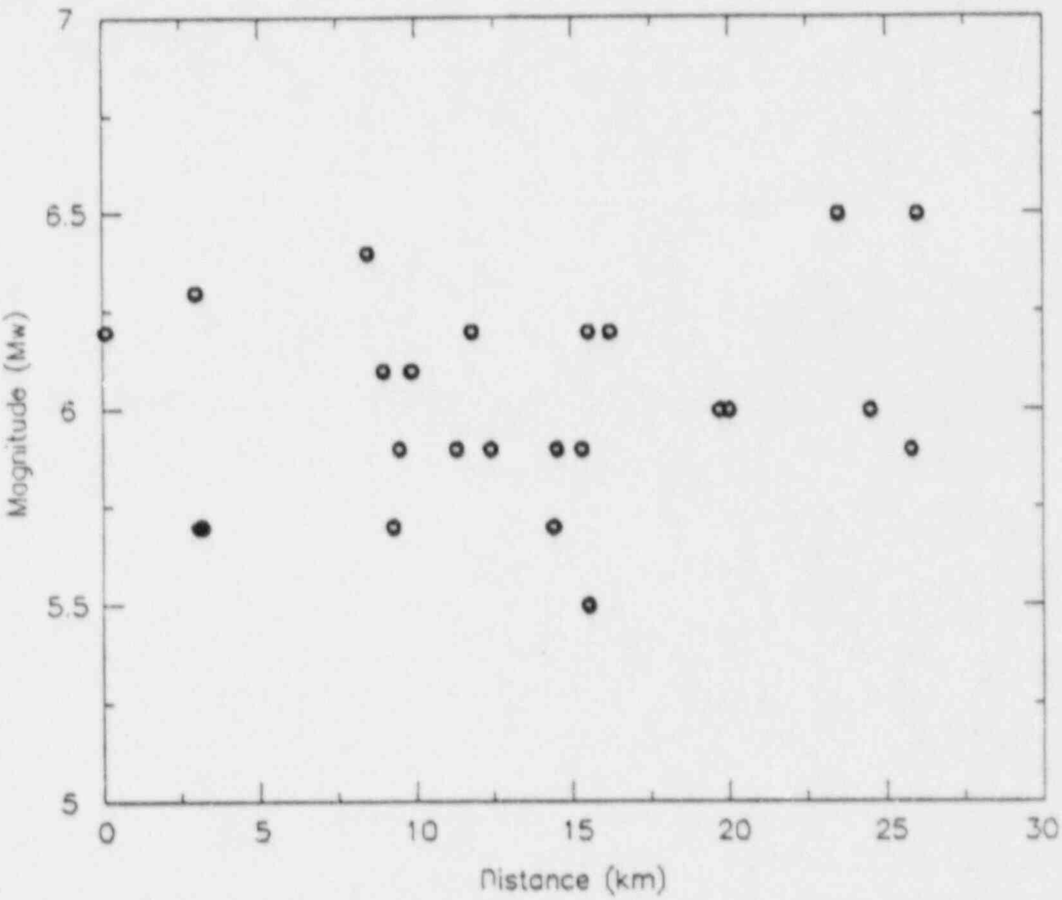
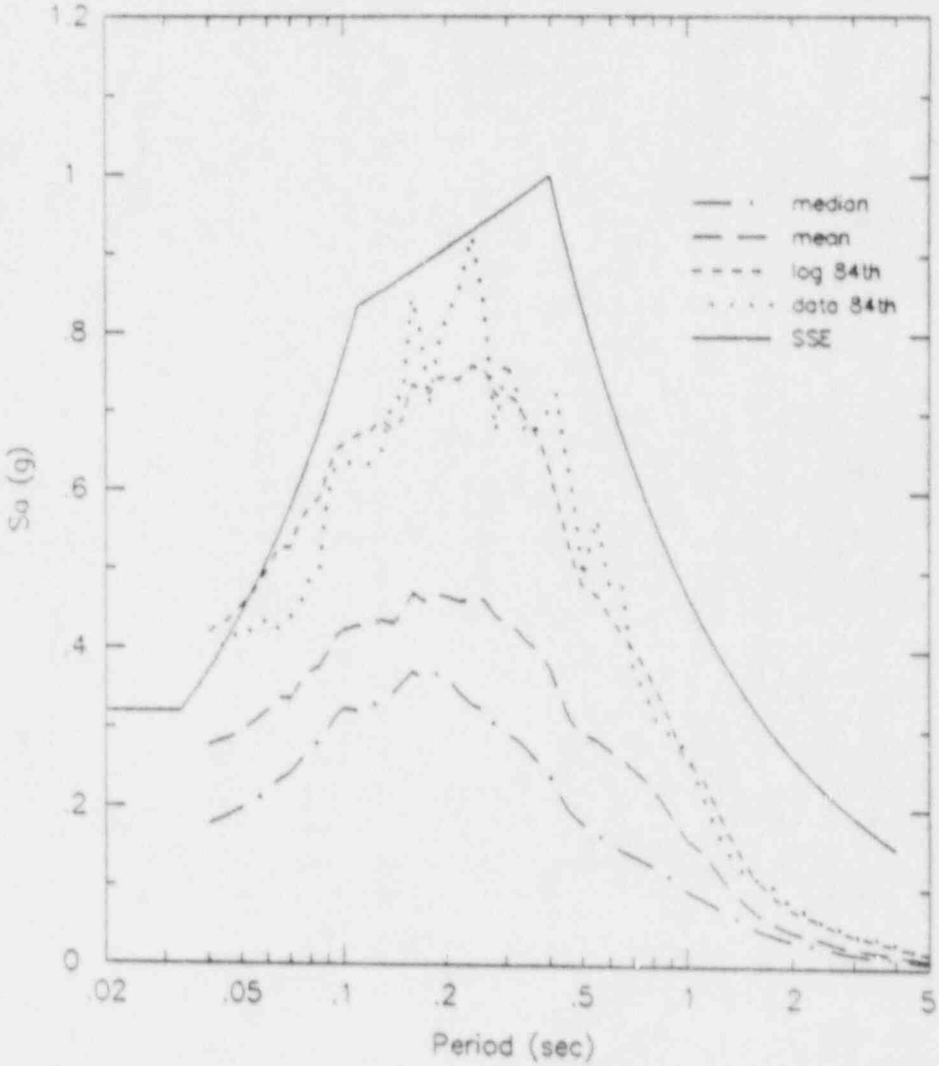
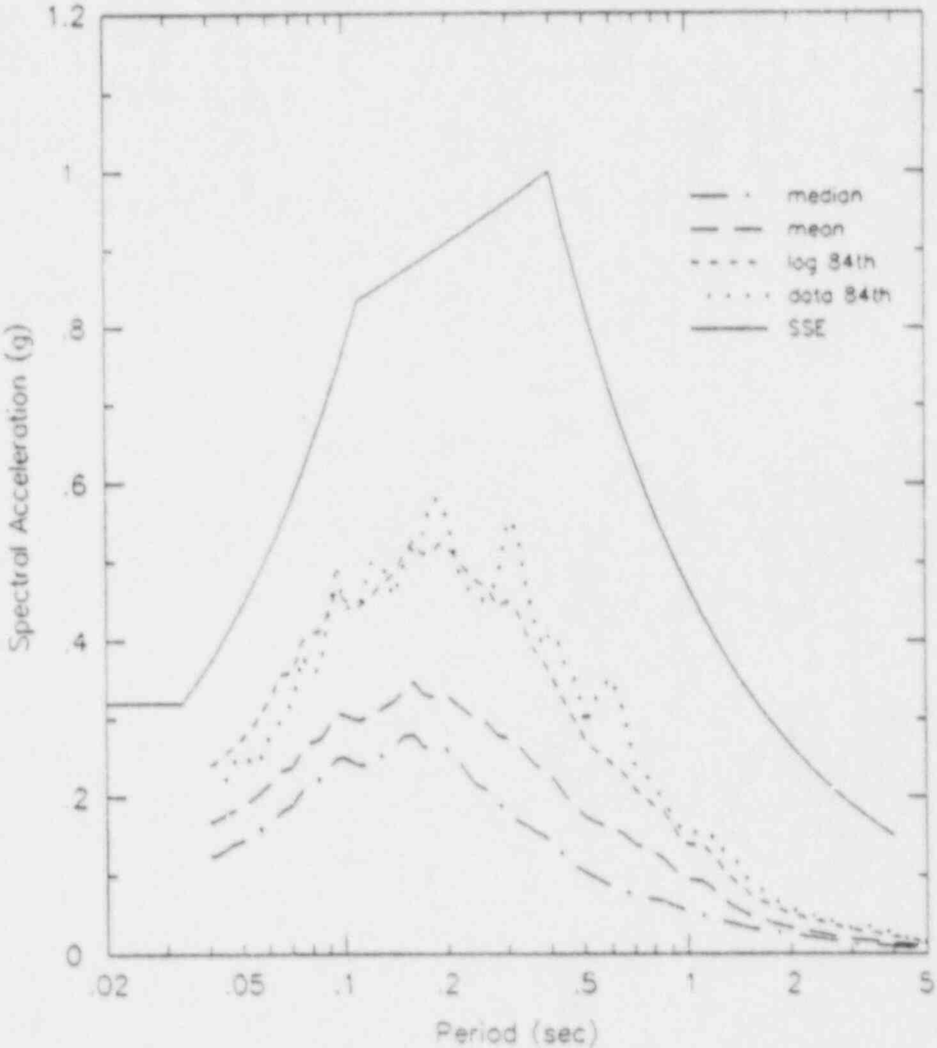


