

# PRELIMINARY REPORT ON THE NORTHSTAR #1 CLASS II INJECTION WELL AND THE SEISMIC EVENTS IN THE YOUNGSTOWN, OHIO AREA

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Management

# PURPOSE AND SCOPE OF THE REPORT

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- ❑ Site characterization and geology
  - ❑ History of Ohio's Class II injection program
  - ❑ Permitting and drilling history of the Northstar Class II wells
  - ❑ Brief history of seismic monitoring
  - ❑ Preliminary interpretation of the data
  - ❑ Evaluation of the data and downhole testing
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# SEISMICITY

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- Seismicity induced by human activities has been well documented
  - Associated with mining, lake filling, geothermal energy-related injection, oil and gas production activities, and injection disposal operations
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# FUNDAMENTAL QUESTIONS OF INDUCED SEISMICITY (FROM DAVIS AND FROHLICH, 1993)

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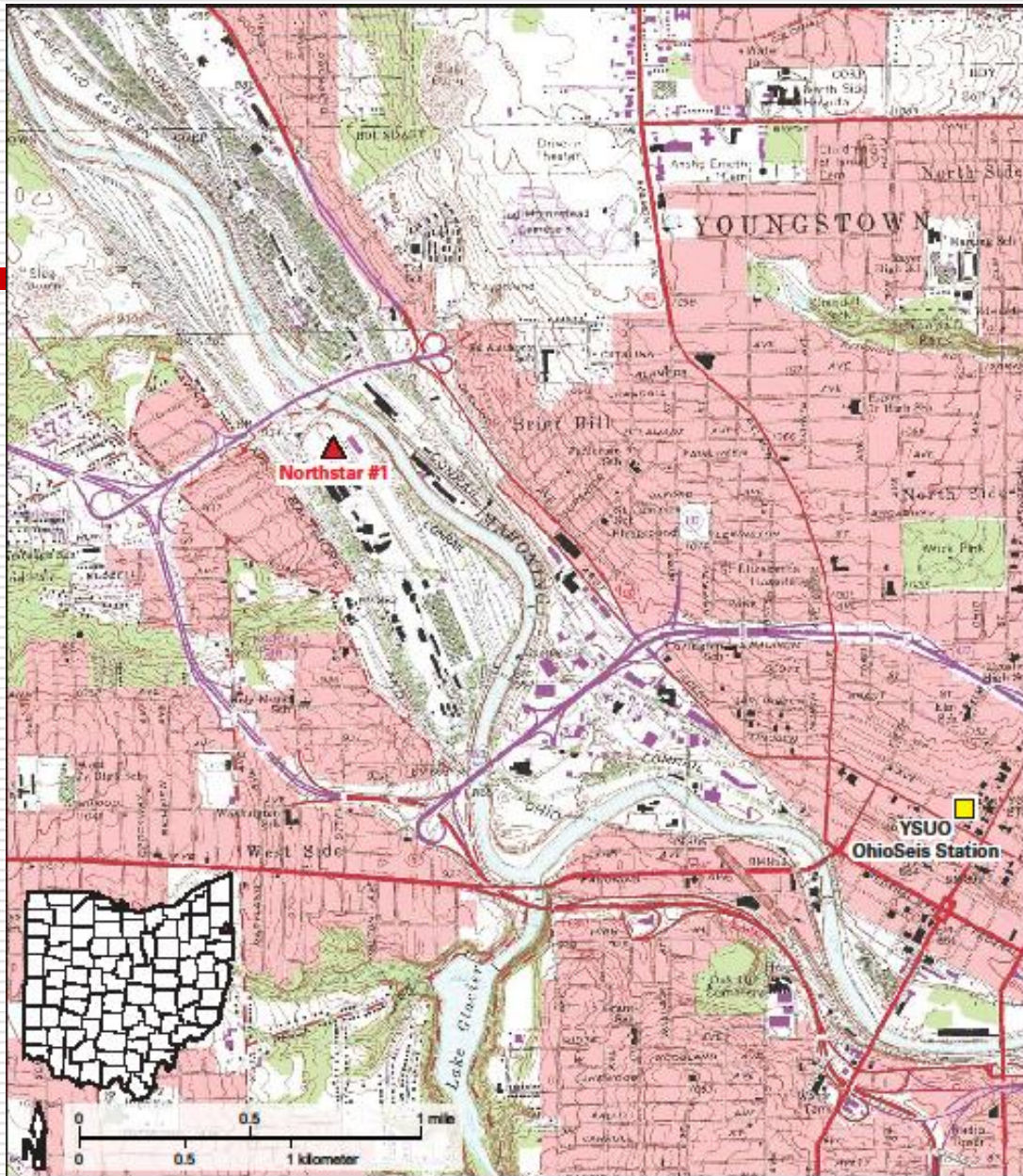
- ❑ Are the events the first known earthquakes of this character in the region?
  - ❑ Is there a clear correlation between injection and seismicity?
  - ❑ Are epicenters near wells (within five kilometers)?
  - ❑ Do some earthquakes occur at or near injection depths?
  - ❑ If not, are there known geologic structures that may channel flow to the sites of earthquakes?
  - ❑ Are changes in fluid pressure at well bottoms sufficient to encourage seismicity?
  - ❑ Are changes in fluid pressure at hypocenter location sufficient to encourage seismicity?
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# WELL LOCATION

