Source Parameters Studies of Historical Intraslab and Crustal Earthquakes of Washington and Oregon: Collaborative Research Between the University of Texas at El Paso and Boise State University

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Element I
Geophysics, seismology, source characteristics, seismotectonics

Investigations Undertaken:

This research is devoted to determining the source locations, source mechanisms, and rupture histories of historic (1930-1965) intraslab and crustal events of the Washington and Oregon region. Digital seismograms of recent (1990-2002) earthquakes in this region will be used to aid in the interpretation of the historic seismograms. It is hoped that at least some of the seismograms of recent earthquakes can be used as Greens functions to more accurately determine the source locations and rupture processes of the historic events. Modeling of regional and teleseismic data for historic events will also be conducted whenever sufficient data sets exist. The first year of the research focused on the source processes intraslab events of the Puget Sound region, including events in 1939, 1946(?), 1949, and 1965 (Figure 1). In our second year we are focusing on studies of crustal events (Figure 1).

We have completed collection of all digital data for recent earthquakes occurring in the vicinity of historic events of interest (Figure 1). Collaborator Jim Zollweg visited seismogram archives at the University of Washington, Berkeley and Denver and sent us scanned images of all historic seismograms he collected. In July of 2003 further copies of paper seismograms were collected at the Caltech seismogram archives. We also received copies of seismograms from observatories located in Japan, Australia, South America and Europe. Most paper copies of seismograms have been hand digitized. The digitization of scanned seismograms required acquisition of new processing software, which was obtained in October 2003. We hope to complete processing scanned images by the end of 2003.

Preliminary results of comparisons between seismograms of the 1949, 1964 and 2001 intraslab earthquakes were presented at the 2003 meeting of the Seismological Society of America (Wiest et al., 2003a). Additional results of the analysis of these intraslab earthquakes will be presented at the fall 2003 meeting of the American Geophysical Union (Wiest et al., 2003b). We plan to present results for both intraslab and crustal earthquakes at the spring 2004 meeting of the Seismological Society of America.

Results:

Comparisons of seismograms of the 2001 Nisqually earthquake to intraslab events in 1965 (Seatac) and 1949 (Olympia) at the same (or similarly located) stations show many striking similarities. Figure 2 compares the north-south component of the Nisqually earthquake recorded at Matsushiro, Japan (top) to the north-south component of the 1965 Seatac earthquake. The 2001 seismogram has been low pass filtered (cut-off frequency of 0.2 Hz).

Figures 3 and 4 compare low pass filtered seismograms (0.2 Hz cut-off) recorded at College, Alaska, and Pasadena, California, for the 1949 Olympia event with similarly low pass filtered seismograms for the Nisqually event. In Figure 3 the initial 25 seconds of the P-wave trains for both events are very similar, however amplitudes begin to grow around 20-25 seconds into the 1949 event. The Pasadena records (Figure 4) show even more similarity between the 1949 and 2001 events, with comparable waveforms recorded for the first 100-150 seconds. Although waveforms of all 3 events appear similar, shaking in both the 1965 and 1949 events was more severe than in 2001, suggesting there must be important differences in rupture characteristics between these events.

The next step in our analysis was to deconvolve the Nisqually records from the older waveforms in order to better characterize the source differences between events. This is illustrated in Figure 5. First the instrument response was removed from the vertical component of the Nisqually earthquake recorded at Pasadena. The record was then convolved with the response of a long-period Benioff seismometer (the instrument operating in 1949). A comparison between the "pseudo Benioff" seismogram for the Nisqually earthquake and the seismogram of the 1949 Olympia earthquake is shown at the top of Figure 5. Both seismograms have been bandpass filtered from 0.01 to 0.1 Hz. Next, the Nisqually seismogram was deconvolved from the Olympia seismogram to obtain a relative source-time function (RSTF). The time window used for the RSTF is indicated by C1 and C2 and is essentially the Pg phase. The bottom trace shows the resulting RSTF, with a low pass filter of 0.2 Hz and phase shift of 40 sec. These results indicate a relative source duration of 12 seconds for the Olympia event. We will perform similar RSTF analyses at other stations in order to determine rupture directivity for the Olympia event.

Non-technical Summary:

This study focuses on earthquake hazards of the Oregon-Washington region. By comparing the seismograms of recent earthquakes (post-1989) to those of historic earthquakes (pre-1966) recorded at the same (or similar) stations, we can determine how similar the older earthquakes are to recent earthquakes whose depths and rupture processes are better known. The first year of study concentrated on earthquakes within the subducting Pacific plate (intraslab), similar to the 2001 Nisqually, Washington earthquake. The second year focuses on crustal events. A better understanding of the depth range and rupture extent of intraslab events will aid determining what physical characteristics of the Pacific plate control these earthquakes.