Figure A-1 Scattergram of Recordings Used in Analysis

EARTHQUAKE	DATE	RUPT	MW	ML	STAN	CLASS	EPD	CLD	COMP	PGA	VMAX	DMAX	FILE NAME
60 records total													
Parkfield, CA	6/27/66	StrikeSlip	6.1	5.6	1438	ABA	38.4	9.9	N65W	0.282	14.50	4.70	PK661438.295
Parkfield, CA	6/27/66	StrikeSlip	6.1	5.6	1438	ABA	38.4	9.9	S25W	0.411	22.50	5.50	PK661438.205
Koyna, India	12/10/67	StrikeSlip	6.3	6.3	9001	DAA	7.0	3.0	LONG	0.631	31.98	7.75	KOY9001.1
Koyna, India	12/10/67	StrikeSlip	6.3	6.3	9001	DAA	7.0	3.0	TRAN	0.490	19.43	4.07	KOY9001.2
Oroville, CA (M)	8/1/75	Normal	5.9	5.7	1051	AAA	12.6	9.5	N53W	0.103	4.80	0.69	OVMN1051.307
Oroville, CA (M)	8/1/75	Normal	5.9	5.7	1051	AAA	12.6	9.5	N37E	0.108	4.10	0.69	OVMN1051.037
Friuli Sequence	9/11/76	Thrust	5.5	5.5	8022	ABA	15.0	15.5	NORT	0.042	0.00	0.00	FRY8022.NOR
Friuli Sequence	9/11/76	Thrust	5.5	5.5	8022	ABA	15.5	15.5	EAST	0.071	0.00	0.00	FRY8022.EAS
Friuli Sequence	9/11/76	Thrust	5.9	5.9	8022	ABA	14.5	14.5	NORT	0.091	3.51	0.21	FRZ8022.NOR
Friuli Sequence	9/11/76	Thrust	5.9	5.9	8022	ABA	14.5	14.5	EAST	0.093	4.41	0.19	FRZ8022.EAS
Friuli Sequence	9/15/76	Thrust	6.1	6.1	8022	ABA	9.0	9.0	NORT	0.069	5.44	0.90	FRBB8022.NOR
Friuli Sequence	9/15/76	Thrust	6.1	6.1	8022	ABA	9.0	9.0	EAST	0.123	6.56	1.58	FRBB8022.EAS
Coyote Lake, CA	8/6/79	StrikeSlip	5.7	5.7	1445	ABA	1.8	3.2	N70E	0.230	20.49	2.38	COY1445.250
Coyote Lake, CA	8/6/79	StrikeSlip	5.7	5.7	1445	ABA	1.8	3.2	N20W	0.160	11.48	1.07	COY1445.160
Coyote Lake, CA	8/6/79	StrikeSlip	5.7	5.7	1408	ABA	15.7	9.3	S40E	0.130	10.32	1.73	COY1408.320
Coyote Lake, CA	8/6/79	StrikeSlip	5.7	5.7	1408	ABA	15.7	9.3	N50E	0.100	3.99	0.66	COY1408.230
Coyote Lake, CA	8/6/79	StrikeSlip	5.7	5.7	1413	ABA	10.3	3.1	S40E	0.340	25.06	3.62	COY1413.320
Coyote Lake, CA	8/6/79	StrikeSlip	5.7	5.7	1413	ABA	10.3	3.1	N50E	0.420	43.84	9.34	COY1413.230
Imperial Valley (M)	10/15/79	StrikeSlip	6.5	6.6	286	AAA	0.0	26.0	S45E	0.210	9.02	1.72	IV79286.135
Imperial Valley (M)	10/15/79	StrikeSlip	6.5	6.6	286	AAA	0.0	26.0	N45E	0.120	4.86	1.87	IV79286.045
Imperial Valley (M)	10/15/79	StrikeSlip	6.5	6.6	6604	AAA	0.0	23.5	N57W	0.157	18.72	8.78	IV796604.303
Imperial Valley (M)	10/15/79	StrikeSlip	6.5	6.6	6604	AAA	0.0	23.5	S33E	0.166	12.14	12.58	IV796604.147
Mammoth Lakes - A	5/25/80	StrikeSlip	6.2	6.1	54214	AAA	12.7	15.5	090	0.079	7.12	3.37	M54214LA.090
Mammoth Lakes - A	5/25/80	StrikeSlip	6.2	6.1	54214	AAA	12.7	15.5	000	0.125	15.10	5.67	M54214LA.000
Mammoth Lakes - A	5/25/80	StrikeSlip	6.2	6.1	54214	AAA	12.7	15.5	090	0.068	6.15	2.93	M54214CR.090
Mammoth Lakes - A	5/25/80	StrikeSlip	6.2	6.1	54214	AAA	12.7	15.5	000	0.109	15.80	5.38	M54214CR.000
Mammoth Lakes - C	5/25/80	StrikeSlip	6.0	6.1	54214	AAA	10.9	19.7	090	0.075	6.25	1.50	C54214LA.090
Mammoth Lakes - C	5/25/80	StrikeSlip	6.0	6.1	54214	AAA	10.9	19.7	000	0.088	6.78	1.20	C54214LA.000
Mammoth Lakes - C	5/25/80	StrikeSlip	6.0	6.1	54214	AAA	10.9	19.7	090	0.060	5.63	1.29	C54214CR.090
Mammoth Lakes - C	5/25/80	StrikeSlip	6.0	6.1	54214	AAA	10.9	19.7	000	0.112	5.77	1.27	C54214CR.000
Mammoth Lakes C01	5/25/80	StrikeSlip	5.7	5.7	54214	AAA	14.2	14.4	090	0.063	3.58	0.51	L54214LA.090
Mammoth Lakes C01	5/25/80	StrikeSlip	5.7	5.7	54214	AAA	14.2	14.4	000	0.099	7.63	1.02	L54214LA.000
Mammoth Lakes C01	5/25/80	StrikeSlip	5.7	5.7	54214	AAA	14.2	14.4	090	0.043	2.12	0.42	L54214CR.090
Mammoth Lakes C01	5/25/80	StrikeSlip	5.7	5.7	54214	AAA	14.2	14.4	000	0.083	6.86	0.95	L54214CR.000
Mammoth Lakes - D	5/27/80	StrikeSlip	6.0	6.2	54214	AAA	14.1	20.0	090	0.207	20.80	3.50	D54214LA.090
Mammoth Lakes - D	5/27/80	StrikeSlip	6.0	6.2	54214	AAA	14.1	20.0	000	0.208	12.40	1.30	D54214LA.000
Mammoth Lakes - D	5/27/80	StrikeSlip	6.0	6.2	54214	AAA	14.1	20.0	090	0.180	17.70	2.86	D54214CR.090
Mammoth Lakes - D	5/27/80	StrikeSlip	6.0	6.2	54214	AAA	14.1	20.0	000	0.219	8.01	0.96	D54214CR.000
Mammoth Lakes - D	5/27/80	StrikeSlip	6.0	6.2	54424	AAA	20.0	24.5	160	0.119	5.46	1.36	D54424.160
Mammoth Lakes - D	5/27/80	StrikeSlip	6.0	6.2	54424	AAA	20.0	24.5	070	0.093	5.85	1.69	D54424.070
Mexicali Valley, MX	6/9/80	StrikeSlip	6.4	6.4	6604	AAA	31.0	8.5	N45E	0.611	32.53	59.68	MX806604.045
Mexicali Valley, MX	6/9/80	StrikeSlip	6.4	6.4	6604	AAA	31.0	8.5	S45E	0.603	23.27	20.90	MX806604.135
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	67	APA	6.0	9.5	N00E	0.960	46.82	4.40	CO567.000
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	67	APA	6.0	9.5	N90W	0.838	46.56	6.15	CO567.090
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	46	APA	13.3	15.3	N90E	0.116	5.63	0.49	CO546T03.090
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	46	APA	13.3	15.3	N00E	0.136	5.57	0.76	CO546T03.000
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	65	APA	8.5	11.3	N00E	0.219	16.67	3.71	CO565P.360
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	65	APA	8.5	11.3	N90W	0.218	16.91	3.52	CO565P.270
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	61	APA	10.0	12.4	N00E	0.231	14.86	3.65	CO561.360
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	61	APA	10.0	12.4	N90W	0.375	16.23	3.27	CO561.270
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	65	APA	8.5	11.3	N00E	0.194	15.88	3.50	CO565F.360
Coalinga, CA AS12	07/21/83	Thrust	5.9	6.0	65	APA	8.5	11.3	N90W	0.219	16.78	3.39	CO565F.270
Morgan Hill, CA	04/24/84	StrikeSlip	6.2	6.2	57217	ABA	24.1	0.1	N75W	1.304	97.70	10.50	MH57217.285
Morgan Hill, CA	04/24/84	StrikeSlip	6.2	6.2	57217	ABA	24.1	0.1	S15W	0.707	51.90	10.30	MH57217.195
Morgan Hill, CA	04/24/84	StrikeSlip	6.2	6.2	57383	ABA	35.9	11.8	N90E	0.293	36.60	5.24	MH57383.090
Morgan Hill, CA	04/24/84	StrikeSlip	6.2	6.2	57383	ABA	35.9	11.8	N00E	0.228	11.30	1.81	MH57383.000
Morgan Hill, CA	04/24/84	StrikeSlip	6.2	6.2	47379	ABA	38.6	16.2	N40W	0.100	2.66	0.48	MH47379.320
Morgan Hill, CA	04/24/84	StrikeSlip	6.2	6.2	47379	ABA	38.6	16.2	S50W	0.073	2.52	0.30	MH47379.230
North Palm Springs	7/8/86	StrikeSlip	5.9	5.9	12206	AKA	28.2	25.8	N90E	0.119	3.60	0.50	NPS12206.1
North Palm Springs	7/8/86	StrikeSlip	5.9	5.9	12206	AKA	28.2	25.8	N00E	0.145	3.82	0.23	NPS12206.3



30 rec (M=5.5-6.5,R<26km) Sa-5%



30 rec W'td (M=5.5-6.5,R<26km) Sa-5%

Question 230.5

Estimate site-specific spectra for a range of percentiles for the maximum earthquake on the Olympia Lineament, using strong-motion data in the appropriate magnitude and distance range. Justify the SSE spectra in light of the site-specific spectra.

Site-specific spectra

- Statistics of recorded motion spectra
- statistics of scaled spectra
- generalized attenuation relationships

