

Introducing WinQuake 2.5

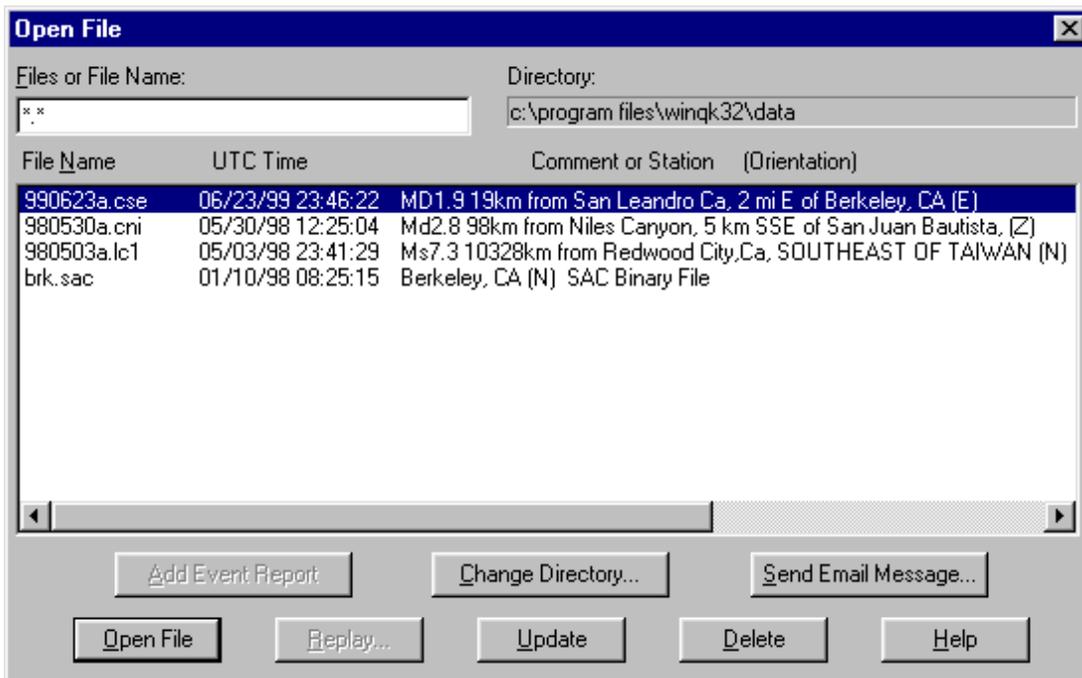
Background

Windows users currently have two programs available for analyzing seismograms, SWAP and WinQuakes. SWAP is freeware and WinQuakes is free to schools upon registration. Both can be downloaded from the PEPP website. Although the two programs do basically the same thing I highly recommend that both programs be available at each school. Each program has some strong points and some limitations and, after some practice, the user will be able to choose the best tool for what they want to accomplish. This introduction is intended to help the user get started in using WinQuakes to analyze seismic data.

WinQuakes can work with data files in either of the following formats: PEPP, SAC, SEED, or PSN (Public Seismic Network).