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- ❑ The Northstar #1 injection well is located in an industrial district of NW Youngstown in Mahoning County, Ohio
- ❑ Well site is on a reclaimed iron foundry





# NORTHSTAR #1 WELL

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- ❑ Original drilled as a stratigraphic test – first deep well in Mahoning County
- ❑ Drilled to 9184 feet on April 13, 2010
- ❑ Permit to convert to Class II injection issued on July 12, 2010
- ❑ Injection commenced on December 22, 2010

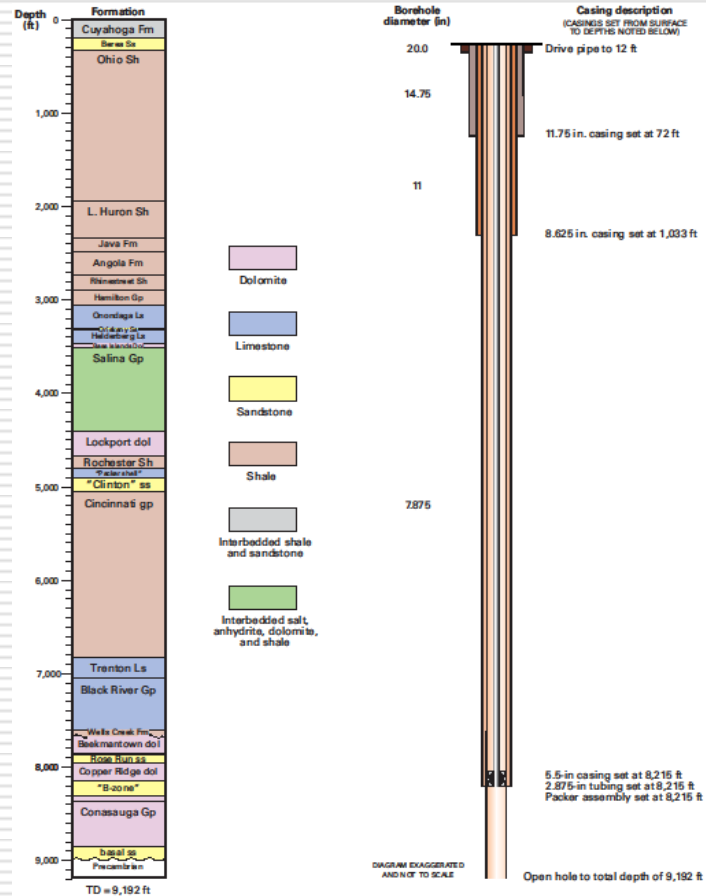


# INJECTION WELL PERMIT

DEPARTMENT OF NATURAL RESOURCES		RESOURCES MANAGEMENT WELL PERMIT		API WELL NUMBER 34-099-2-3127-00-00	
OWNER NAME, ADDRESS D & L ENERGY INC (Owner # 2851) 2761 SALT SPRINGS RD YOUNGSTOWN OH 44502			DATE ISSUED 7/12/2010	PERMIT EXPIRES 7/12/2011	
			TELEPHONE NUMBER	(330) 792-9524	
IS HEREBY GRANTED PERMISSION TO: <input checked="" type="checkbox"/> Comm/ <input type="checkbox"/> Water Injection - <input type="checkbox"/> Oil/gas			AND ABANDON WELL IF UNPRODUCTIVE		
COMPLETION DATE IF PERMIT TO PLUG:					
DESIGNATION AND LOCATION:			SURFACE NAD27	TARGET NAD27	
LEASE NAME NORTH STAR(SBWM #10)			X: 250822		
WELL NUMBER 1			Y: 634715		
COUNTY MAHONING			LAT: 41.12934		
CRUS. TOWNSHIP YOUNGSTOWN			LONG: -80.88301		
TRACT OR ALLOTMENT					
SURFACE FOOTAGE LOCATION 3379L & 4380DL OF TWP					
TARGET FOOTAGE LOCATION					
TYPE OF TOOLS: Air Rotary/Fluid Rotary			GEOLOGICAL FORMATION(S):		
PROPOSED TOTAL DEPTH 9104 FEET			KNOX-PRECAMBRIAN		
GROUND LEVEL ELEVATION 857 FEET					
SPECIAL PERMIT CONDITIONS: Salt Water Injection Well (Class II) Construction and Operating Conditions					
CONDITIONALLY APPROVED CASING PROGRAM (SUBJECT TO APPROVAL OF THE OIL AND GAS WELL INSPECTOR):					
CASING IN HOLES:					
8-5/8" - 1010					
3-1/2" CASING 8215' CEMENTED TO A MINIMUM OF 300' ABOVE INJECTION ZONE					