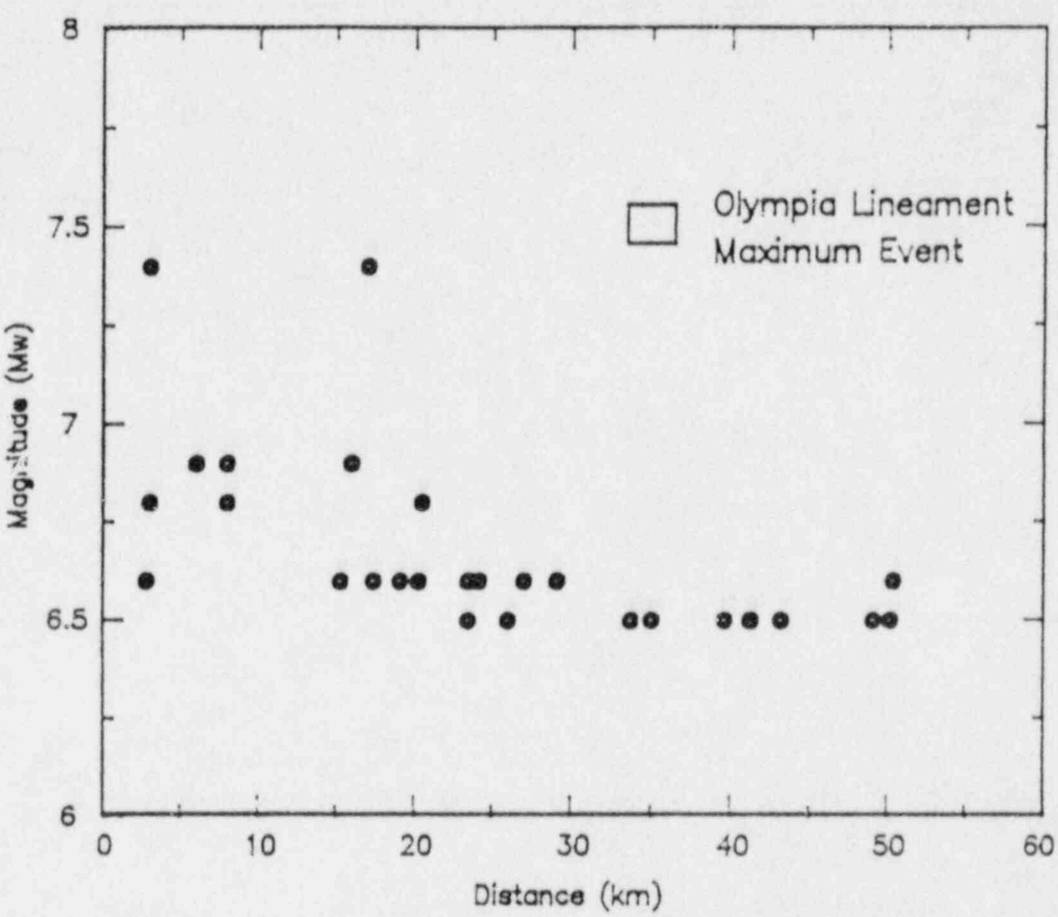


Figure 230.5-1. Scattergram of Recordings Used in Analysis

Table 230.5-1

RECORDS USED IN STATISTICAL ANALYSIS

Earthquake Name	Date	Fault Type	Mw	Station	Dist (km)	Comp	Amax (g)	Scaling Factor Geom	J-B	Camp
San Fernando, CA	02/09/71	Thrust	6.6	279	2.8	S16E	1.170	0.2677	0.3206	0.2571
San Fernando, CA	02/09/71	Thrust	6.6	279	2.8	S74W	1.080	0.2677	0.3206	0.2571
San Fernando, CA	02/09/71	Thrust	6.6	266	19.1	S00W	0.096	0.8449	0.8452	0.9162
San Fernando, CA	02/09/71	Thrust	6.6	266	19.1	S90W	0.204	0.8449	0.8452	0.9162
San Fernando, CA	02/09/71	Thrust	6.6	126	24.2	S69E	0.200	1.0960	1.0717	1.1743
San Fernando, CA	02/09/71	Thrust	6.6	126	24.2	S21W	0.159	1.0960	1.0717	1.1743
San Fernando, CA	02/09/71	Thrust	6.6	127	23.5	N21E	0.147	1.0595	1.0395	1.1374
San Fernando, CA	02/09/71	Thrust	6.6	127	23.5	N69W	0.131	1.0595	1.0395	1.1374
San Fernando, CA	02/09/71	Thrust	6.6	128	20.3	N21E	0.374	0.9009	0.8968	0.9747
San Fernando, CA	02/09/71	Thrust	6.6	128	20.3	N69W	0.288	0.9009	0.8968	0.9747
San Fernando, CA	02/09/71	Thrust	6.6	220	15.3	N00E	0.181	0.6800	0.6898	0.7398
San Fernando, CA	02/09/71	Thrust	6.6	220	15.3	S90W	0.154	0.6800	0.6898	0.7398
San Fernando, CA	02/09/71	Thrust	6.6	141	17.4	S00W	0.188	0.7688	0.7742	0.8356
San Fernando, CA	02/09/71	Thrust	6.6	141	17.4	S90W	0.180	0.7688	0.7742	0.8356
San Fernando, CA	02/09/71	Thrust	6.6	121	29.1	N56E	0.068	1.3695	1.3066	1.4455
San Fernando, CA	02/09/71	Thrust	6.6	121	29.1	N34W	0.103	1.3695	1.3066	1.4455
San Fernando, CA	02/09/71	Thrust	6.6	104	27.0	N03E	0.172	1.2484	1.2039	1.3265
San Fernando, CA	02/09/71	Thrust	6.6	104	27.0	N87W	0.223	1.2484	1.2039	1.3265
San Fernando, CA	02/09/71	Thrust	6.6	278	50.4	N55E	0.078	2.9351	2.5151	2.9023
San Fernando, CA	02/09/71	Thrust	6.6	278	50.4	N35W	0.059	2.9351	2.5151	2.9023
Gazli, USSR	05/17/76	Thrust	6.8	9201	3.0	NORT	0.655	0.2642	0.2908	0.2517
Gazli, USSR	05/17/76	Thrust	6.8	9201	3.0	EAST	0.699	0.2642	0.2908	0.2517
Tabas, Iran	09/16/78	Thrust	7.4	9101	3.0	N16W	0.810	0.2430	0.2117	0.2249
Tabas, Iran	09/16/78	Thrust	7.4	9101	3.0	N74E	0.700	0.2430	0.2117	0.2249
Tabas, Iran	09/16/78	Thrust	7.4	9102	17.0	N80W	0.379	0.5258	0.4961	0.5327
Tabas, Iran	09/16/78	Thrust	7.4	9102	17.0	N10E	0.391	0.5258	0.4961	0.5327
Imperial Valley (M)	10/15/79	StrikeSlip	6.5	286	26.0	S45E	0.210	1.2667	1.2190	1.3583
Imperial Valley (M)	10/15/79	StrikeSlip	6.5	286	26.0	N45E	0.120	1.2667	1.2190	1.3583
Imperial Valley (M)	10/15/79	StrikeSlip	6.5	6604	23.5	N57W	0.157	1.1224	1.0961	1.2135
Imperial Valley (M)	10/15/79	StrikeSlip	6.5	6604	23.5	S33E	0.166	1.1224	1.0961	1.2135
Irpinia, Italy	11/23/80	Normal	6.8	B-I	8.0	N00E	0.133	0.3903	0.3918	0.4037
Irpinia, Italy	11/23/80	Normal	6.8	B-I	8.0	N90E	0.191	0.3903	0.3918	0.4037
Irpinia, Italy	11/23/80	Normal	6.8	Cal	20.5	N00E	0.159	0.8195	0.8145	0.8719
Irpinia, Italy	11/23/80	Normal	6.8	Cal	20.5	N90E	0.177	0.8195	0.8145	0.8719
Coalinga, CA Main	05/02/83	Thrust	6.5	46175	35.0	N45E	0.173	1.8624	1.6982	1.9339
Coalinga, CA Main	05/02/83	Thrust	6.5	46175	35.0	S45E	0.137	1.8624	1.6982	1.9339
Coalinga, CA Main	05/02/83	Thrust	6.5	36177	33.7	N65E	0.179	1.7689	1.6255	1.8455
Coalinga, CA Main	05/02/83	Thrust	6.5	36177	33.7	N25W	0.122	1.7689	1.6255	1.8455
Coalinga, CA Main	05/02/83	Thrust	6.5	36176	41.2	S70E	0.139	2.3430	2.0615	2.3813
Coalinga, CA Main	05/02/83	Thrust	6.5	36176	41.2	N20E	0.101	2.3430	2.0615	2.3813
Coalinga, CA Main	05/02/83	Thrust	6.5	36438	43.2	N90E	0.065	2.5103	2.1846	2.5348
Coalinga, CA Main	05/02/83	Thrust	6.5	36438	43.2	N00E	0.074	2.5103	2.1846	2.5348
Coalinga, CA Main	05/02/83	Thrust	6.5	36422	49.1	N90E	0.089	3.0395	2.5646	3.0145
Coalinga, CA Main	05/02/83	Thrust	6.5	36422	49.1	N00E	0.062	3.0395	2.5646	3.0145
Coalinga, CA Main	05/02/83	Thrust	6.5	36453	39.6	N90E	0.087	2.2134	1.9652	2.2618
Coalinga, CA Main	05/02/83	Thrust	6.5	36453	39.6	N00E	0.079	2.2134	1.9652	2.2618
Coalinga, CA Main	05/02/83	Thrust	6.5	36444	41.3	N90E	0.133	2.3512	2.0676	2.3889
Coalinga, CA Main	05/02/83	Thrust	6.5	36444	41.3	N00E	0.075	2.3512	2.0676	2.3889
Coalinga, CA Main	05/02/83	Thrust	6.5	36420	50.2	N90E	0.123	3.1440	2.6384	3.1085
Coalinga, CA Main	05/02/83	Thrust	6.5	36420	50.2	N00E	0.138	3.1440	2.6384	3.1085
Nahanni, Canada	12/23/85	Thrust	6.9	0	6.0	N10E	1.101	0.3286	0.3258	0.3290
Nahanni, Canada	12/23/85	Thrust	6.9	0	6.0	N80W	1.345	0.3286	0.3258	0.3290
Nahanni, Canada	12/23/85	Thrust	6.9	0	8.0	N30W	0.418	0.3789	0.3716	0.3878
Nahanni, Canada	12/23/85	Thrust	6.9	0	8.0	S60W	0.585	0.3789	0.3716	0.3878
Nahanni, Canada	12/23/85	Thrust	6.9	0	16.0	N00E	0.194	0.6176	0.6121	0.6527
Nahanni, Canada	12/23/85	Thrust	6.9	0	16.0	N90W	0.186	0.6176	0.6121	0.6527

Table 230.5-2. ROCK STRONG-MOTION RECORDING STATIONS

Stn.* No. *	Station Name		Station Description Instrument Housing (Ref.)	Subsurface Conditions (Ref.)
104	ARCADIA: SANTA ANITA DAM; RIGHT ABUTMENT		Instrument Shelter (02)	Granodiorite to Quartz Diorite (02)
121	FAIRMONT RESERVOIR: RIGHT ABUTMENT		1-Story Bldg. Ground (03)	5m Soil over Granite (02). Granite (01)
126	LAKE HUGHES ARRAY #04:		Instrument Shelter (01)	Weathered Granite (01)
127	LAKE HUGHES ARRAY #09: WARM SPRINGS		1-Story Bldg. Ground (01)	Gneiss (01). 3m Soil over Granite (02)
128	LAKE HUGHES ARRAY #12: ELIZABETH LAKE		1-Story Bldg. Ground (01)	1m-3m Soil over Conglomerate (01)
141	LA: GRIFFITH PARK OBSERVATORY		3-story Bldg. Ground (01)	Granite (01)
220	LA: 3838 LANKERSHIM BLVD		20-story Bldg. Bsmt (01	Shale/Sandstone (01)
266	PASADENA: OLD SEISM LAB. CIT		3-Story Bldg. Bsmt (01)	Granite (01)
278	PUDDINGSTONE RESERVOIR DAM: LEFT ABUTMENT		Instrument Shelter (02)	Volcanic Conglomerate (02)
279	PACOIMA DAM: LEFT ABUTMENT		Instrument Shelter (02)	Gneiss Diorite/Quartz Diorite (02)
286	SUPERSTITION MOUNTAIN: USAF CAMERA SITE		1-Story Bldg. Ground (01)	Granite (01)
6097	MACKENZIE MTNS. NW TERR. CANADA: NAHANNI SITE 1		Free-field Instrument (13)	Bedrock (13)
6098	MACKENZIE MTNS. NW TERR. CANADA: NAHANNI SITE 2		Free-field Instrument (13)	Bedrock (13)
6099	MACKENZIE MTNS. NW TERR. CANADA: NAHANNI SITE 3		Free-field Instrument (13)	Bedrock (13)
6604	CERRO PRIETO. MEXICO		Instrument Shelter (01)	Rock (01). Basaltic Tephra (11)
8026	BAGNOLI IRPINO. ITALY		1-story Bldg. Ground (24)	Limestone and Dolomitic Limestone (24)
8031	CALITRI. ITALY		1-story Bldg. Ground (24)	Sandstones (24)
9001	KOYNA DAM. INDIA: SEISMOGRAPH STATION		Dam Gallery	Basalt
9101	TABAS. IRAN		Small Bldg. Ground (22)	1m-2m Soil over Weathered Rock (22)
9102	DAYHOOK. IRAN		Small Bldg. Ground (15)	Cretaceous Limestone (15)
9201	KARAKYR POINT. USSR		Portable Station (12)	Interbedded Clay and Sandstone (12)
36176	PARKFIELD: VINEYARD CANYON #03W	(1405)	Instrument Shelter (01)	Sandstone (18)
36177	PARKFIELD: VINEYARD CANYON #02E	(1406)	Instrument Shelter (01)	Franciscan (18)
36420	PARKFIELD GOLD HILL #03W		Instrument Shelter (18)	Sandstone (18)
36422	PARKFIELD: STONE CORRAL #02E		Instrument Shelter (18)	Sandstone (18)
36438	PARKFIELD: STONE CORRAL #04E		Instrument Shelter (18)	Sandstone (18)
36444	PARKFIELD: FAULT ZONE #10		Instrument Shelter (18)	Sandstone (18)
36453	PARKFIELD: FAULT ZONE #11		Instrument Shelter (18)	Thin Soil over Sandstone (18)
46175	SLACK CANYON: HIDDEN VALLEY RANCH	(1404)	Instrument Shelter (01)	Granite (01)

NOTE: (1) Number in parentheses within station name for CDMG Stations is the USGS Station Number. These stations are now part of the CDMG California Strong Motion Instrumentation Program.

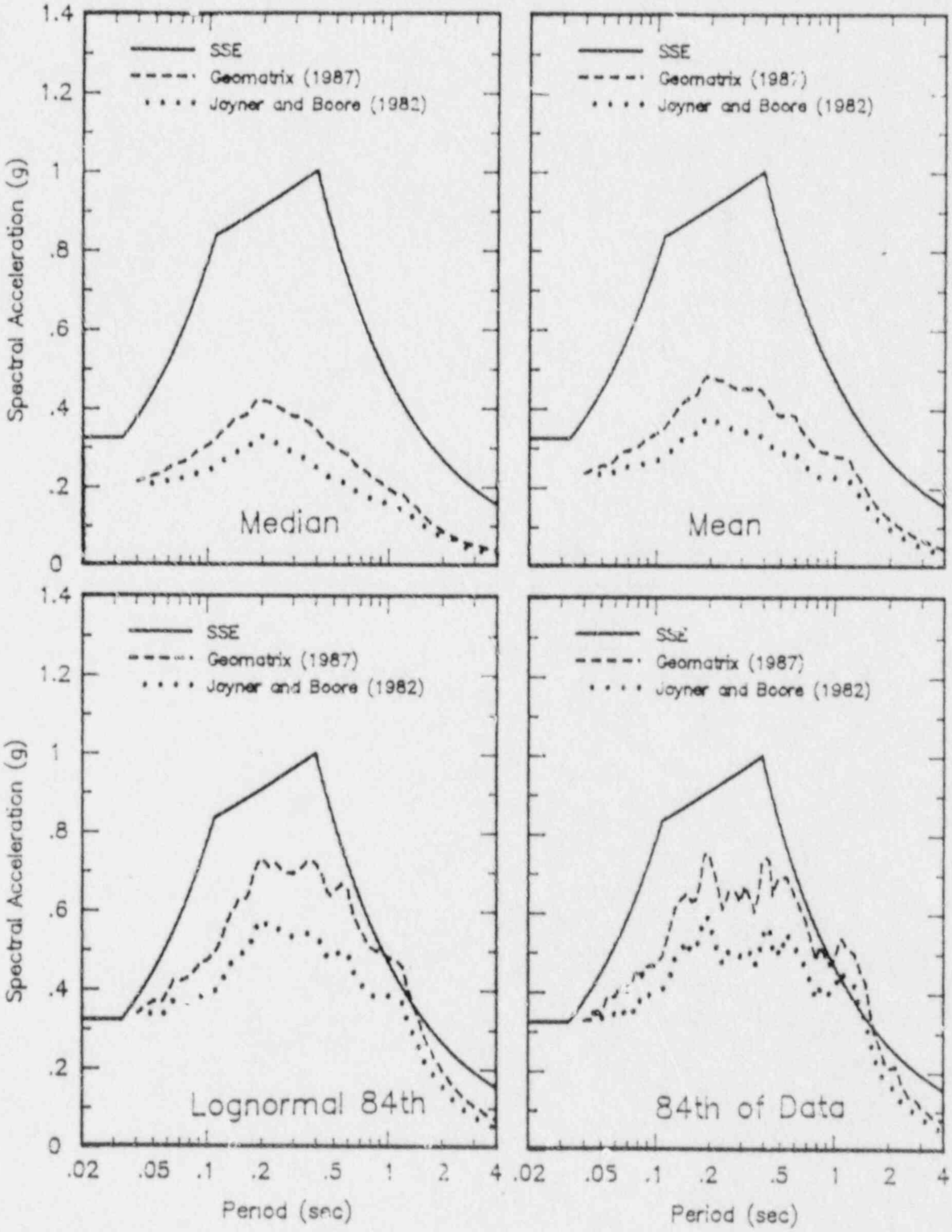


Figure 230.5-2. Site-Specific Spectra Based on Statistical Analysis of Recorded Spectra Scaled to Magnitude 7.5 and Distance 35 km