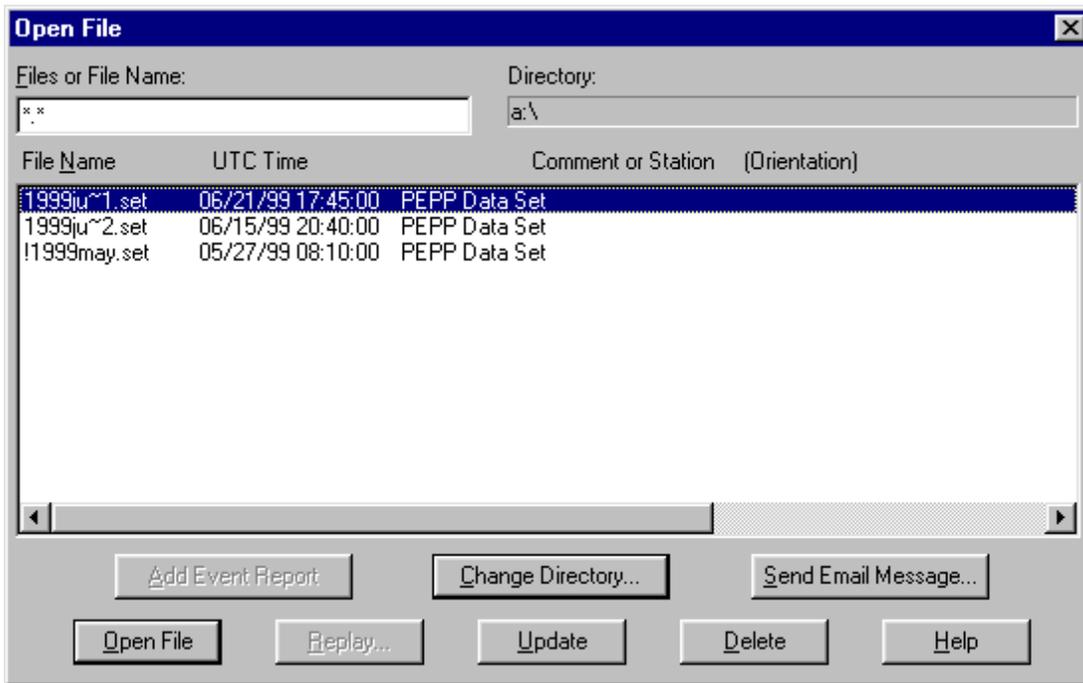
Loading a file

For the purpose of this introduction I'll assume that the user has installed WinQuakes and has data on a removable disk ready to be analyzed (similar instructions apply to Windows 3.1). When the program is started it automatically goes to the **Open File** window, shown below, and displays the files available in the WinQuakes data folder.

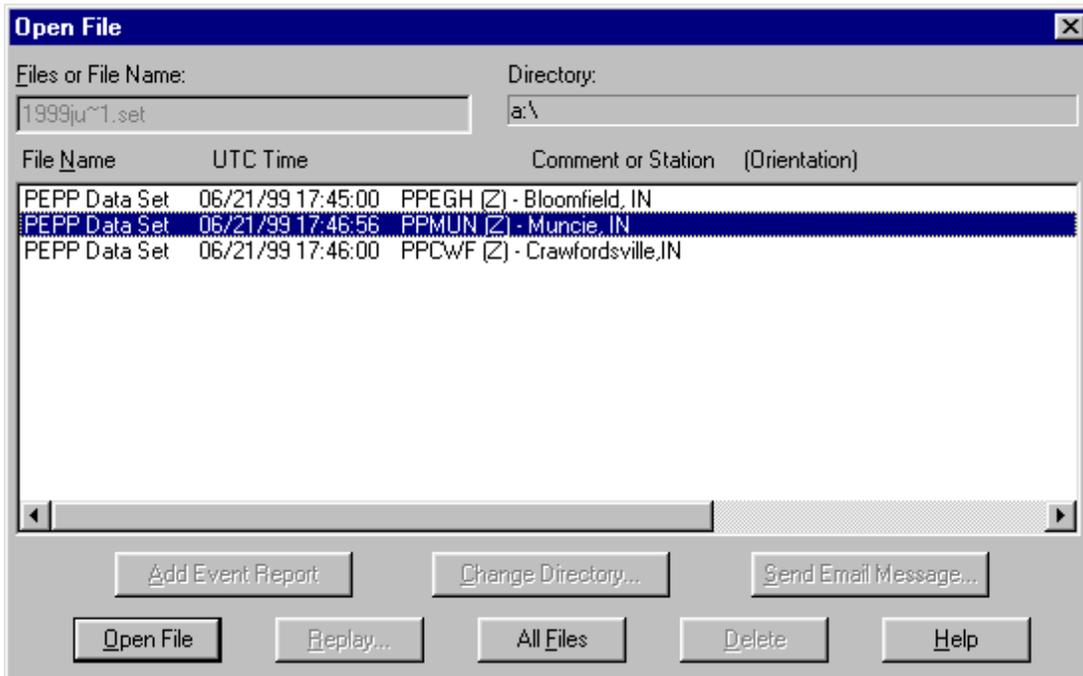


In order to open the files on the user's disk the appropriate directory must be selected.