Reports Published:

Wiest, K., D.I. Doser, and J. Zollweg, 2003a, Source Processes of Western Washington Intraslab Earthquakes (1939-1965), (abstract), Seismol. Res. Lett. 74, 239.

Wiest, K., T. Theiner, A. Velasco, and D. Doser, 2003b, Source parameter studies of historical and recent earthquakes of the Cascadia Subduction zone and Mendocino Triple Junction region, submitted to Fall Meeting, Amer. Geophys. Union, Sept. 2003.

Availability of Data Sets:

Copies of seismograms used in this study are available in digital form. Contact the principal investigator, Dr. Diane Doser, for more details at (915)-747-5851 or doser@geo.utep.edu.

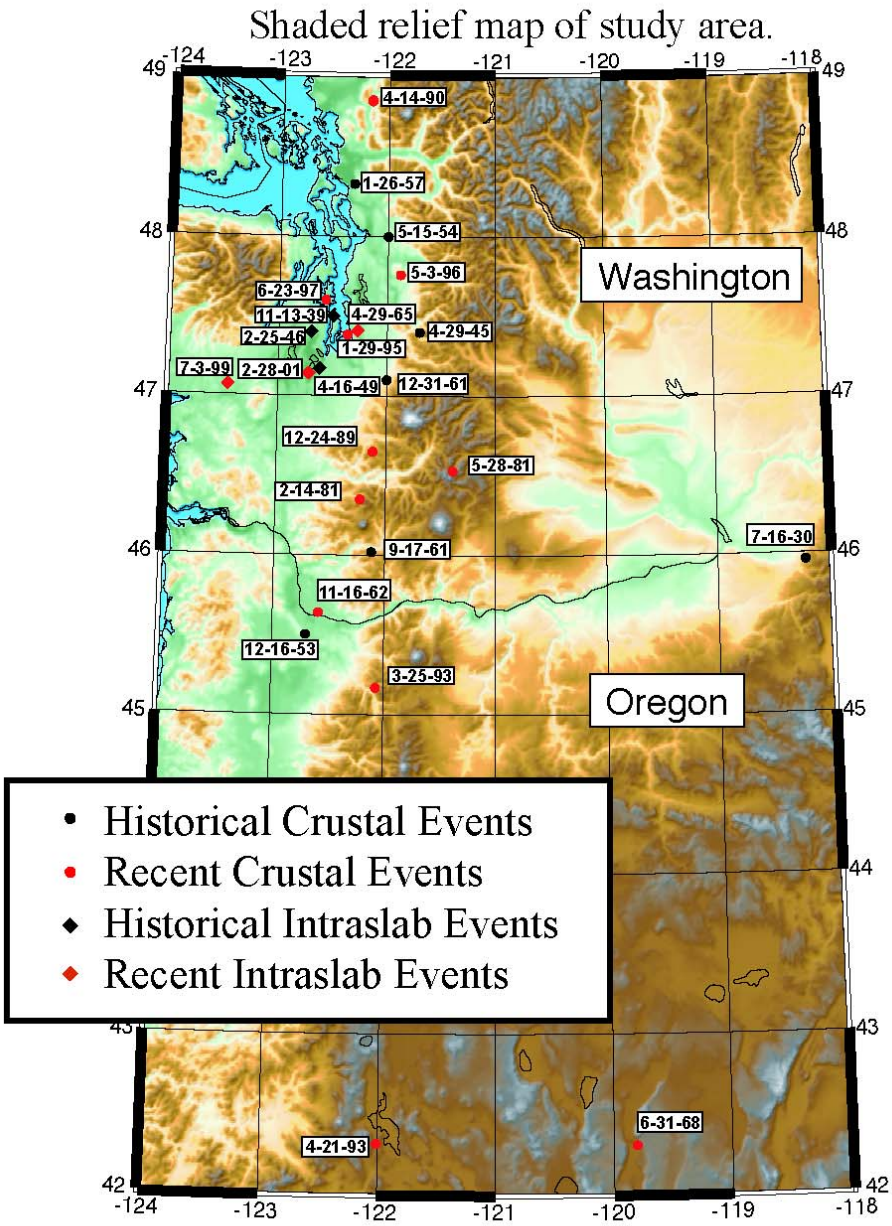
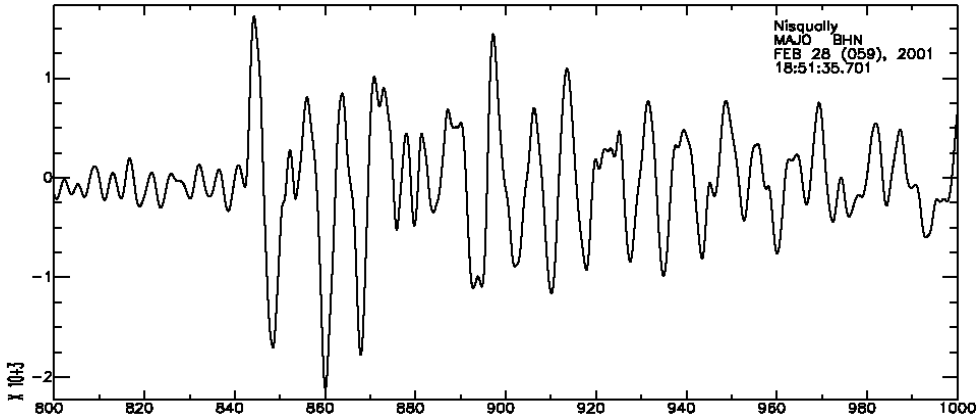