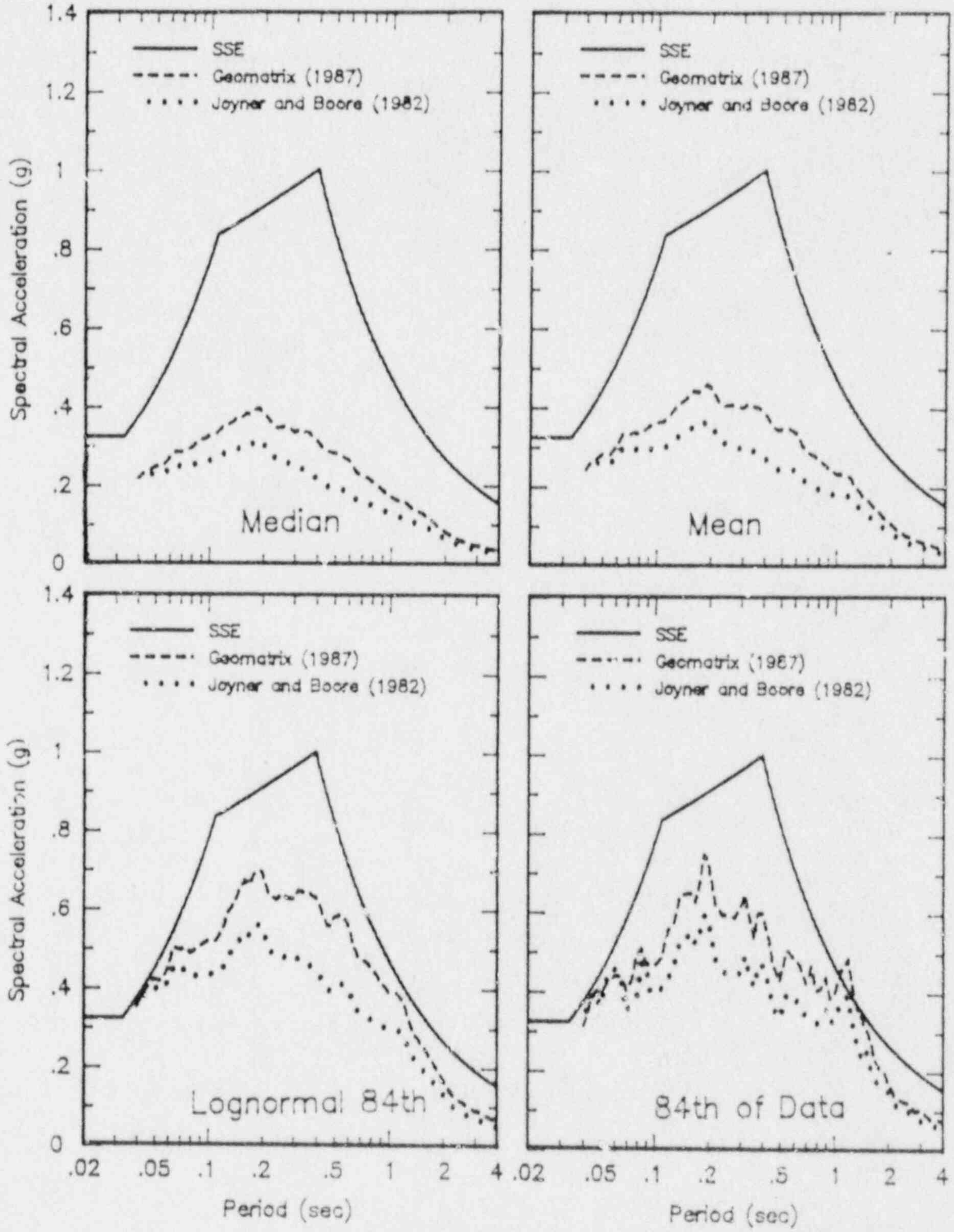


Figure 230.5-3. Site-Specific Spectra Based on Weighted Statistical Analysis of Recorded Spectra Scaled to Magnitude 7.5 and Distanc 5 km

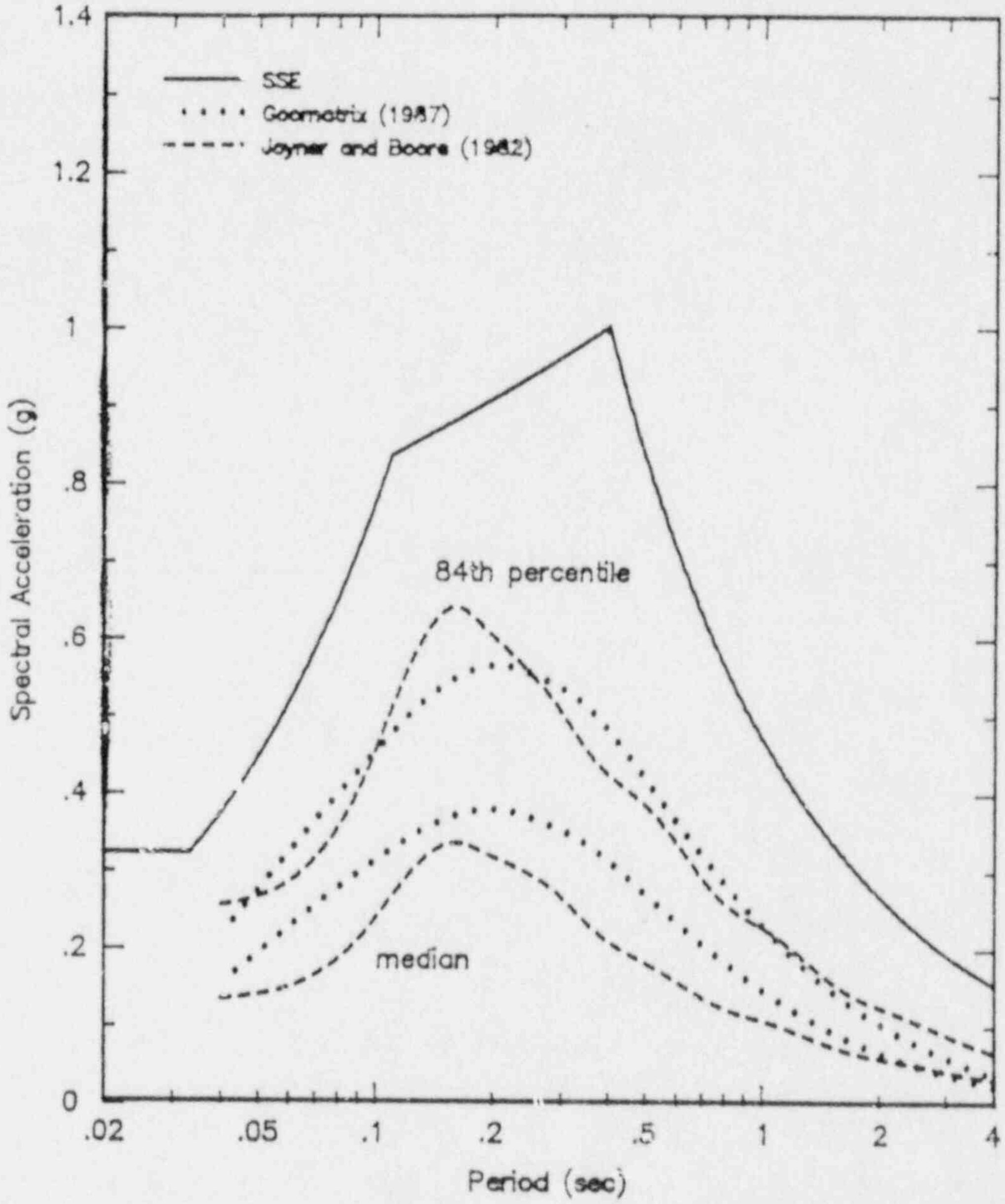


Figure 230.5-4. Site-Specific Spectra Based on Empirical Attenuation Relationships

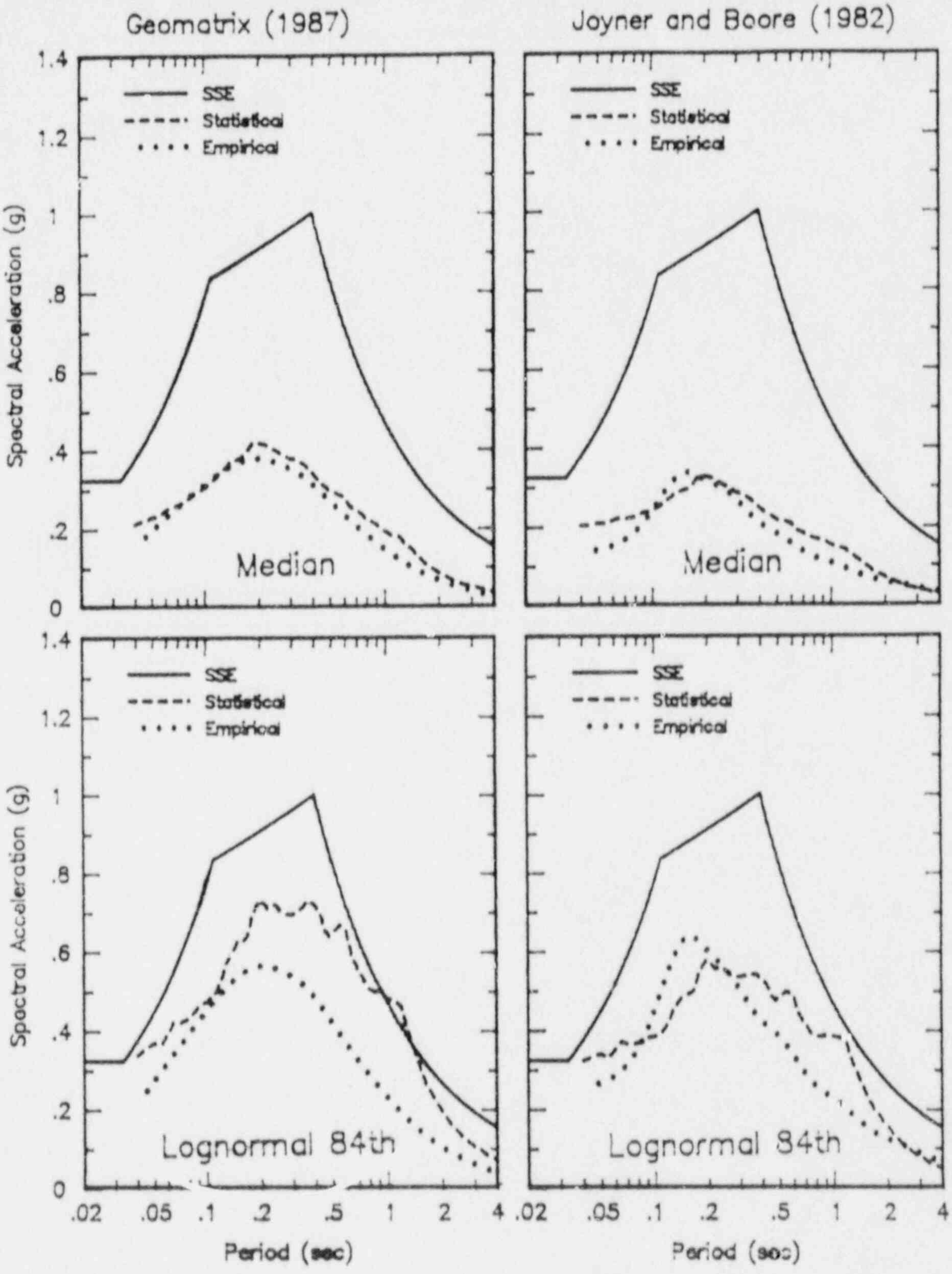


Figure 230.5-5 Comparison of Statistical and Empirical Site-Specific Spectra

~~H N-S cross section.~~

SEISMICITY

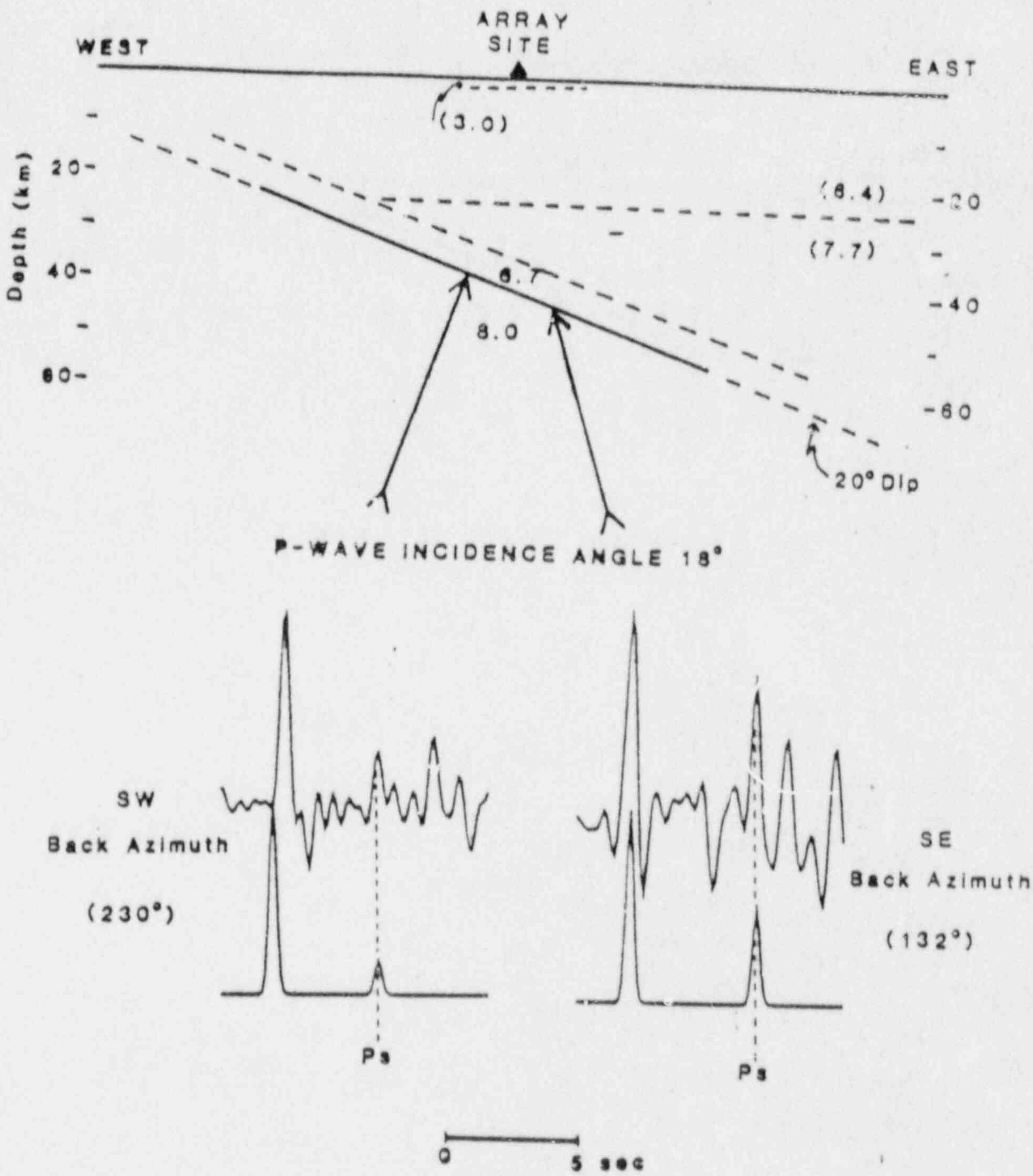


Fig. 10. (Top) Simple model explaining the observations in Figure 9 consists of a interface at 40 km depth that dips east at about 20° degrees. (Bottom) Comparison of the synthetic response for this model with the data from Figure 9.