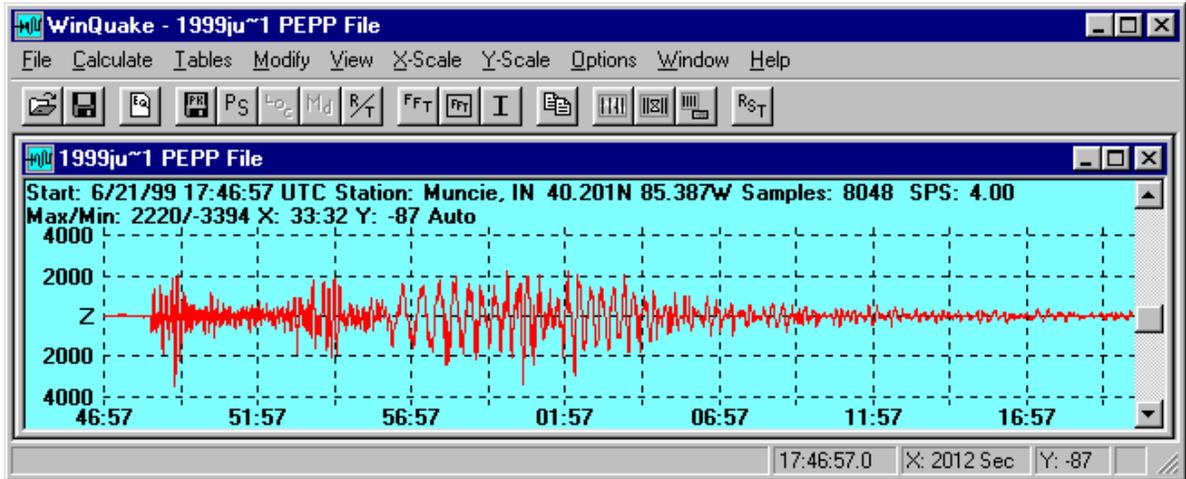
Click and select the directory containing the PEPP files.



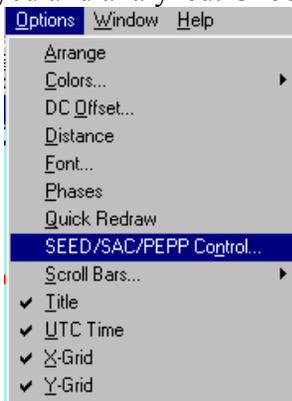
In this example the data for three different earthquakes are available in data sets that were downloaded from the PEPP website but only one data set can be opened at a time. Highlight the desired data set and click **Open File**.



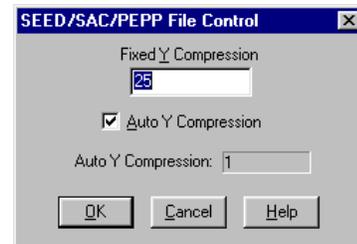
Select a file from the data set and click **Open File** again. Your open file screen should resemble the one below. (This example image has been made smaller to save space).



After a file is opened there are several drop-down menus available that allow the user to control how the data is displayed and analyzed. Choose **Options** and select



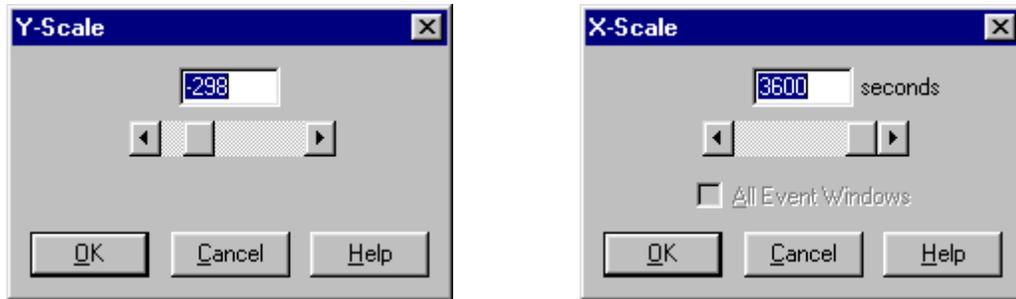
SEED/SAC/PEPP Control.



