GEOL100 Homework #2, Fall 2008

Cause of the Mogul, Nevada, earthquake swarm, Spring 2008

**INTRODUCTION**

In this homework assignment, you will examine seismicity related to: (1) a typical fault-generated earthquake sequence, the February, 2008 Wells earthquake, and (2) a typical volcanic-generated earthquake sequence at Mt. St. Helens. For each of these, you will describe the distribution of earthquakes on the ground surface and at depth in the earth, and look for characteristics that are unique to each kind of earthquake. You will also look for distinctive patterns in the size or depth of the earthquakes with time, again to establish criteria for determining the *cause* of seismicity.

You will then look at seismic records from the “Mogul earthquake swarm” in Spring, 2008, and determine whether it looks like it was generated by faulting or by volcanic activity. Finally, what about the Mogul earthquake swarm is unusual?

**FAULT-GENERATED EARTHQUAKES**

Earthquakes produced by slip along a fault are typically followed by smaller earthquakes (“aftershocks”) produced as the crust surrounding the fault plane adjusts to the displacement. Aftershocks usually occur along the full length of the fault rupture, and may be along the fault plane itself or in a zone around it. For example, see the map (Fig. 1) and cross-section (Fig. 4) of the earthquakes that followed the February, 2008, earthquake near Wells, Nevada, as well as the depth range (Fig. 2) and 10-day plot of earthquake magnitude vs. time (Fig. 3).

To see 3D animation: http://www.seismo.unr.edu/feature/2008/wells3D.avi

If you would like to see more about the Wells EQ sequence, go to the Nevada Seismological Lab (NSL) website:http://www.seismo.unr.edu/feature/2008/wells.html

Include the answers to these questions about the Wells earthquake data in your report: 1) What is the map pattern of earthquakes related to the Wells earthquake? (What is the direction and length of the longest dimension of the earthquake distribution on the map? … the shortest dimension?)

2) What kind of slip surface (and what depth range) do the earthquakes show below the ground surface? (i.e., is it a plane? a wide zone? A cylinder? vertical? tilted?)

Using these answers, describe the fault plane that moved during the earthquake.

3) How did the magnitude and frequency of earthquakes change with time for the

first ten days?

**MAGMA-GENERATED EARTHQUAKES**

Earthquakes generated as magma moves toward the surface prior to (or associated with) a volcanic eruption typically start deep in the crust (10 – 15 km) and get shallower as the magma moves upward. For example, see the map (Fig. 5) and cross-section (Fig. 6) of earthquakes associated with the 1998 – 2008 volcanic activity at Mt. St. Helens, WA for the last decade, which includes an eruption event (below). A plot of earthquakes depths with time for 1980 – 1998 (Fig. 7) shows the deep-to-shallow pattern associated with magma moving up through the crust. It also shows magma moving up to a shallow magma chamber (about 2 km depth) but not to the surface.

Go to USGS http://vulcan.wr.usgs.gov/Volcanoes/MSH/framework.html if you would like to see more about earthquakes and volcanic activity at Mt. St. Helens.

Include the answers to these questions about Mt. St. Helens EQ data in your report:

1) What is the map pattern of the 1998-2008 earthquakes? How large an area do

they cover?

2) Over what depth range do they occur?

3) Using these answers, what is the three-dimensional shape of the 1998-2008 earthquake sequences?

4) How is this pattern different from the three-dimensional pattern of earthquakes

related to motion along a fault?

5) What is distinctive about the depth/time pattern of earthquakes related to volcanic activity?

**THE MOGUL EARTHQUAKE SWARM**

The reason for the earthquakes measured near Mogul, Nevada, in the spring

and early summer of 2008 was initially puzzling to seismologists and geologists

because the distribution of the earthquakes (in space and in time) did not closely follow

either of these typical patterns. A map of the earthquake epicenters is below (Fig. 8). Well over 2000 earthquakes were recorded during the Mogul earthquake swarm (most of

these were too small to be felt), and all were relatively shallow (see depth plot, Fig. 9).

The largest earthquake in the swarm, a magnitude 4.7 on April 25, occurred almost two months after the start of the activity (see magnitude vs. time, Fig. 10).

Watch the animation of how the earthquake swarm developed at: http://www.seismo.unr.edu/feature/2008/Animation\_mogul.avi

An interactive plot of 3-dimensional distribution of these earthquakes, on the NSL

website is even more informative. Rotate the plot in order to see the 3-D distribution of

the earthquakes.

Include the answers to these questions about the Mogul EQ data in your report:

 1) What is the map pattern of the Spring, 2008 Mogul earthquakes? (How large an area do they cover? What is the direction and length of the longest dimension of the earthquake distribution on the map?)

 2) What depth range do they cover?

 3) Using these answers, what do you think is the cause of the Spring 2008 Mogul earthquake swarm? Give at least two reasons that support your answer.

4) Finally, what are two observations about the Mogul swarm that are not consistent with other, more typical, earthquakes of this type?

You should turn in: A short write-up in the usual format.

Part of your grade (as always) is based on correctly distinguishing data from interpretation.

Do not expect the grader to search through your report to find everything! Since you will be describing three different earthquake sequences in your report, be sure to distinguish between them very clearly – e.g., bold headings for your outline or paragraphs, and the same kinds of data, presented in the same order, for each event. For example:

A. Wells earthquakes

Observations

1. map pattern

2. depth pattern

3. magnitude vs. time

4. depth vs. time

Interpretations

1.

2.

B. Mt. St. Helens

Observations

1. map pattern

2. depth pattern

3. magnitude vs. time

4. depth vs. time ...

NOTE: All of the figures for this assignment will be posted in color on WebCampus. Most of them are much easier to read that way, so I recommend that you look at the color versions while you are working on this project.

Fig. 1: Map of Wells earthquake and aftershocks

Fig. 2: Depth distribution of Wells earthquakes and aftershocks

Fig. 3: Magnitude of Wells earthquake and aftershocks vs. time

Fig. 4: Cross-section of Wells earthquake and aftershock locations

Fig. 5: Map of Mt. St. Helens earthquake distribution

Fig. 6: Depth distribution of Mt. St. Helens EQs, S-N and E-W lines

Fig. 7: Depth of earthquakes at Mt. St. Helens, 1980 – 1998; note deep-to-shallow pattern

associated with magma moving upward through the crust

Fig. 8: Mogul earthquake locations Feb. 28 – August 1, 2008

Fig. 9: Depth of earthquakes at Mogul, spring, 2008

Fig. 10: Magnitude of Mogul earthquakes vs. time

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