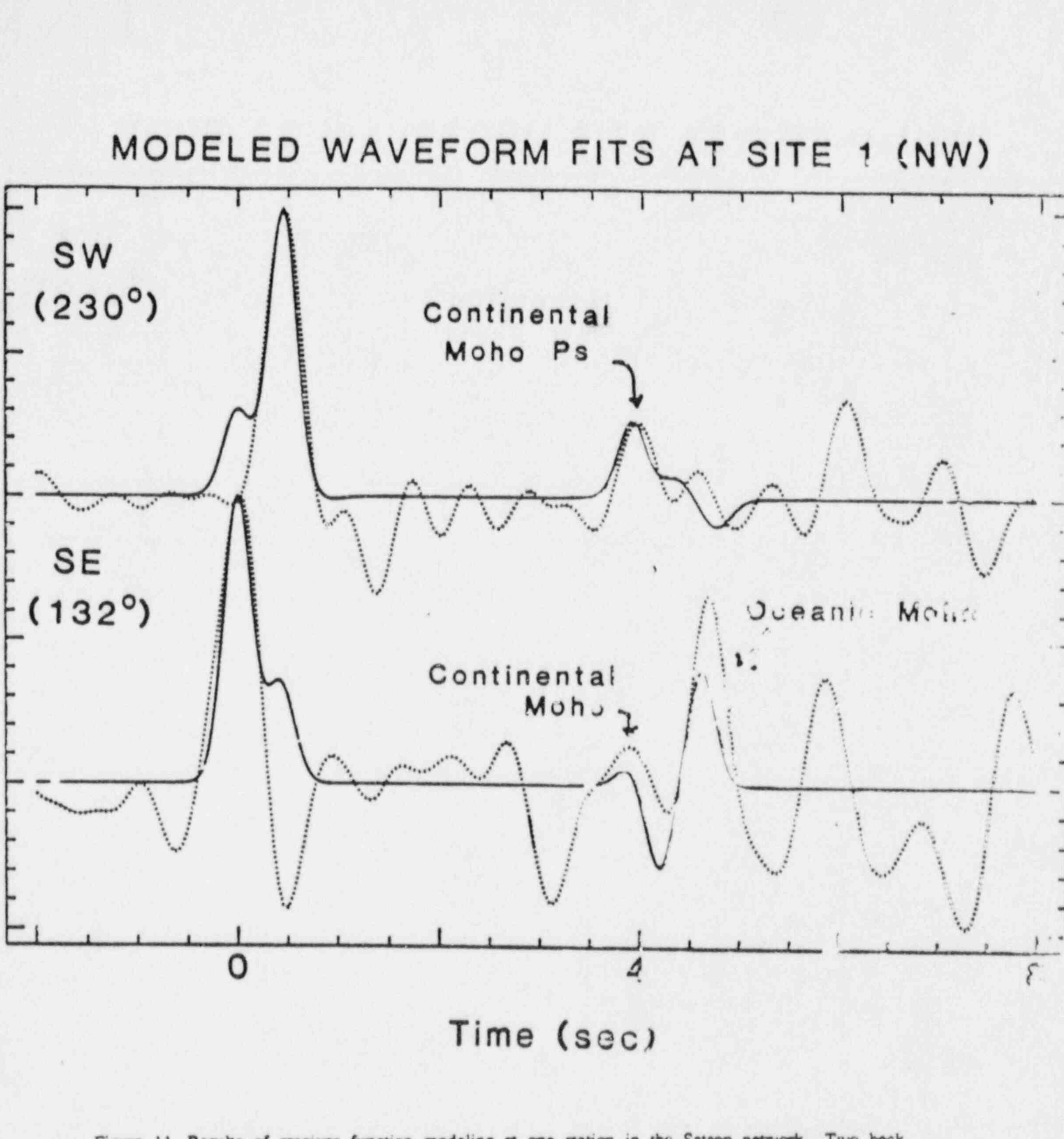


Figure 11. Results of receiver function modeling at one station in the Satsop network. Two back azimuths are shown. Dotted traces represent the average of stacked data, with path and source effects removed by deconvolution. Solid traces represent response to a theoretical slab model at 37 km depth beneath the array dipping at 25° at an azimuth of 125°.

(2)

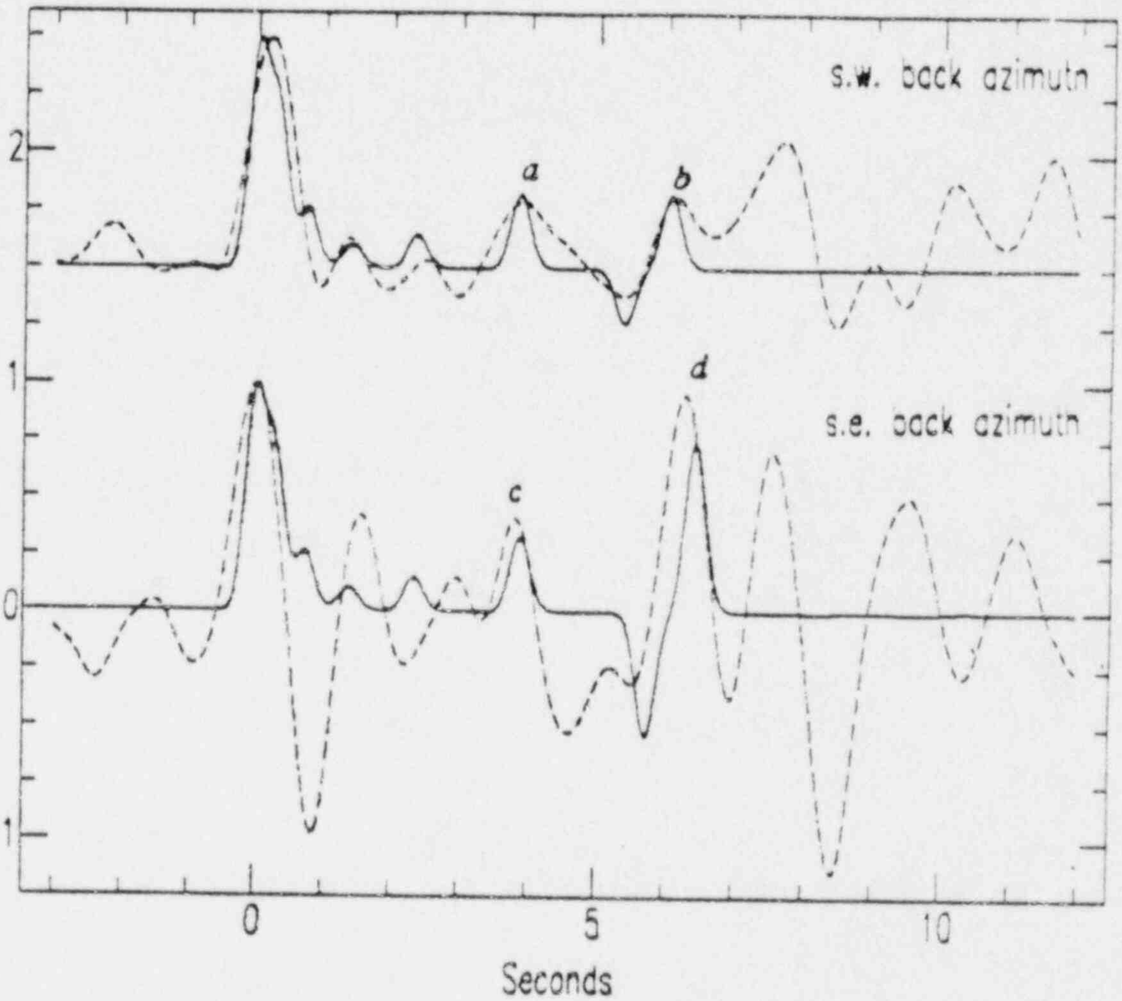


Figure 4.9. Synthetic reproduction (solid traces) of arrivals *a*, *b*, *c* and *d* in the real data (dashed traces) using lithospheric model (Table 4.3).

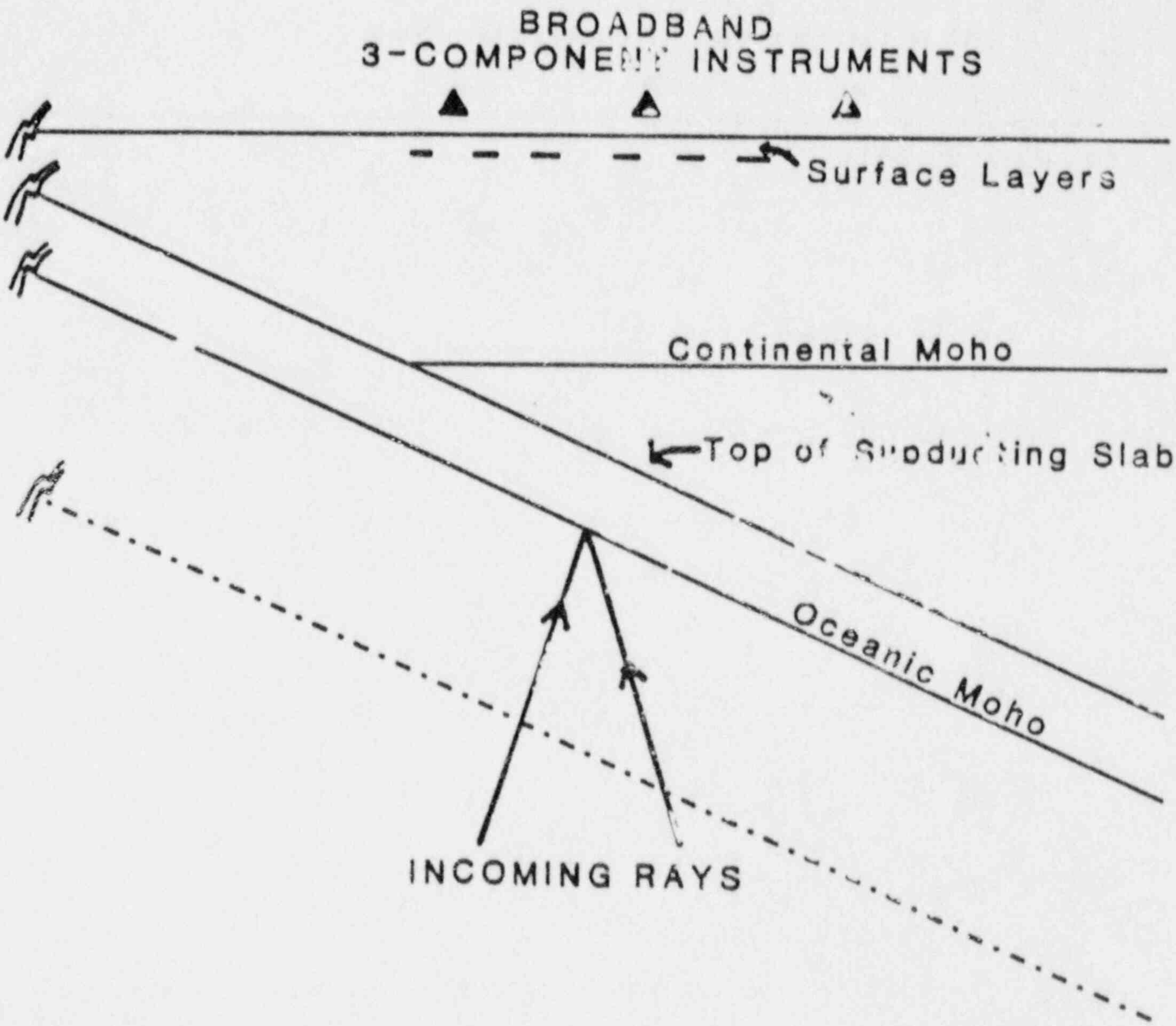


Figure 10. Schematic cross section of a broad-band experiment to record P to S energy conversions arising from teleseismic P waves impinging on a subducting slab. Rays coming from down-dip direction will produce efficient P to S conversion, while rays coming from up-dip will produce less efficient conversion.

