



Student Handout 3
Earthquakes and Gas Wells: Correlation vs. Causation
Webquest Instructions

Directions: Use the web or print resources provided to answer the following questions. You will record your findings on a separate research results sheet.

1. Natural Gas Wells and Earthquake Frequency---State data

- A. Go to: https://www.eia.gov/dnav/ng/hist/na1170_sar_8a.htm
- B. Describe the trend in number of Natural Gas wells from 1990 to 2012.
- C. Identify two periods which saw a sharp increase in the total number of Natural Gas wells in Arkansas.

<https://www.geology.arkansas.gov/geohazards/earthquakes-in-arkansas.html>

Scroll down to Arkansas Earthquake Archive 1699 - 2021 and download the file here:

https://www.geology.arkansas.gov/docs/xl/geohazards/EarthquakeArchive1699_2021.xlsx. This Excel files as posted on the website have reference and title information which may make it difficult to sort the columns. If needed, ask your teacher for access to a spreadsheet in which the title and reference data have been removed. Open this sheet, click a column to sort, click the Data tab, then sort as needed. Students can sort by date, magnitude of quake, county, etc.)

- D. Use the data to determine the number of magnitude 3 or greater earthquakes in Arkansas each even year period from 1990 to 2012 and 2011. You may want to create a graph for ease of comparison.
- E. Compare the earthquake data to the number of gas wells.
- F. Does the evidence show an overall correlation between the natural gas wells and the number of earthquakes in Arkansas? Look specifically at the two periods of sharp increase in total numbers of wells. Was there a correlation between increased drilling and earthquakes?
- G. What county accounted for the largest number of earthquakes from 2011 to 2012?
- H. Does this data prove that natural gas wells are the cause of increased earthquake activity in Arkansas? Explain.

2. Natural Gas Wells and Earthquake Frequency---County data

Go to:

http://www.solarplan.org/documents/Well%20Production%20Profiles%20for%20the%20Fayetteville%20Shale%20Gas%20Play%20Revisited_Mason_9%20April%202012.pdf. Find the graph entitled “Annual number of Wells Completed by County” on page 12.

<https://encyclopediaofarkansas.net/entries/fayetteville-shale-6011/> Counties in the Fayetteville Shale Play.

The Fayetteville Shale Play is a reservoir of natural gas 50-550 feet below the surface. Hydraulic fracturing is used to access the natural gas and bring it to the surface. Hydraulic fracturing is a process which pumps millions of gallons of water, sand and chemicals underground to make tiny fissures (cracks) in the rock to release the gas.



- A. Compare the bar graph showing the number of wells by county and the Earthquake Epicenter Map.
- B. Describe the relationship between the number of wells and the number of earthquakes on a county by county basis?
- C. Do these graphs and maps suggest a correlation between hydraulic fracturing in the Fayetteville Shale Play and the concentration of earthquakes in the area? Explain.

3. Injection wells in Fayetteville Shale Play and South West Arkansas Oil Fields

Go to: <http://www.aogc.state.ar.us/maps/googleEarth.aspx>

Follow the instructions on this page to download Commercial and Fayetteville Shale Class II Disposal Wells and (If you do not have Google Earth you will need to conduct the free download)/

Look at the cluster of gas wells in central Arkansas and the cluster of oil wells in Southwest Arkansas. With Google Earth you will be able to zoom in on individual wells and obtain data as to which are oil, gas, or injection wells.)

Go to: <https://www.geology.arkansas.gov/geohazards/earthquakes-in-arkansas.html> Scroll down and download Arkansas Earthquake Archive

Some of the water used during the hydraulic fracturing process is recycled, some is returned to its original location, but a large amount of the water is disposed of permanently in injection wells. This waste water is pumped into underground rock formations far below freshwater supplies. Injection wells are also used to store waste water from oil wells underground.

- A. Determine the number of injection wells by county in both the Fayetteville Shale Play and the South West Arkansas oil fields.
- B. Determine the number of magnitude 3 or greater earthquakes (from 2002 to 2011) in the counties where injection wells are located.
- C. Have all counties with injection wells had the same number of earthquakes?
- D. Do these maps and earthquake data suggest a correlation between the number of injection wells and the occurrence of earthquakes? Explain.

4. Earthquakes and Fault lines in the Fayetteville Shale Play

Go to: http://www.gis.arkansas.gov/Docs/GISB/2014/20140305_Attachment1.pdf or search the internet using: Permanent Disposal Well Moratorium Area

https://www.geology.arkansas.gov/docs/pdf/maps-and-data/geohazard_maps/arkansas-seismicity-map.pdf

and search for: Three Centuries of Earthquakes in Arkansas

- A. Record the number of injection wells located on the map outlining the permanent disposal well moratorium.
- B. Name the injection wells located closest to the concentration of earthquake activity.
- C. What do the yellow circles on the “Three Centuries of Earthquakes in Arkansas” map represent?
- D. In which Fayetteville Shale Play county are the yellow circles located? Does this agree with data discovered in step 1 of this web quest?



- E. Consider only the earthquakes in the central part of the state. Record the number of 4.0-4.9 earthquakes by year.
- F. What do these maps and data tell you about the age of the faults found in the Fayetteville Shale Play?
- G. Do these maps and data show a correlation between injection wells and earthquakes?
- H. Do these maps and data show a correlation between faults and earthquakes?
- I. Do these maps and data indicate a cause for the increase in earthquakes in the Fayetteville Shale Play?

The cluster of earthquakes between Holland and Mount Vernon on the Disposal Well Moratorium Area map is located at Enola, Arkansas.

Go to:

https://www.geology.arkansas.gov/docs/pdf/maps-and-data/geohazard_maps/central-arkansas-media-map.pdf or search the internet for Enola Swarm Map Area.

- J. What was the Enola Swarm and when did it occur?
- K. Based on all the evidence you have collected, is the Enola Swarm correlated to the increase in natural gas wells drilled between 2010 and 2012? Explain.
- L. L. How does the map of the Enola Swarm area help you determine the cause of the drastic increase in earthquakes in Faulkner County (middle of the Fayetteville shale play) during the years 2010-2012?

5. Analysis: The data you have examined show several correlations. These correlations do not necessarily indicate causation. After examining the data, what is the most likely cause of the increased number of earthquakes in the Fayetteville Shale Play during 2011? Support your claim with evidence. Be prepared to share your conclusions with the class.