Check the **Auto Y-Compression** box. This allows the program to display PEPP data properly

Adjusting the Window

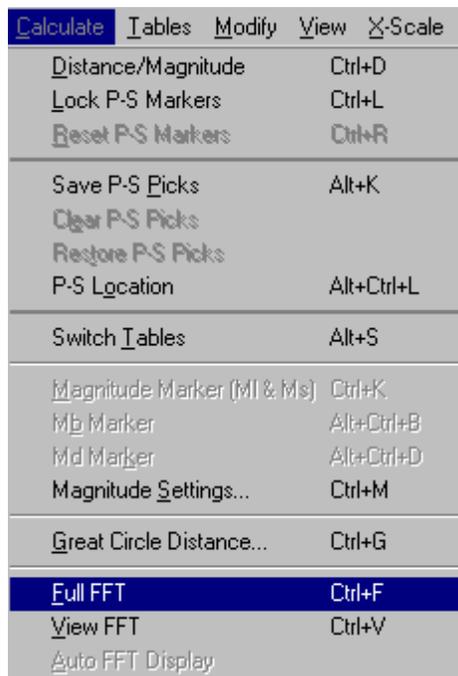
When the program opens a file all data points are displayed in the available window. The amplitude of the display is controlled by the vertical scroll bar or by adjusting the value in the **Y-Scale** option. A positive value increases the y-scale and a negative value compresses it. It is usually simplest to use the scroll bar on the right side of the screen.



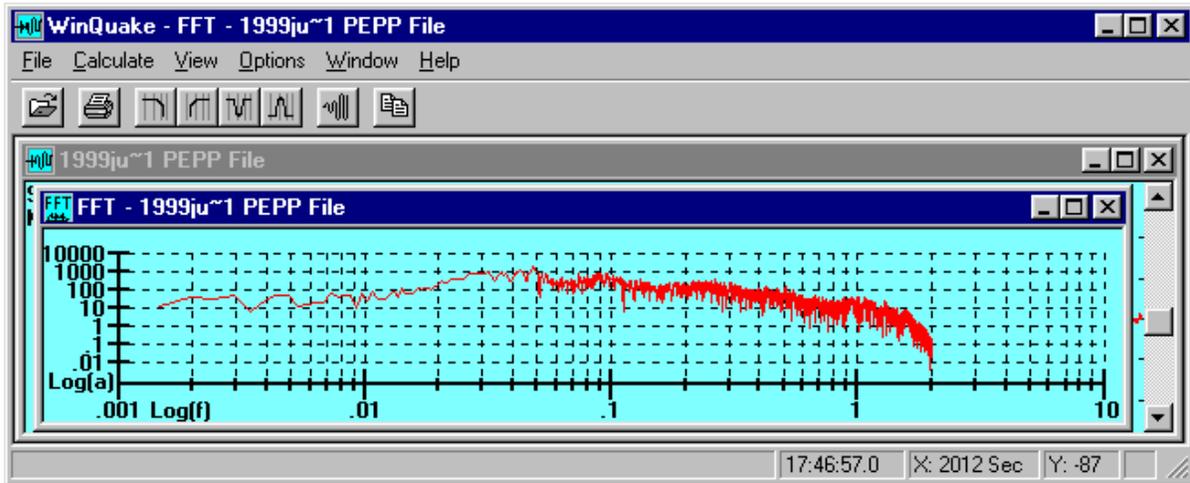
The horizontal scale can be changed by entering a new value in the **X-Scale** box or by selecting a region on the graph. The horizontal axis displays the UT of the data points. The **X-Scale** box shows the total number of seconds on the current display. This can range from 1 second up to the total time in the original sample. To select a region of the graph, locate the cursor at one side of the desired area. Double click and drag the vertical cursor to enclose the region of interest. To return to the original display choose **Reset** from the **View** menu or use the reset button  on the tool bar.

Filtering the Data

An important feature of WinQuakes that is not available on SWAP is the ability to filter data. This process of filtering is done to eliminate as much "noise" as possible from the seismogram in order to clearly identify events and pick out phases. If your data looks very noisy and cluttered beyond use, it still may contain valuable information that can be identified after filtering. Before the data can be filtered the file must first be analyzed to determine the frequency content. Applying a Fast Fourier Transform (FFT) to the data does this. From the **Calculate** menu select **Full FFT**, or use the  button on the toolbar.