Figure 1 – Map of study area showing historic and recent intraslab and crustal events of interest to this study.



Copy of historical seismogram of 1965 South Seattle earthquake, M=6.5, recorded near Matsushiro, Japan.

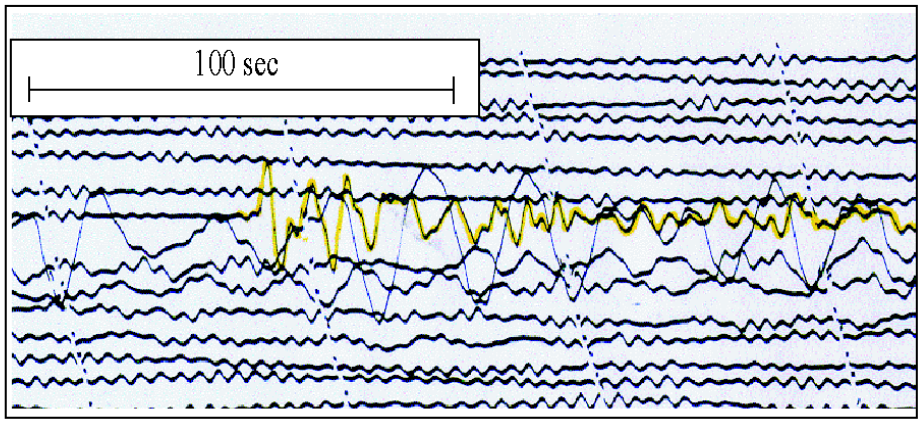


Figure 2 – Comparison of seismograms of the 2001 Nisqually earthquake (top) and 1965 Seatac earthquake (bottom) recorded at Matsushiro, Japan (north-south component). The Nisqually seismogram has been filtered using a low-pass filter with 0.2 Hz cut-off.

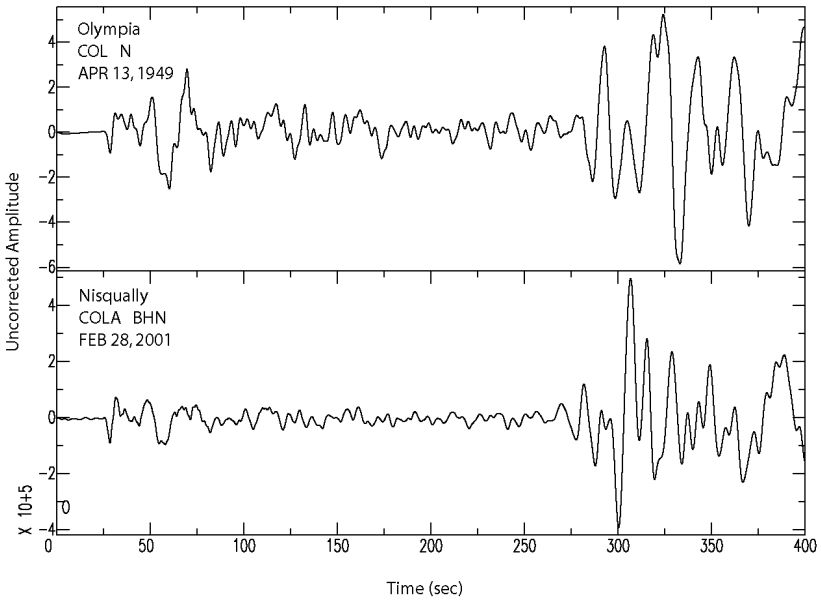


Figure 3- Comparison of seismograms (both low-pass filtered with cut-off of 0.2 Hz) for the 1949 Olympia (top) and 2001 Nisqually earthquakes (bottom) recorded at College, Alaska (north-south component).