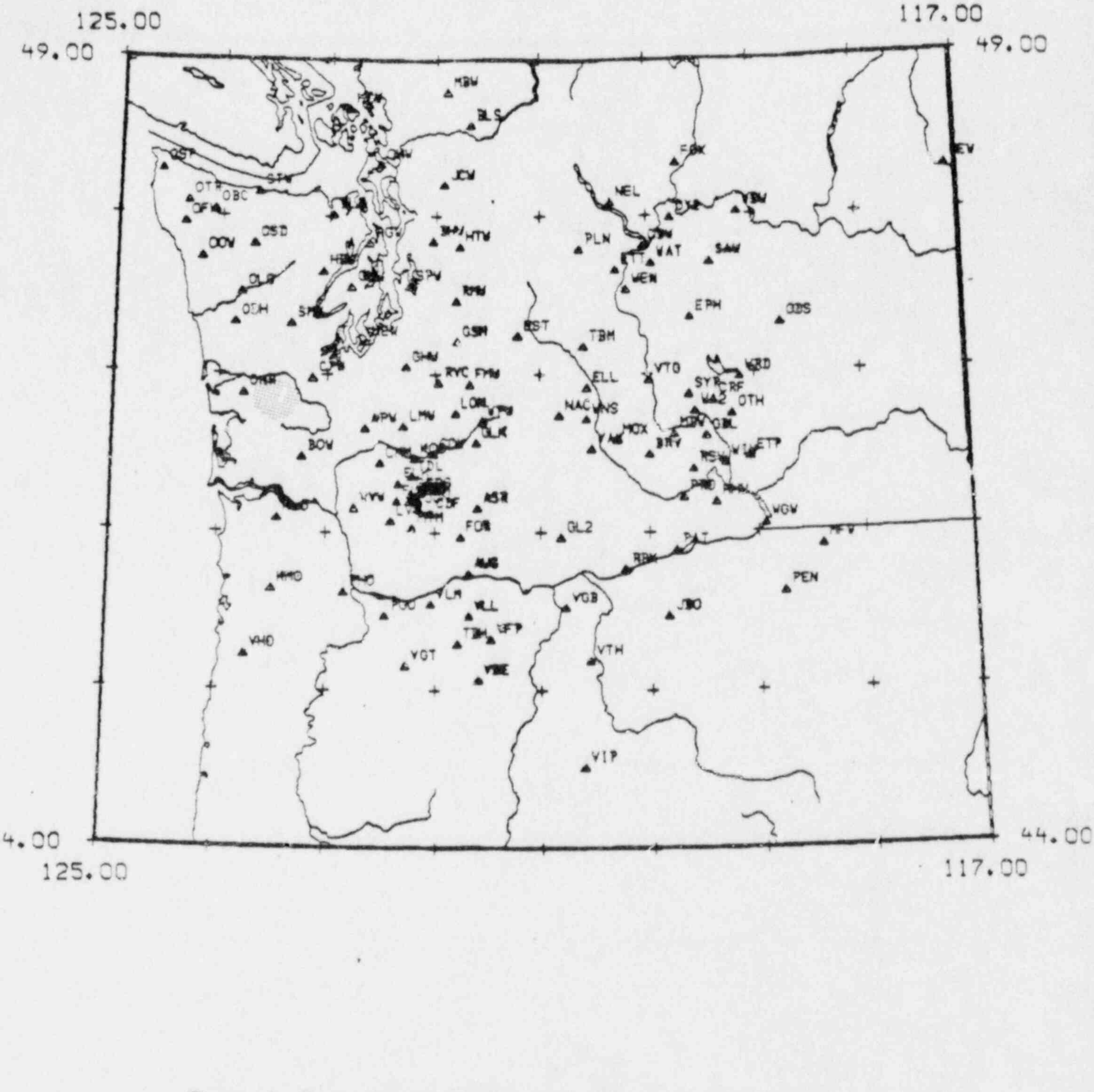
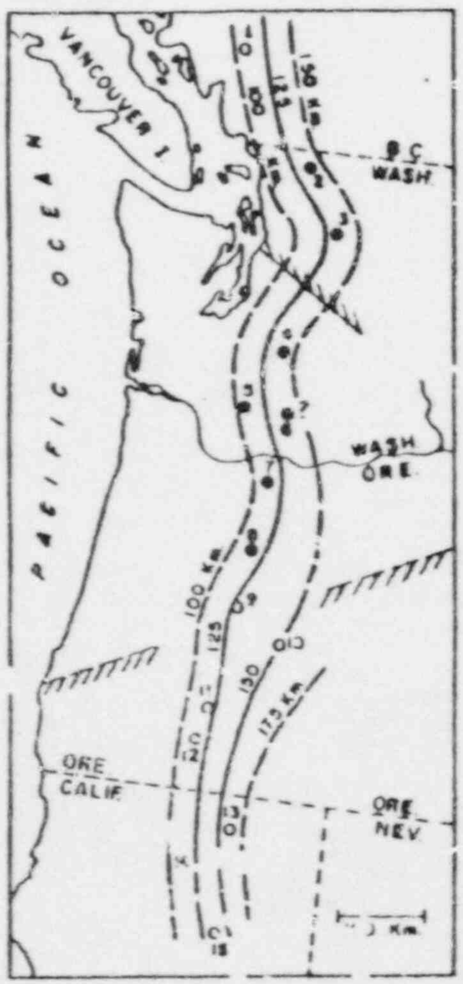


Figure 1. Seismograph stations operating during the second quarter 1985.

a)



b)

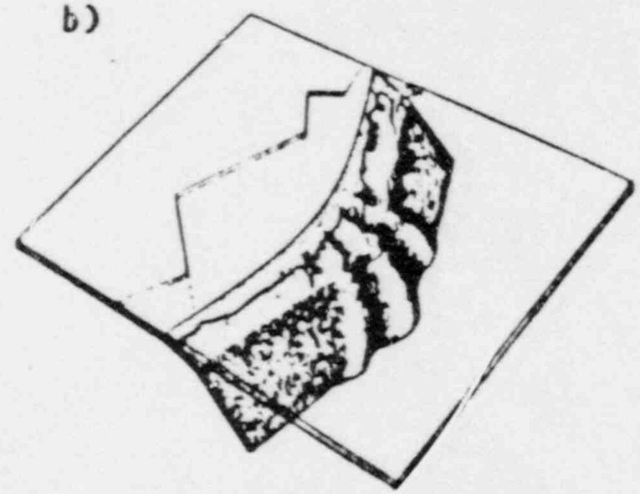
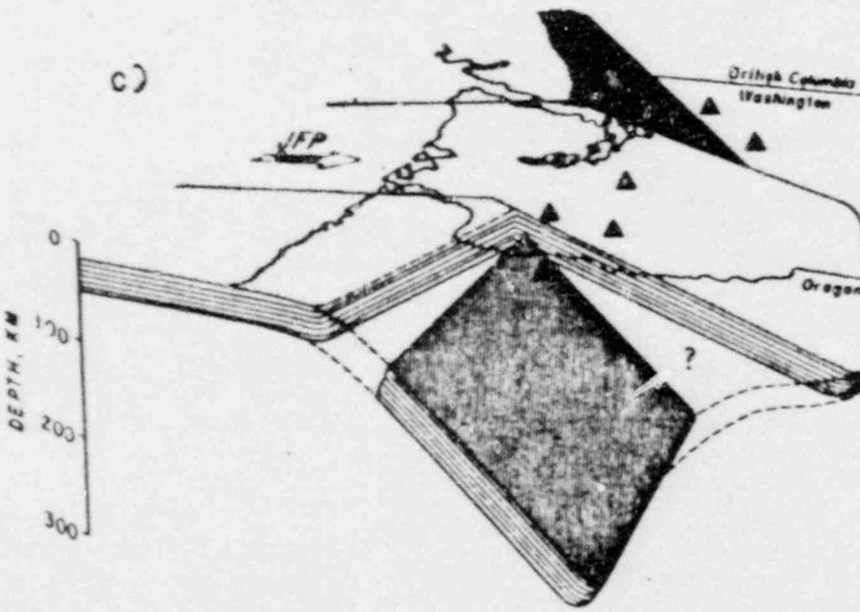
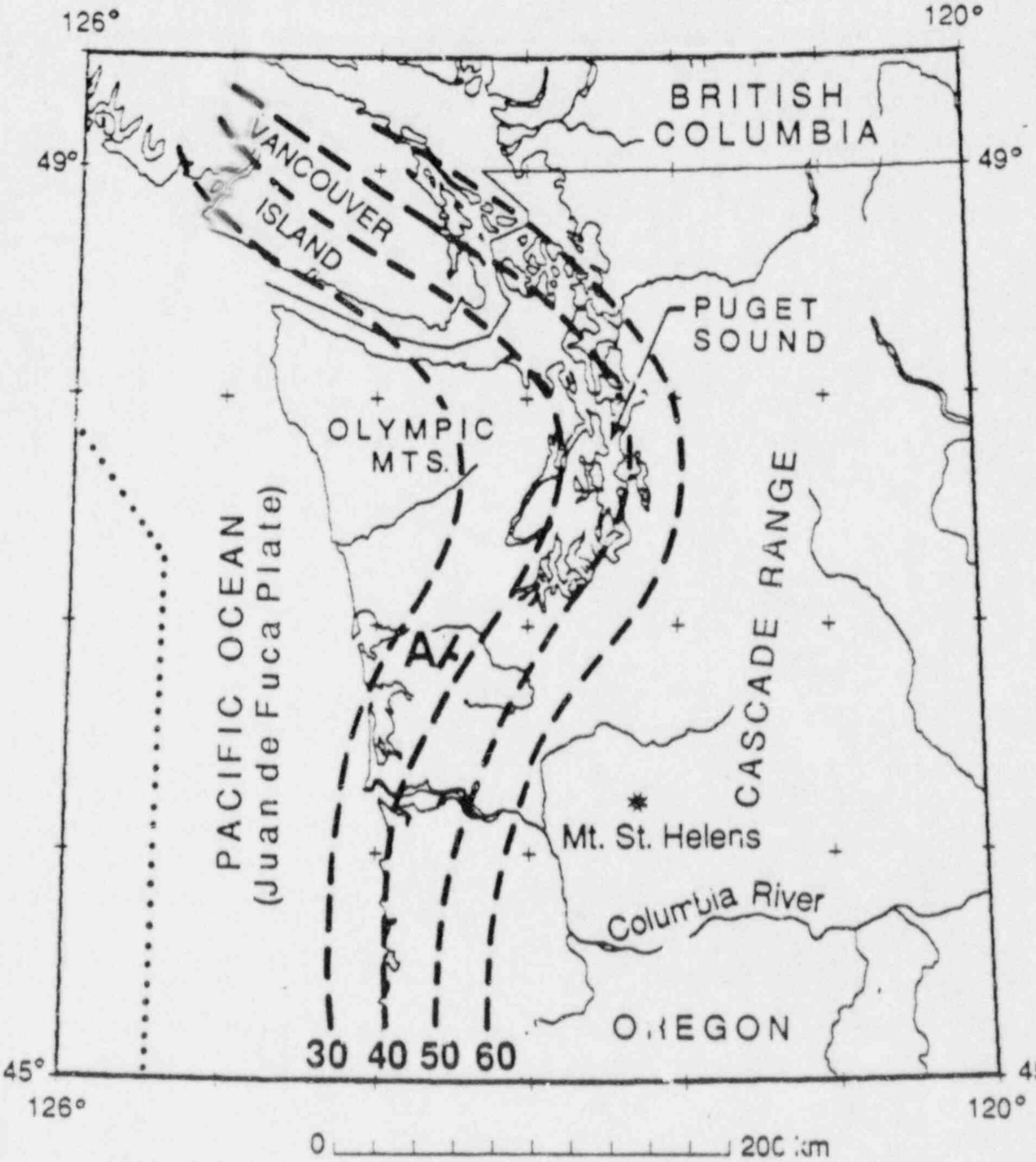


Figure 9. Three models of Juan de Fuca slab configuration: a) from Dickenson, 1970; b) from Rogers 1983; and c) from Michaelson and Weaver, 1986.

c)





126°
120°
BRITISH
COLUMBIA
49°
49°
VANCOUVER
ISLAND
PUGET
SOUND
OLYMPIC
MTS.
PACIFIC OCEAN
(Juan de Fuca Plate)
CASCADE RANGE
Mt. St. Helens
Columbia River
OREGON
30
40
50
60
45°
45°
126°
120°
0
200 km