The FFT will be calculated and a graph will show the frequencies of the vibrations recorded by the seismometer. Your screen will look somewhat like the one below. Note that the menu bar and tool bar buttons have changed. There is a new **Calculate** menu used to access the filters described next. If you choose **View FFT** or , the FFT will be shown but the filter menu will not be accessible.



Once the FFT has been calculated, filters can be applied to eliminate unwanted frequencies. WinQuakes has four different filters: high pass, low pass, notch and band pass. Each filter eliminates different frequency ranges and sometimes it's desirable to apply more than one get the "cleanest" seismogram.

high pass-  used to eliminate low frequencies. The lowest acceptable frequency is entered and the filter passes all frequencies higher than the cutoff.

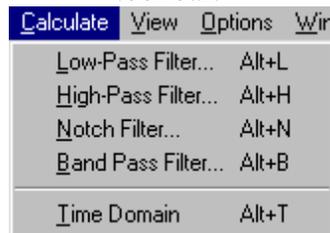
low pass-  used to eliminate high frequencies. The highest acceptable frequency is entered and the filter passes all frequencies lower than the cutoff.

notch-  used to eliminate a band of frequencies. A high frequency and a low frequency are entered and the filter removes all frequencies between the two limits.

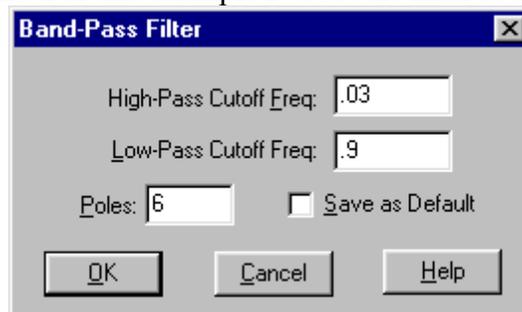
band pass-  used to eliminate frequencies above and below set limits. A high frequency and a low frequency are entered and the filter passes all frequencies between the two limits. Other frequencies are eliminated.

Experienced analysts can probably get the best results possible from the data relatively quickly but most of us are novices and will have to go through a process of trial and error to begin to get useful results. Use the following procedure to filter your data and you will begin to get a feel for how the process works:

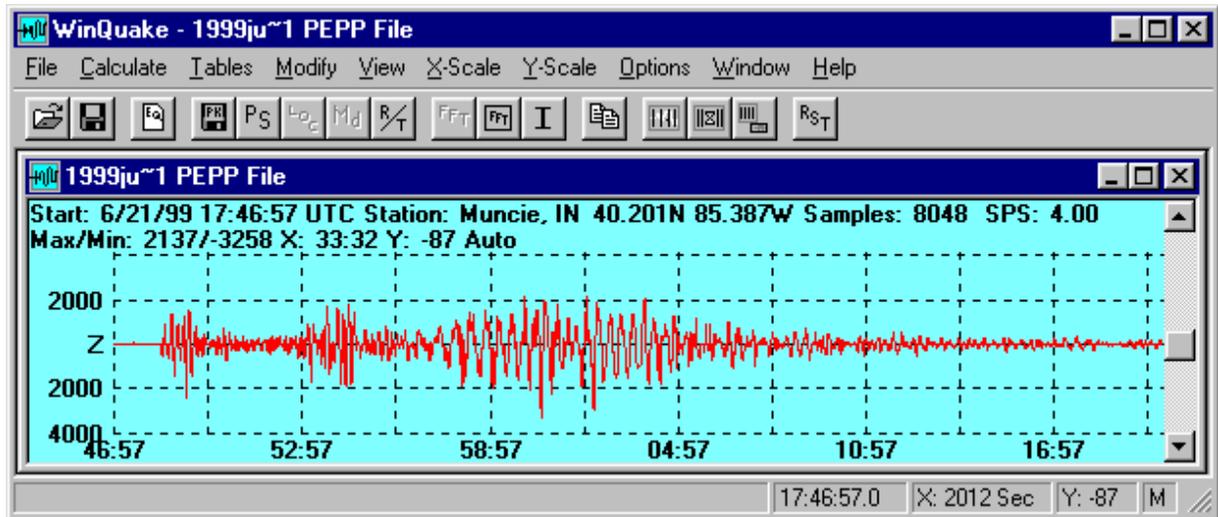
1. Open a seismogram in WinQuakes and examine the seismograph. With experience you may be able to gain some clues about which filter to use.
2. From the **Calculate** menu select **Full FFT**, or use the button on the toolbar . The FFT will be calculated and a graph will show the frequencies of the vibrations recorded by the seismometer.
3. Examine the FFT spectrum and try to determine the range of frequencies in your data that are most likely to have come from an earthquake.
4. Select a filter from the new **Calculate** menu or select the appropriate button from the tool bar.



