"Under Pressure" ©1982: A Comparison of Stress Field Orientations Between Geothermal Areas and Volcanic Regions.

Denine Calvin and Heather Lehto, PhD

Abstract

The emphasis of this research is to determine local stress field orientation in geothermal areas that are unrelated to volcanic activity. I will be concentrating on Dixie Valley, Nevada, using data obtained from public databases to compute fault plane solutions. From this I believe I will find that the local stress field is aligned with the regional stress field. Through my research I hope to determine the orientation of the local stress field in nonvolcanic settings in hopes of applying this to volcanic areas to better understand the local volcanic stress fields observed during quiescent times. My research will also find if stress field orientation changes over time, either naturally or through injection. I will complete my research from August of 2014 through to December 2014.

*****

Introduction

Dixie Valley is one of the largest geothermal plants in the Basin and Range Province, located within Churchill County (Fig. 1) between the Stillwater and Clan Alpine Ranges of Nevada. Its flow system is related to normal faulting and permeability of country rock formed through extensional tectonics. The Dixie Valley Basin is approximately 20 kilometers long and is asymmetrical in shape. It is the lowest topographical valley in Northern Nevada and is located within the Central Nevada Seismic Belt, which trends north-northeast through central Nevada (*Hickman*, 1998). The stratigraphy of the area from youngest to oldest consists of: Quaternary basin fill sediments, Tertiary basalts and silicic volcanics, Cretaceous intrusive Granodiorite, Jurassic Boyer Ranch quartzite atop the Humboldt Igneous Group, and then Triassic Meta Sediments (*Blackwell*, 2007).

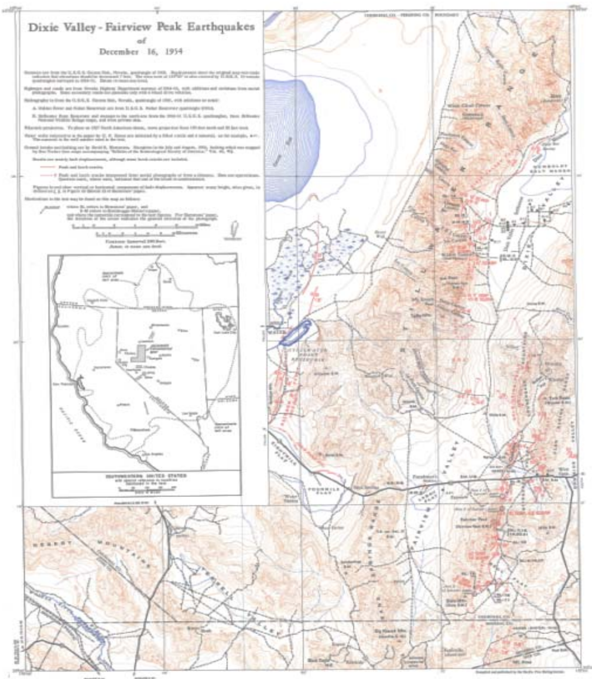


Fig 1: Dixie Valley location map. (*Torcher*, 1957)

Mount Saint Helens' seismicity has been closely monitored for over thirty years. In these thirty years, it has been shown that the stress field orientation changes (by about 90°) from quiescent periods to active periods. Since the cataclysmic eruption in 1980 (*Lehto*, 2013), the changes in stress field orientation have been linked to changes in volcanic activity (*Lehto*, 2013). Right after the eruption, stress field orientation was NE-SW (*Barker and Malone*, 1991) due to inflation of a shallow dike (*Lehto*, 2013). From 1987-1992 (quiescence), stress field orientation was shown to be SE-NW and NE-SW. It has been theorized that it is due to area faulting changing from normal to reverse and/or strike slip (*Lehto*, 2013). It could also be due to natural pore pressure changes which are masked during heightened activity of the shallow dike. As this has not been definitively explained, I plan to use my findings from a nonvolcanic area to explain this duality. With my research, I may be able to attribute the dual stress field orientations during quiescence as being due solely to pore pressure changes and that the NE-SW orientation during eruptive periods is due to volcanic activity.