FIG. 4

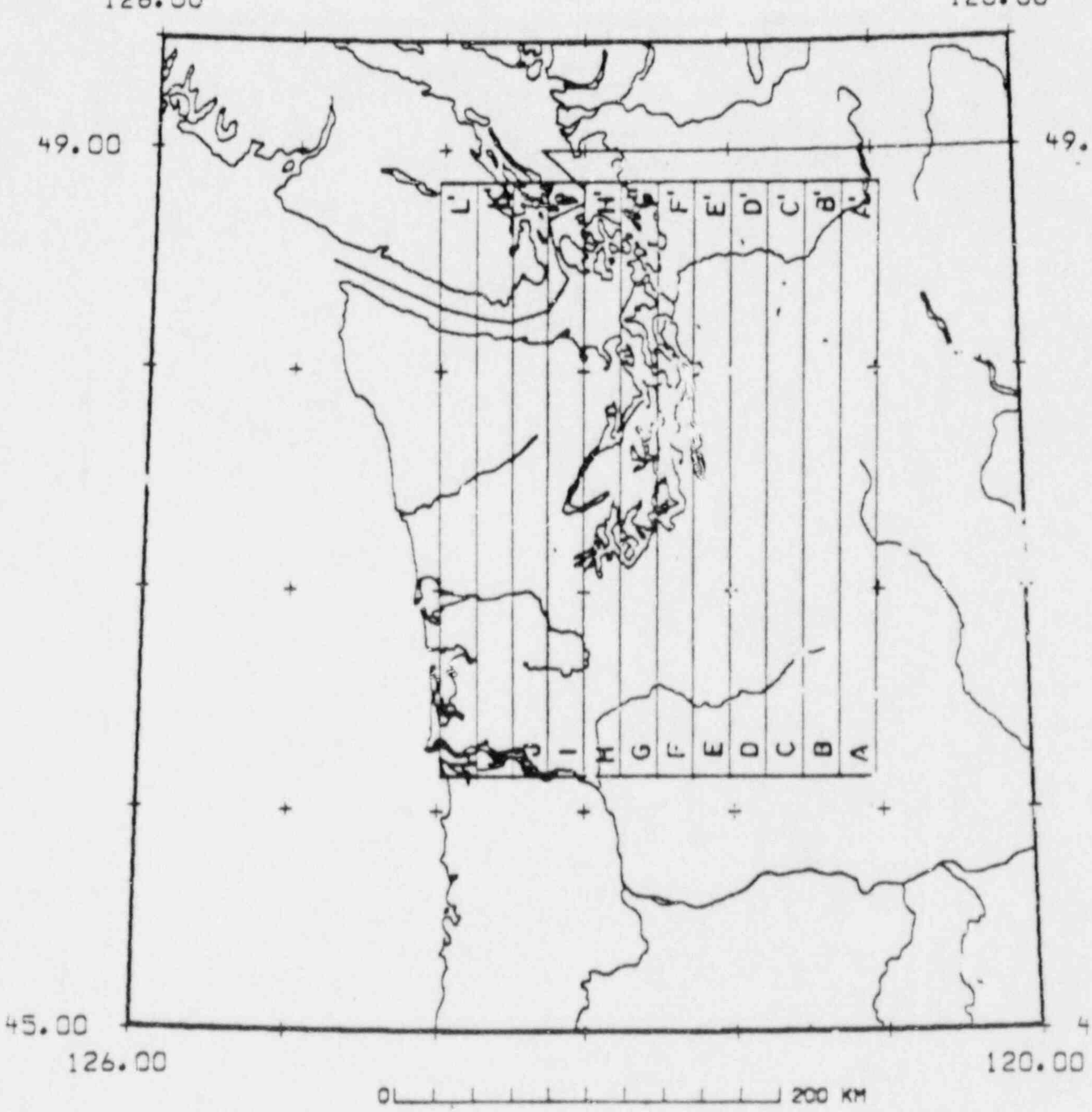


Figure 8. a) Map view showing selection regions for 12 cross-sections in Fig. 8b. b) North-South cross sections of selected western Washington earthquakes (from Fig. 5). No vertical exaggeration.

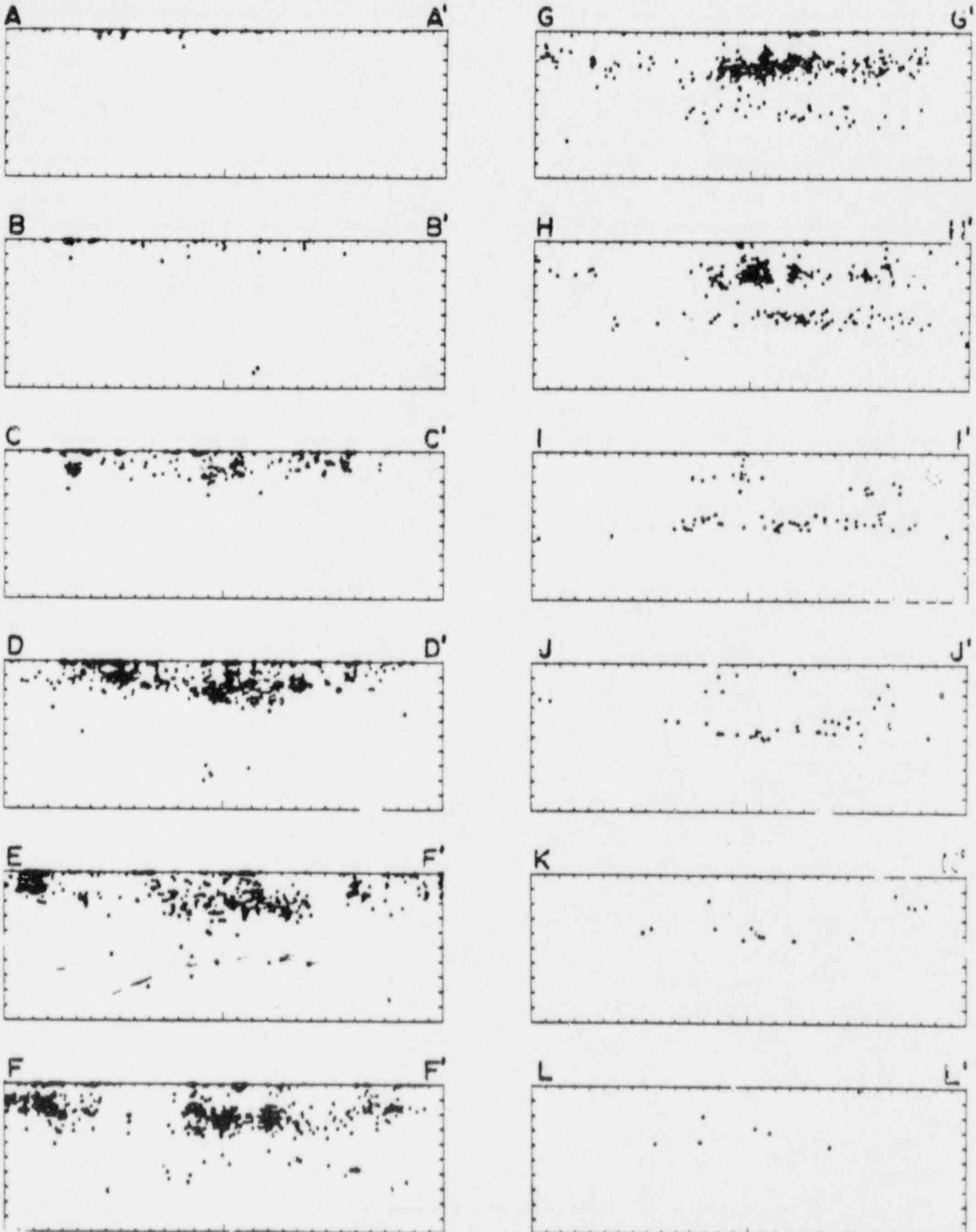


Figure 8b) North-South cross sections of selected western Washington earthquakes (from Fig. 5). No vertical exaggeration.

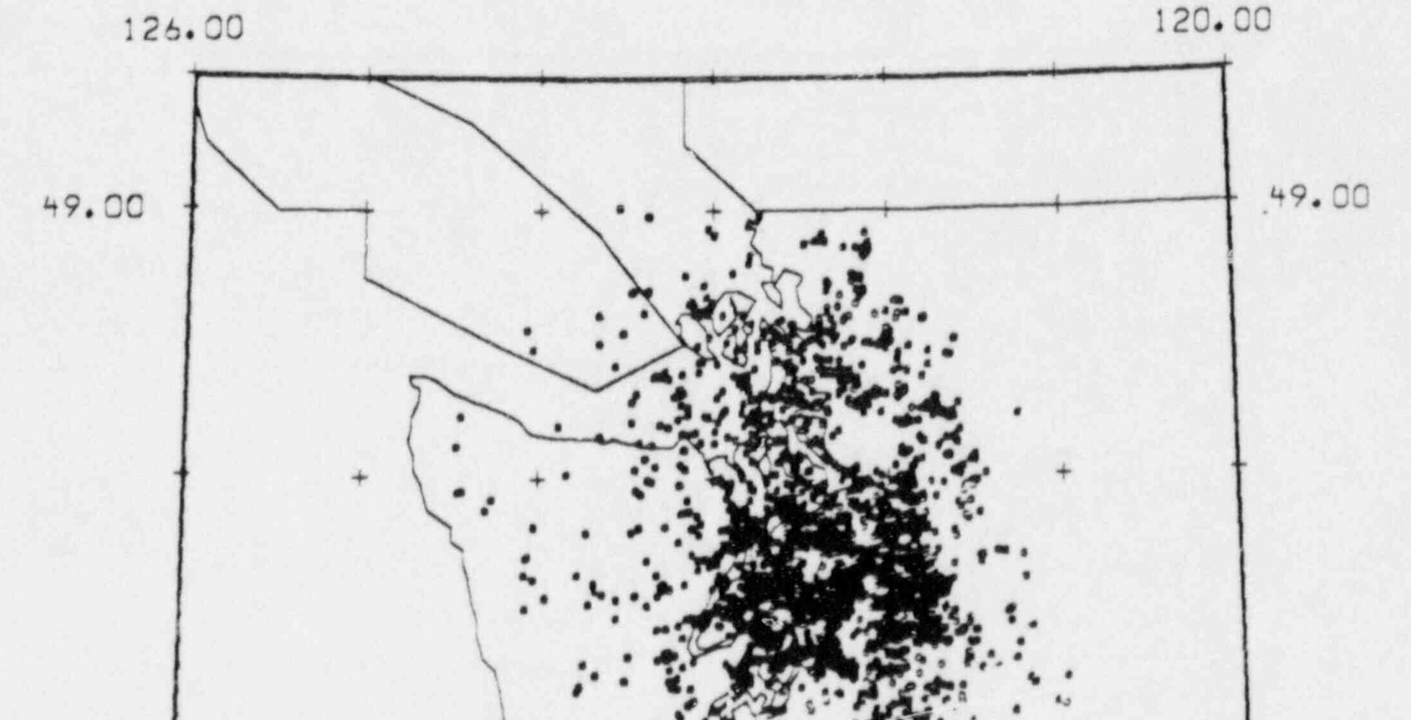


Figure 5. Epicenters of selected earthquakes in western Washington, 1970 - 1986. Selection criteria are described in Fig. 3. One symbol size is used for all events, regardless of magnitude.