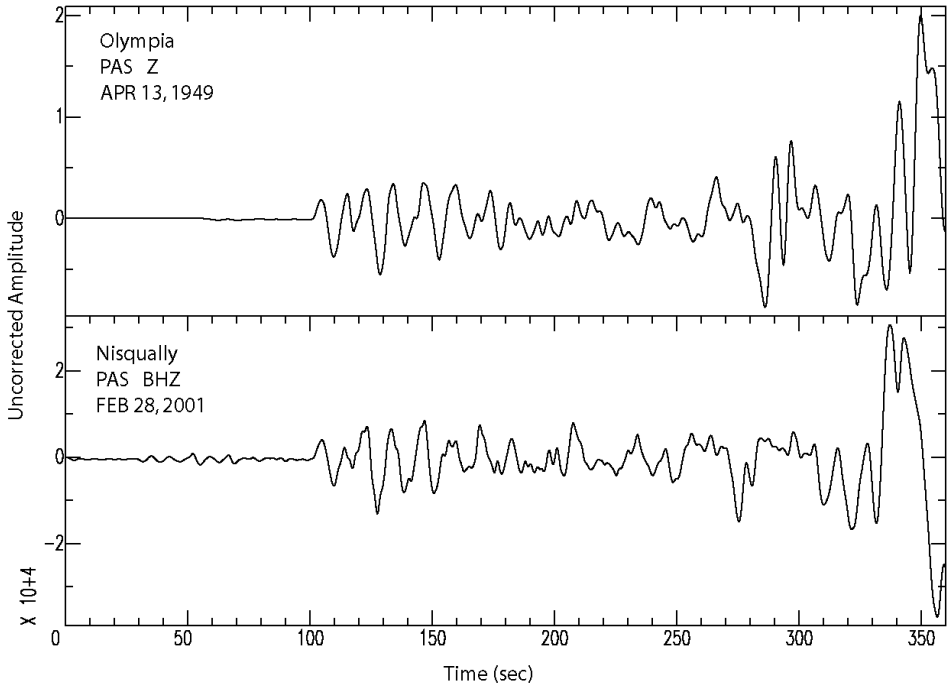
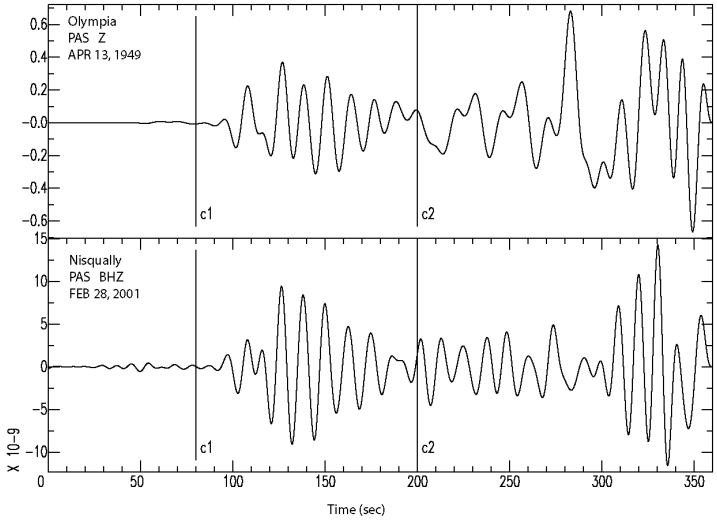


Figure 4 - Comparison of seismograms (both low-pass filtered with cut-off of 0.2 Hz) for the 1949 Olympia (top) and 2001 Nisqually earthquakes (bottom) recorded at Pasadena, California (vertical component).



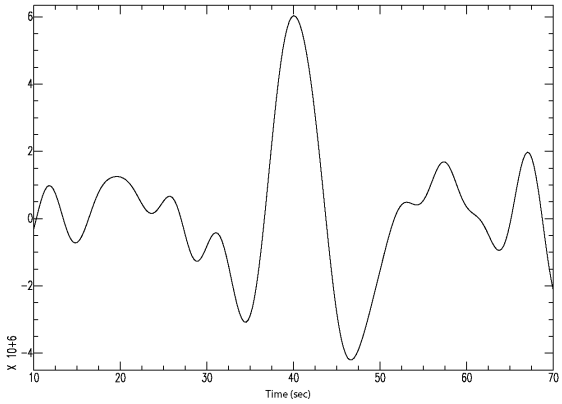


Figure 5 - Comparison of 1949 Olympia seismogram (top) to 2001 Nisqually seismogram (middle) for vertical component at Pasadena. Nisqually seismogram was obtained by deconvolving instrument response from the record and then convolving the record with the 1949 long-period Benioff response. Both seismograms were bandpass filtered between 0.01 and 0.1 Hz. C1 to C2 indicates time window about the Pg phase used to determine the relative source time function (RSTF) (shown at bottom). The RSTF was low-pass filtered (0.2 Hz cut-off) and phase shifted by 40 seconds.