It's probably not a bad idea at first to try a band pass filter and experiment with the limits to see what happens. For this example I've set the filter at the indicated limits.



5. After applying the filter you will get a new FFT showing the filtered spectrum. You will now need to do a reverse FFT. Select **Time Domain** from the **Calculate** menu or use the  button. This will produce the seismogram again with but with some frequencies removed. The result of using the filter is shown below. Although the change is not dramatic, some of the higher frequencies have been removed.



Once the reverse FFT has been applied you can't undo it. If you want to try something different with the original data you will need to close the file and reload it. However you can continue to work with the filtered seismogram. Note that the **FFT** button is blanked out in the screen above. In order to do additional filtering you will first need to close the FFT Window. (This may be hidden under the seismogram). The **FFT** button will now be active and the process can be repeated.

Remember that the data that was loaded originally has been modified. The new seismogram should be saved under a new file name in order to preserve the original data as well as the filtered data.

WinQuakes does not provide PEPP format for saving files so files saved in WinQuakes can't be uploaded to Princeton.

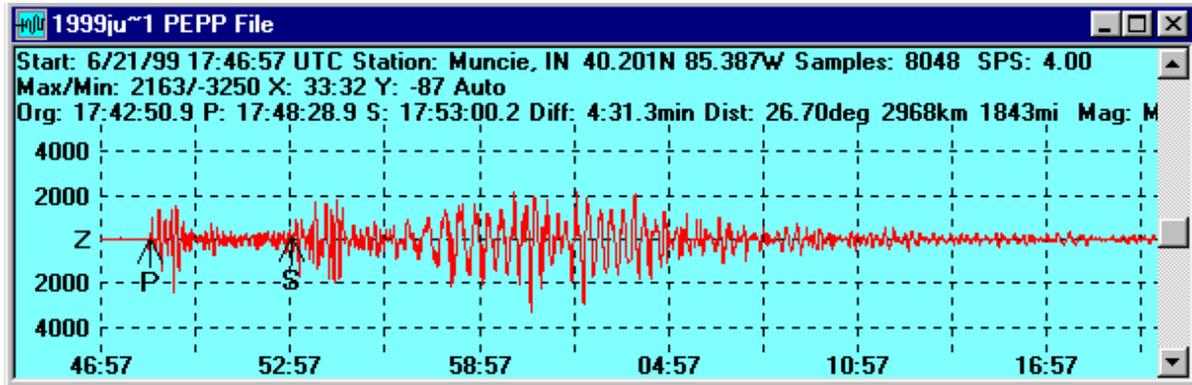
Locating Phases

The process of locating phases on the seismogram usually starts with identifying the arrival of the P wave and the S wave. WinQuakes lets the user pick both arrivals and then uses these choices to determine additional information about the event.

