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Seismic Hazard Investigations in the Pacific Northwest

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Investigations

1. Operation of the western Washington regional seismograph network, and routine preliminary analysis of seismic events in western Washington

2. Analysis and interpretation of Pn observations for both eastern and western Washington

3. Development and implementation of automated processing of seismic events using digital network data

4. Crustal structure determination in the vicinity of Mt. St. Helens and in the greater Puget Sound region from earthquakes and explosions recorded digitally on the local and regional networks

5. Locations, focal mechanisms and occurrence characteristics of crustal and subcrustal earthquakes beneath western Washington and their relationship to subduction processes

6. Automated spectral analysis of digital seismic data for determination of source parameters for local earthquakes in the Pacific Northwest

Results

1. Network operation for stations in western Washington, eastern Washington, and northern Oregon continued normally. No unusual regional earthquake activity was recorded outside of the Mt. St. Helens region. A new station (OSD) which provides critical data for depth determination in the subduction complex beneath the Olympic Peninsula was established in the central Olympic Mts. Reconfiguration of the telemetry routes and the installation and reinstallation of stations in the northeast part of the Puget Sound basin is underway and scheduled for completion for autumn 1984. An analysis of magnitude thresholds for catalog completeness was done for the network, and will be utilized henceforth in report and catalog presentations. Efforts are underway to establish a uniform data base of earthquake phase data for the greater western Washington region, from 1970 through the transition to digital data acquisition in 1980 to the present. Eventually, pre-network instrumental and historic data will be merged into

a uniform data base with appropriate quality indicators.

2. Results from Pn analysis reinforce the existence of significant differences in structure between eastern and western Washington. East of the Cascade Range, Pn velocity averages 8.18 +/- 0.02 km/sec, whereas the average for western Washington is 7.77 +/- 0.02 km/sec. Anisotropy appears to be significant east, but relatively unimportant west, of the Cascades. Calculated Moho dip east of the Cascades, assuming no lateral change in crustal velocity, is about 0.7 degree whereas the calculated regional dip for the west is about 2.1 degrees in a southeasterly direction. There is little direct evidence in the regional Pn data for Moho dip associated with a dipping slab beneath western Washington.

3. A new algorithm for phase picking has been developed and incorporated into an automated processing program for digital network data. In the current configuration, feedback is provided between phase picking and location processing to reduce the number of blunders due to noise spikes and poor signal-to-noise ratio. An important aspect of automated processing is making quantitative and consistent estimates of phase picking errors for both P and S phases and coda length estimates. We are undertaking a complete recalibration of our auto-processed coda duration measurements for the purpose of improving the consistency and accuracy of local magnitude determinations. The current version of our program is being run in a test mode and is also being used for special studies. Use of automatic processing in our routine network data analysis is feasible based on results to date. We view these efforts as being important in the long range to improve the quantity, quality and consistency of network data analysis. In recently completed work on structure inversion, for example, we exclusively utilized auto-picked phase data.

4. A joint P/S layered structure inversion program was developed to use earthquake and explosion arrival times, providing additional constraint on structure determination where high quality S arrivals are measured. The method uses coupled P and S models, and makes use of an an independently determined VP/VS ratio. Using the joint P/S inversion program, crustal structure at Mt. St. Helens was inverted from both earthquake and explosion arrival times. The incorporation of S phases offers significantly greater stability to the modeling process than the use of P phases alone. Our final model indicates that the P velocity in the vicinity of St. Helens rises rapidly to about 6.1 km/sec at 1 km depth (very high shallow velocity) and then increases slowly in approximately a linear fashion to about 6.5 km/sec at 20 km depth. In comparison with the Puget Sound region, higher velocities are reached at shallower depths but mid-crustal values are somewhat lower. Using auto-picked digital data for 58 seismic events (48 earthquakes, 10 explosions), we inverted for a coupled P and S velocity model for the greater Puget Sound region. The final model, although similar to our previous model in the depth range from about 12 km to 30 km, has a thinner surface layer of velocity 5.4 km/sec and a slight velocity reversal in the interval 30-40 km. km. The constraint on the velocity in the 30-40 km depth range, an earthquake free zone, with our new model appears to be better than that previously obtained. This structure inversion

effort is preliminary to undertaking a careful analysis of deep earthquake seismicity.

5. Focal mechanisms for small earthquakes are commonly utilized to infer tectonic stress directions and trajectories. In the Puget Sound region, the volumetric distribution of earthquakes offers an excellent opportunity to study stresses associated with subduction. Such studies provide one of the most reliable methods to assess the degree of coupling between the overlying North American and the subducted Juan de Fuca plates. McKenzie (1969) has shown quantitatively how preexisting faults or fractures can distort the interpretation of stress directions when these are based on the common assumption of fracture of previously unbroken rock. Since there are probably no regions of the earth's crust or upper mantle that behave as unfractured rock, caution is required. With reasonable assumptions as to the effect of the earth's free surface and the relative magnitudes of the principal stresses, we can use McKenzie's results to show that substantial error may be introduced if strike-slip earthquakes are used to determine the P axis for the Pacific Northwest. By contrast, thrust or normal earthquakes should provide better estimates of the azimuth of P or T axes. We are studying a data base of well recorded regional earthquakes in order to test this hypothesis, and possibly reconcile varying values of P axis azimuth estimated from northwest earthquakes. These studies of regional tectonics are critically dependent on the data base efforts discussed in (1) above.

6. Routines for determining seismic moment, corner frequency, and stress drop from digital seismic data are being tested. A synthetic source spectrum is fit to the amplitude density spectrum for P, S, and coda waves corrected for instrument response and Q. All events located by the routine processing will ultimately have source parameters determined by this process. Periodic testing of the process is underway. Calibration of amplitude-frequency responses of network stations is crucial to this effort, and is ongoing.

Reports

Crosson, R.S. and D.A. Bame, 1984, A Spherical Source Model for Volcanic Earthquakes (abs), EOS, (in press).

Ludwin, R.S. and R.S. Crosson, 1984, The Azimuth of Regional Tectonic Compression in the Pacific Northwest from Shallow Thrust Earthquakes (abs), EOS, (in press).

Noson, Linda Lawrance, R.S. Ludwin, and R.S. Crosson, 1984, Compilation of Earthquake Hypocenters in western Washington, 1979, Washington Division of Geology and Earth Resources Information Circular, (in press).

Univ. of Wash. Geophysics Program, 1984, Earthquake Hazard Evaluation in the Pacific Northwest, 1981-1982 Final Technical Report U.S.G.S.

Contract 14-08-0001-19274.

Univ. of Wash. Geophysics Program, 1984, Earthquake Hazard Evaluation in the Pacific Northwest, 1982-1983 Final Technical Report U.S.G.S. Contract 14-08-0001-21192.

Univ. of Wash. Geophysics Program, 1984, Quarterly Network Report 84-A on Seismicity of Washington and Northern Oregon Jan 1 through March 31, 1984,27p.

Univ. of Wash. Geophysics Program, 1984, Quarterly Network Report 84-B on Seismicity of Washington and Northern Oregon April 1 through June 30, 1984,26p.

Zervas, C., 1984, A Time-Term analysis of Pn Velocities in Washington, M.S. Thesis, Univ. of Washington.