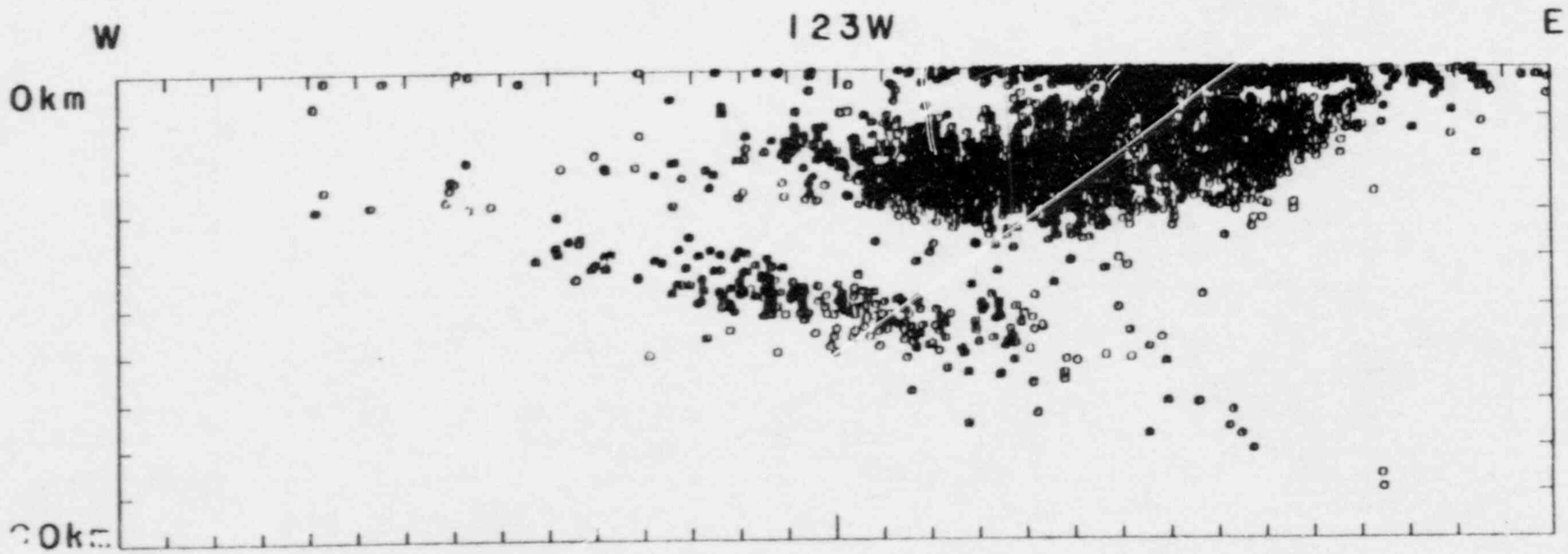
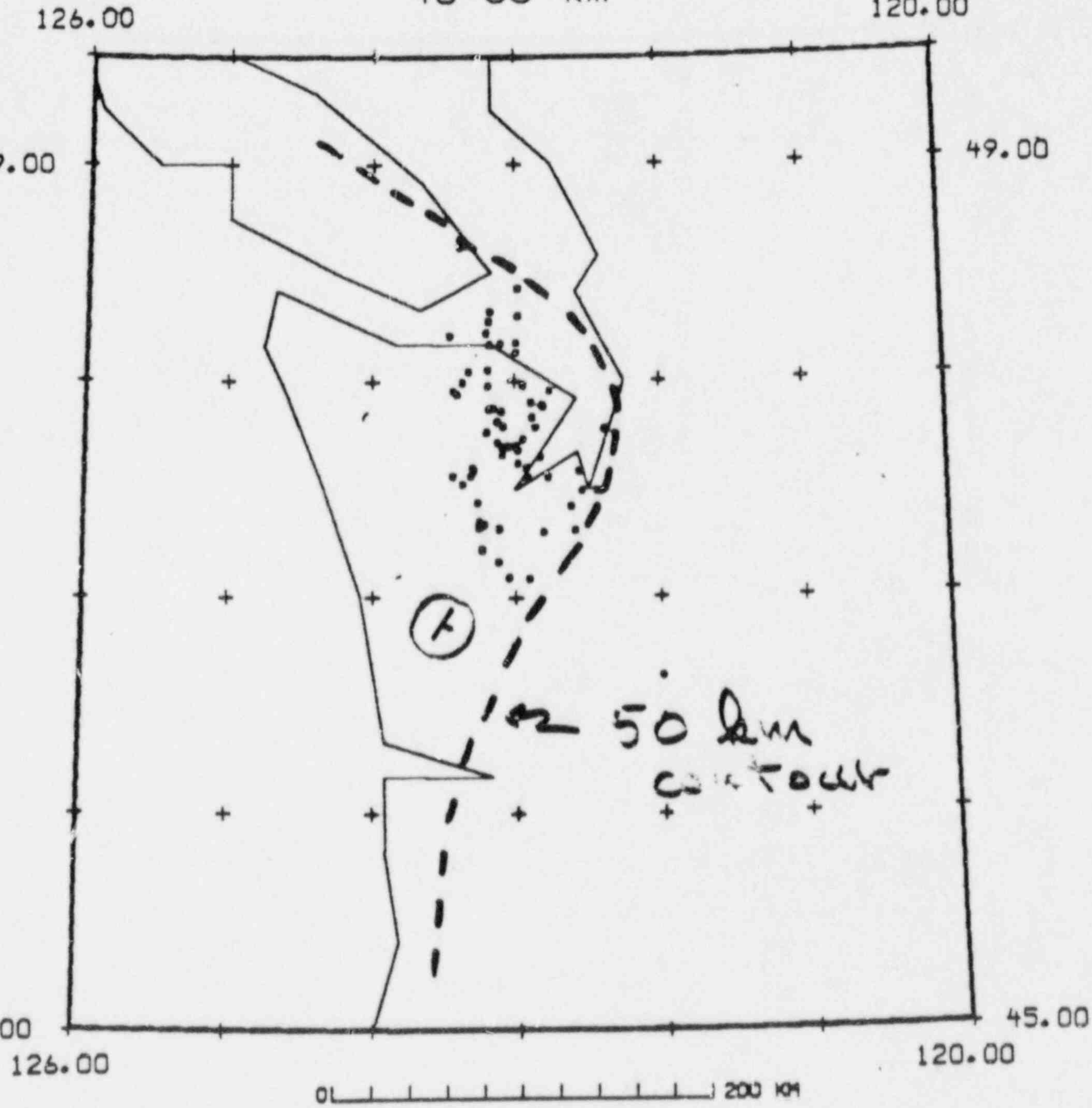


Figure 6. East-West cross-section of all data shown in Fig. 5. Center of plot is at 123°W and scale intervals are 10 km. One symbol size is used for all events. Cross sections has no vertical exaggeration.

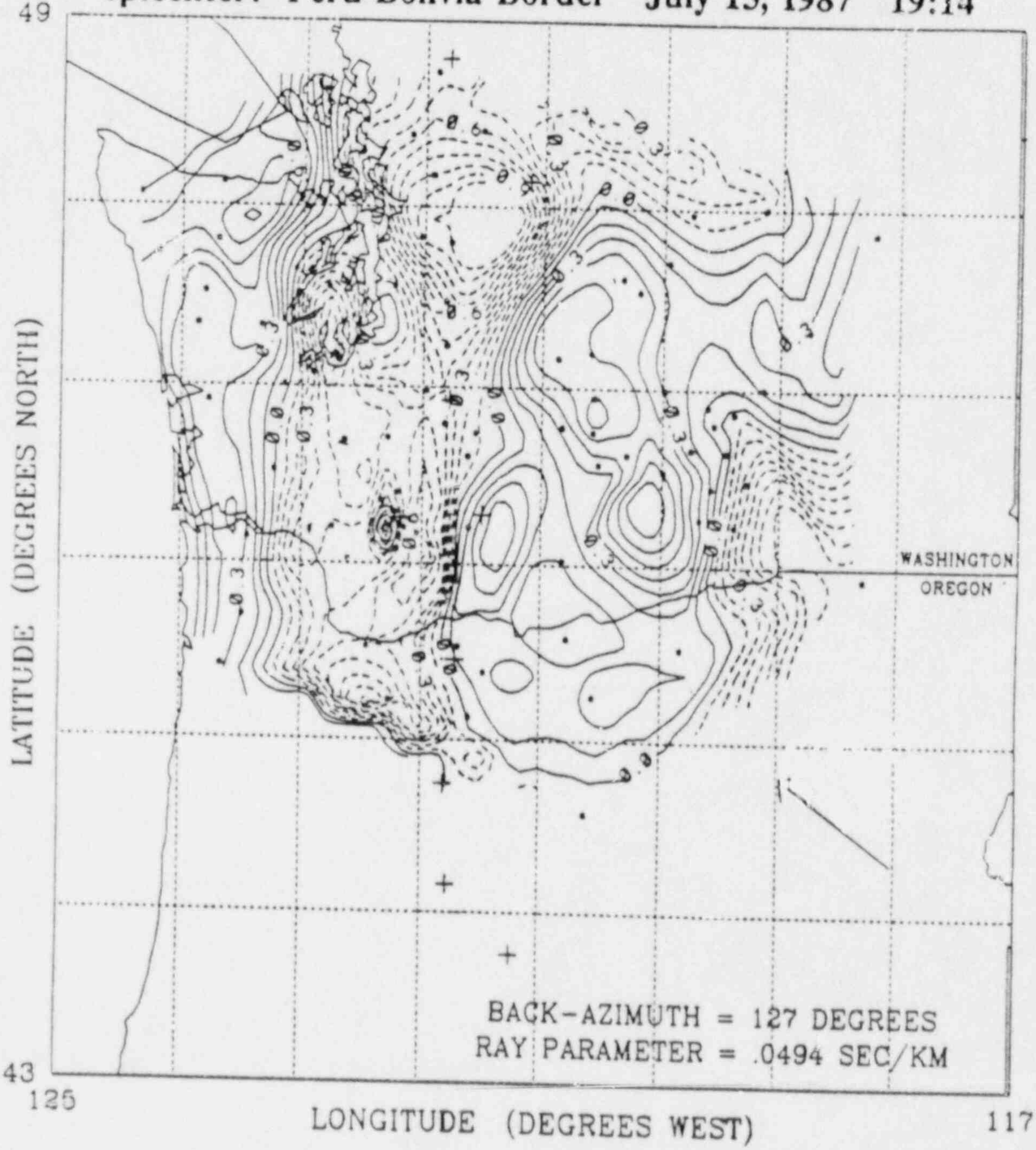
45-50 km



126.00
120.00
49.00
49.00
45.00
45.00
126.00
120.00
50 km contour
0
200 KM

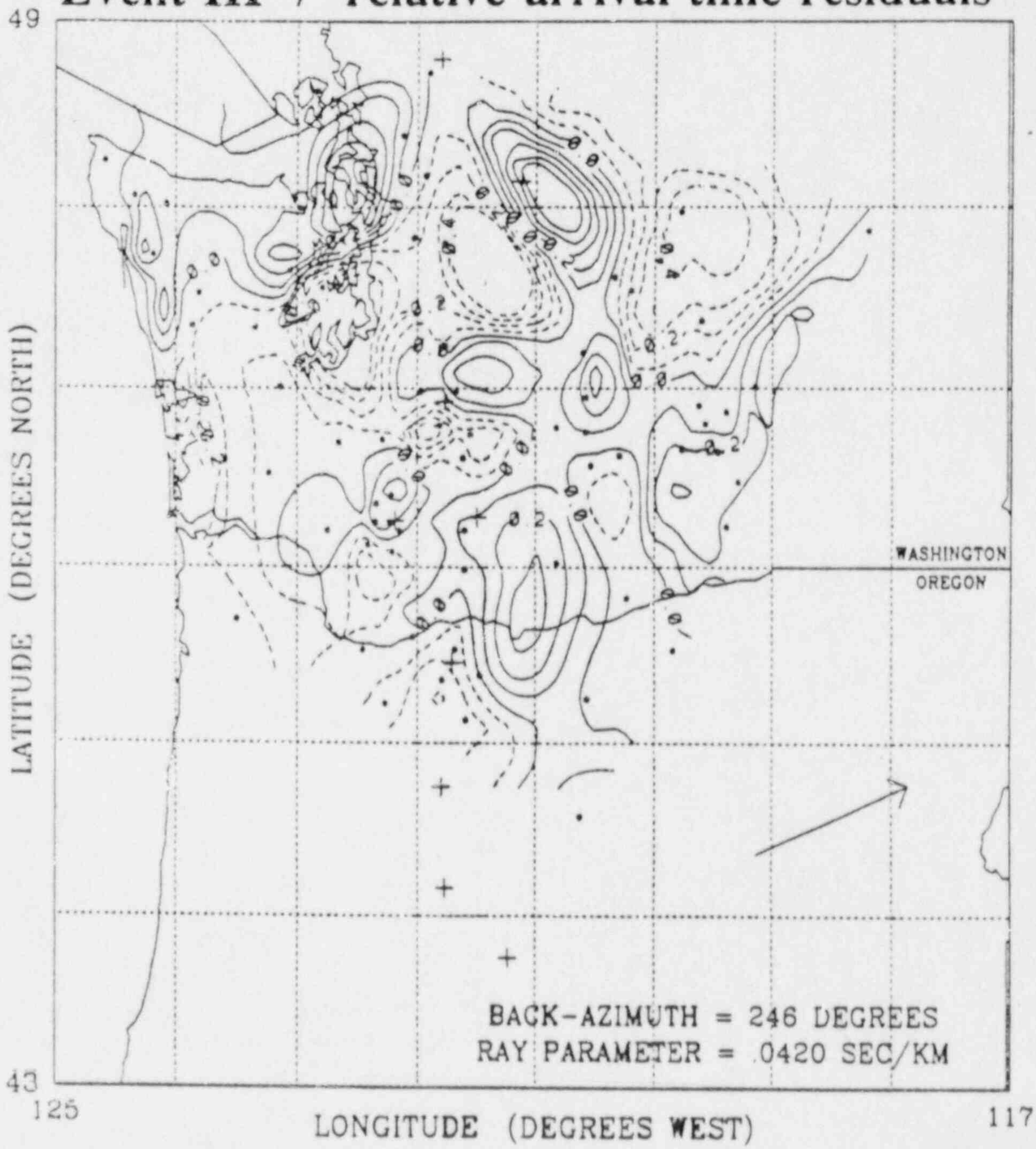
Event IV / relative arrival time residuals

epicenter: Peru-Bolivia Border July 13, 1987 19:14



from CORR / LSQR derived arrival times

Event III / relative arrival time residuals



from CORR / LSQR derived arrival times