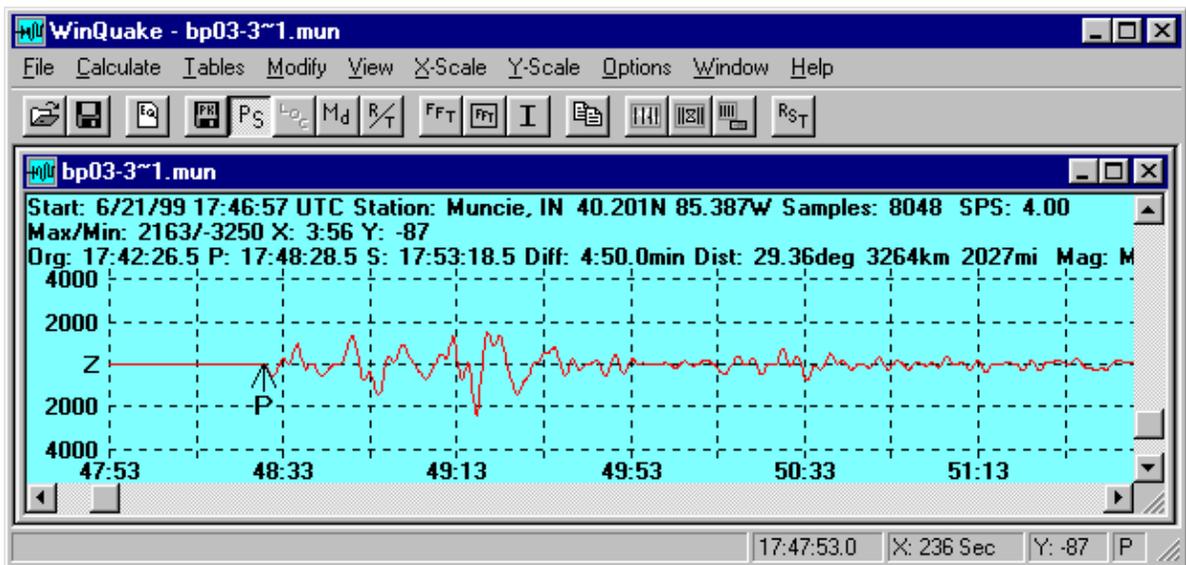
After opening the desired seismogram, select the **PS** button from the tool bar. Arrows labeled P and S will appear on the seismogram and a new line will appear in the text heading at the top. This line shows the P and S arrival time from the current locations of the pointers and information such as origin time and distance based on these locations. The values shown will change as the pointers are moved.

First locate the approximate Pwave arrival. Look for a distinct change in the seismogram above any background noise. Locate the P arrow at your arrow best estimate and then

repeat the process for the S wave. Remember that the S wave arrival is usually a stronger pulse arriving up to several minutes after the P wave. The exact determination of the arrival time is not critical at this point. Your seismogram should resemble the one shown below (small, for illustration only- a larger window would be used for your work).



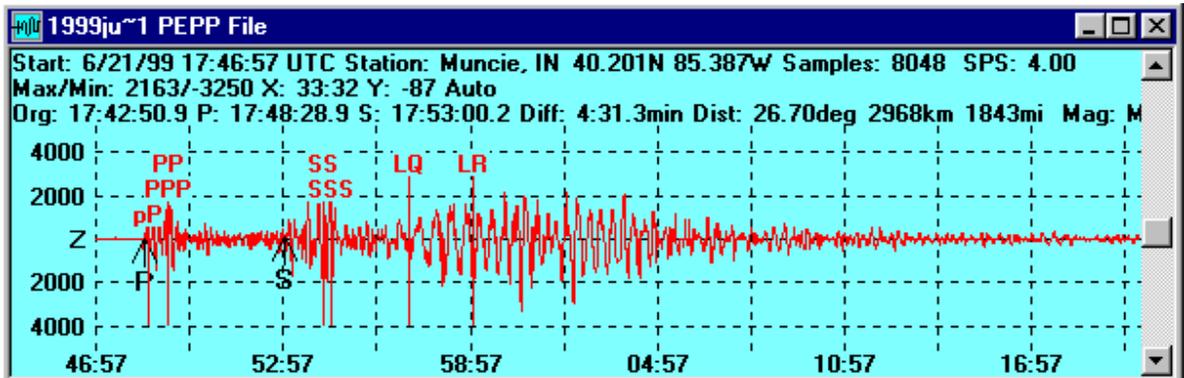
The P and S picks are only estimates at this point. Now choose **Lock P-S Markers** from the **Calculate** menu. This retains the relative positions of the pointers as the screen is expanded. The markers can still be moved, however, to pick new arrival times. In order to determine the arrival times more precisely select a region around the chosen P arrival and expand the view. Relocate the P wave marker to the selected P wave arrival. An example is shown below.



Repeat the process for the location of the S wave arrival. The text line will now display the new P and S arrival times and the calculated origin time, P - S interval, and distance to the event in degrees, kilometers and miles. After picking the arrival times the

seismogram may be returned to its original scale by choosing **X-Scale** and moving the slider all the way to the right.

WinQuakes can also be used to help identify other phases that may be present in the seismogram. Once the P and S arrivals have been chosen, other possible phases can be shown by selecting the  button from the tool bar. This will produce a display like the one shown next.