Methods

For this project I studied a geothermal area that is not associated with volcanic activity. I used data freely obtained from Incorporated Research Institutions for Seismology (IRIS) to determine the orientation of the local stress field. Magma intrusions change the local stress field at active faults and trigger earthquakes (*Lehto et al 2013*). By applying this knowledge to geothermal areas, we can understand the influence of hydrothermal fluids on the local stress field.

I used open source seismological software on the existing computers in the Physics and Geology Department in the analysis of said data with the hope of using information gained to test my hypotheses. Analysis of the changes in local stress field can be used to forecast impending volcanic eruptions.

Objective 1:

Pick and relocate earthquakes. Relocation uses known arrival times to estimate the location of hypocenters.

Objective 2:

Compute and analyze fault plane solutions. Fault plane solutions represent slip on a fault and the pressure and tension axes represent the axes of maximum shortening and extension, respectively. In computing a fault plane solution, scientists use the principle that motion on a fault controls the pattern of seismic wave radiation (*Anderson*, 2013). This motion is distributed into four quadrants in which the motion is alternately push (up) or pull (down). The pressure and tension axes of the FPS can then be used as a proxy for the local stress field.

Objective 3:

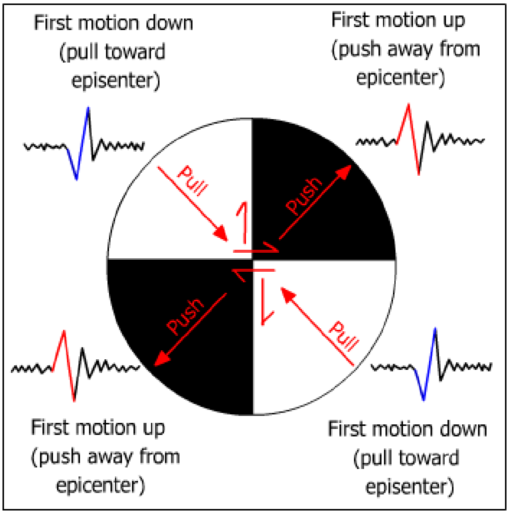
Analyze any changes in orientation of local stress field with time and compare to the orientation of the regional stress field.

Hypothesis 1:

My hypothesis is that the local stress field at Dixie Valley is due to pore pressure changes and that is aligned with the regional stress field, which is oriented E-W (*Hodgkinsons and Stein*, 1996).

Hypothesis 2:

The local stress field is due to pore pressure changes but is not aligned with regional stresses.



Results and Discussion

The purpose of this research was to determine the orientation of the stress field in Dixie Valley, apply the information gained to the Mount Saint Helens area known stress field orientation during quiescence in order to understand why its fault plane solutions change and "behave" the way that they do during inactivity.

I was able to obtain data for 121 earthquakes, mostly from IRIS. Of these, only 51 had at least 3 phases. Unfortunately, many of the phases were for stations that were collocated and were essentially one data point. This meant that most of the earthquakes were not locatable and my research came to a screeching halt. If my research were continued I would suggest finding locally recorded data and not regionally located data.

References

Barker, S. and Malone, S., 1991 "Magmatic System Geometry at Mt St Helens Modeled From the Stress Field Associated with Post Eruptive Earthquakes." *Journal of Geophysical Research-Solid Earth and Planets* 96, 11883-11894.

Blackwell, David, Smith, Richard and Richards, Maria, 2007 "Exploration and Development at Dixie Valley, Nevada. A Summary of DOE Studies" *Geothermal Reservoir Engineering*.

Hickman, Stephen, Zoback, Mark and Benoit, Richard, 1998 "Tectonic Controls on Reservoir Permeability in the Dixie Valley, Nevada Geothermal Field" *Geothermal Reservoir Engineering*, 291-298.