Introduction to Phase Picking with *SeisGram2K*

Accurately identifying and determining the arrivals of seismic phases is one of the fundamental analysis routines in seismology. From event location to seismic tomography, arrival times of different phases (commonly called "picks" in the seismological community) form the basis of most advanced processing techniques and statistical analyses. In this exercise, we will learn to identify the arrivals of longitudinal (P) and shear (S) waves in local recordings of the Corinth Rift Laboratory Network. We will then use their arrival times to locate an earthquake.

Quick Installation

To install the software (note that you do not have to as we will be in a class with already-installed software):

1. Download and install the latest version of Java (here).
2. Download the latest version of SeisGram2K (a file called *SeisGram2KXX.jar,* where XX is the version number, e.g. *SeisGram2K80.jar)* from here.
3. Download the map *CRL_School_2023_map.tif* and the sample data archive *CRL_School_2023_pick_data.zip* from here and extract the included folder. The structure of the directory is *year/month/day/event_code/waveforms.*
4. You can now launch SeisGram2K by running the file downloaded in Step 2!

Exercise: Phase Picking & Event Location

The goal of this exercise is to pick the arrival times of P and S phases in at least three stations and then, find the epicenter of the earthquake. *SeisGram2K* can process popular seismic data types, such as SAC and MSEED. The waveform files used in the current exercise are named according to the following scheme:

`YYYY.JJJ.HH.MM.SS.ffff.NT.STAT.mseed`

The first part is comprised by the year (YYYY), Julian day (JJJ), hour (HH), minute (MM), second (SS) and decimal seconds (ffff) of the initial event's origin time. Then, the network (NT) and station (STAT) codes are specified. For example, the recording of an earthquake in station MG03 of the CRL seismological network (code CL) that occurred on 2019-03-03T22:05:54.4690 UTC is named:

`2019.062.22.05.54.4690.CL.MG03.mseed`

Each of these files contains recordings from more than one component.

To determine the phase arrivals:

1. Launch *SeisGram2K* and go to the directory of one of the four given events. Select a station that belongs to the CRL network.

HINT: To view a seismogram in *SeisGram2K*, go to File->Open File and then navigate to the desired waveform file. Remember, the naming convention mentioned above and the code for the CRL seismological network!

2. Prepare the waveforms by removing noise and other features that might obfuscate the arrivals of the two phases.

HINT: To "clean up" the to-be-analyzed waveforms, two preparatory actions are taken: (a) we remove the trend of the signal and (b) filter out noise. To remove the trend, go to Tools->Time domain and then select RemTrend. If they were not before, waveforms should now be centered around the zero of the amplitude axis. To apply a filter, go to Tools->Filter, then select then select Butterworth. Use a low frequency of 1.0 Hz and a high frequency of 10.0 Hz.

3. Determine the arrivals of the P and S waves. What are their arrival times?

HINT: Select the Pick option at the top left of the window (third row of the toolbar). Select the phase type to be picked from the leftmost drop-down menu (e.g. P). Then, click on the point of arrival in the waveform (a vertical line will appear) and press the Set button. The arrival time will be shown at the command window, near the bottom, e.g.

MG02 HHZ CL ? Z ? P ? ? 20190303 2205 56.267 +/- 0.000s Amp: 30.28098

The arrival time is `20190303 2205 56.267` (year, month, day, hour, minute, second). If the S arrival is picked after the P one, another line will show the difference in the arrival times:

Ts-Tp=1.458s

4. Find the epicentral distance at the station, from the T_s-T_p time. How far away from the earthquake's epicenter is each station?

HINT: Use the travel-time curves tool to estimate the epicentral distance. The tool can be accessed from the icon, located at the second row of the toolbar. Using the left mouse button, you can drag a horizontal bar until the T_s-T_p at the top is the one measured. The `dist` field shows the epicentral distance (in km).

5. Repeat Steps 2 through 4 for two more stations.

6. On the given map, which you must have printed, draw a circle around each station, corresponding to the epicentral distance estimated. What are the coordinates of the earthquake's epicenter?

HINT: First, convert the epicentral distance from km to map-length (cm), according to the given scale. Then, draw a circle around each station, with the radius equal to the epicentral distance. The epicenter should be located at the center of the locus formed by the section of the three circles. You can now find the coordinates (in decimal degrees) using the map's grid.

Triangulating the location by using travel-time curves is one of the simplest (and least accurate) methods to find the position of an earthquake. Modern location techniques involve sophisticated software that use tens or hundreds of phase arrivals.