Selecting the  button from the tool bar shows a table of arrival times for the indicated phases.

Phase Times		
Origin	17:42:47.8	
P	17:48:28.5	340.7
pP	17:48:37.5	349.7
PP	17:49:14.7	386.9
PPP	17:49:16.2	388.4
S	17:53:01.8	614.0
SS	17:54:16.6	688.8
SSS	17:54:34.7	706.9
LQ	17:57:05.3	857.5
LR	17:59:08.6	980.8

Close Help

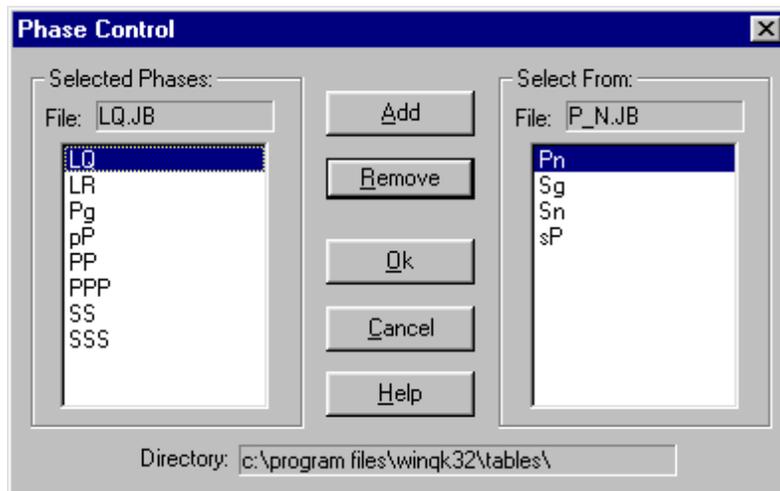
This table corresponds to the phases shown above.

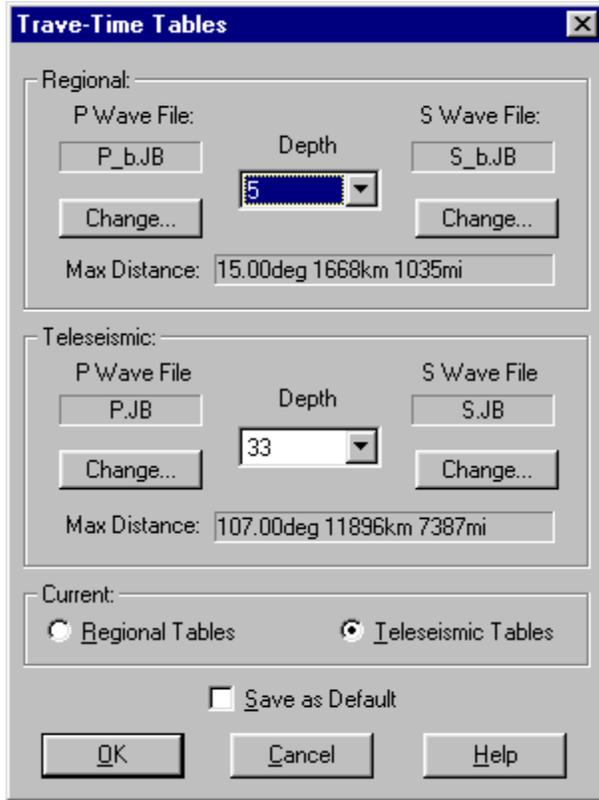
In order to determine the possible phases and arrival times WinQuakes use two tables and sets of files that must be selected correctly in order for the results to be reasonably reliable. Choosing **Tables** from the menu produces the following choices for selecting the best time-travel tables to be used in identifying possible phases:

1. First the appropriate table, Regional or Teleseismic, must be selected.
2. Next the approximate depth of the event must be chosen.
3. Finally there is a choice of possible phases to be displayed from different possible P and S wave files.

Switching between Regional and Teleseismic tables can be done quickly using the  button

if the other selections have been set. The phase control button  brings up the phase control menu which allows phases to be added or removed from phase files.





Obviously the reliability of the phase identifications depends upon several factors and should not be depended upon until the user has some experience in analyzing seismograms.