3-3/8" TUBING @ #140 SET ON A PACKER @ 75' ABOVE INJECTION ZONE					
This permit is NOT TRANSFERABLE. This permit, or an exact copy thereof, must be displayed in a conspicuous and easily accessible place of the well site before permitted activity commences and remain until the well is completed. Ample notification to inspector is necessary.					
OIL AND GAS WELL INSPECTOR:			FIRE AND EMERGENCY NUMBERS:		
ROBERTS CARL (330) 451-9424			FIRE: ( ) - 911		
WAYNE SCHALK - Supervisor (330) 284-7830			MEDICAL SERVICE: ( ) - 911		
DISTRICT: (330) 222-1827					
INSPECTOR NOTIFICATION					
The oil and gas inspector must be notified at least 24 hours prior to:					
1. Commencement of site construction					
2. Pit excavation and closure					
3. Commencement of drilling, reworking, cementing or plugback operations					
4. Indentment and cementing of all casing strings					
5. BOP testing					
6. Well abandonment					
7. Plugging operations					
The oil and gas inspector must be notified immediately upon:					
1. Discovery of defective well construction					
2. Ejection of any natural gas or H <sub>2</sub> S gas during drilling in urban areas					
3. Discovery of defective well construction during well abandonment					
4. Determination that a well is a lost well					
5. Determination that a well is a dry hole					
			John F. Husted CHIEF, DIVISION OF NATURAL RESOURCES MANAGEMENT		

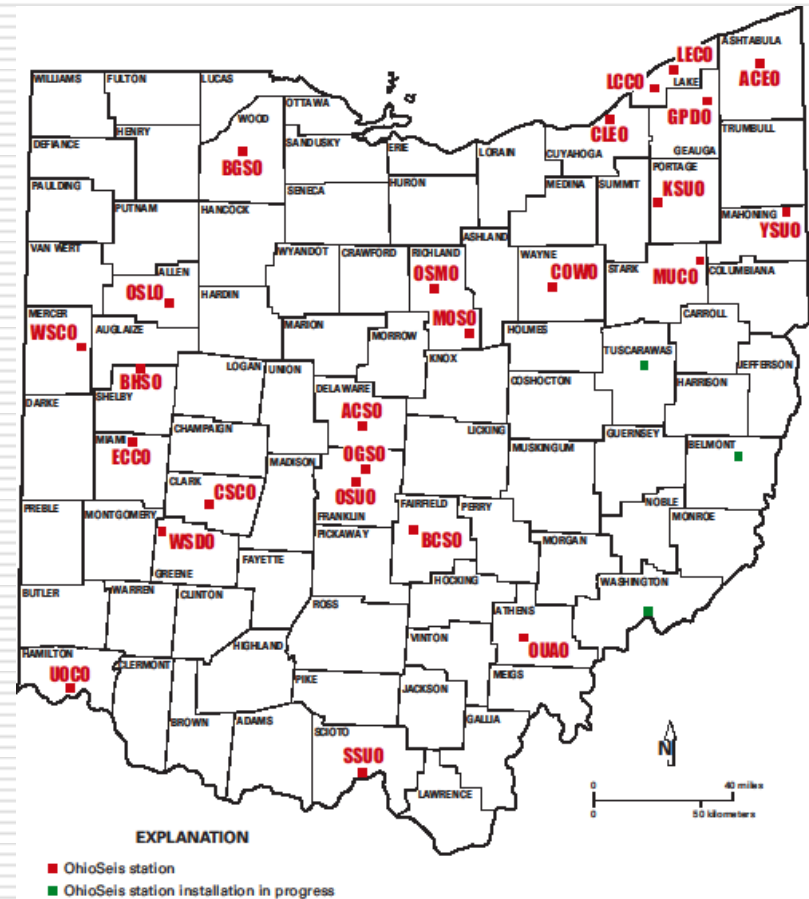


# WELL CONSTRUCTION



# OHIO SEISMIC NETWORK

- Historically, seismic monitoring in Ohio was sporadic and seismic events below 3.0 were not accurately determined prior to 1999
- In 1999, Ohio Seismic Network was established
- Now have 29 stations established
- Youngstown State station joined the network in 2003



# MAP OF EARTHQUAKES IN OHIO



# SEISMIC EVENTS

- The first two seismic events happened on March 17, 2011
- Magnitude of 2.1 and 2.6
- Ten additional events occurred with the 4.0 event occurring on December 31, 2011

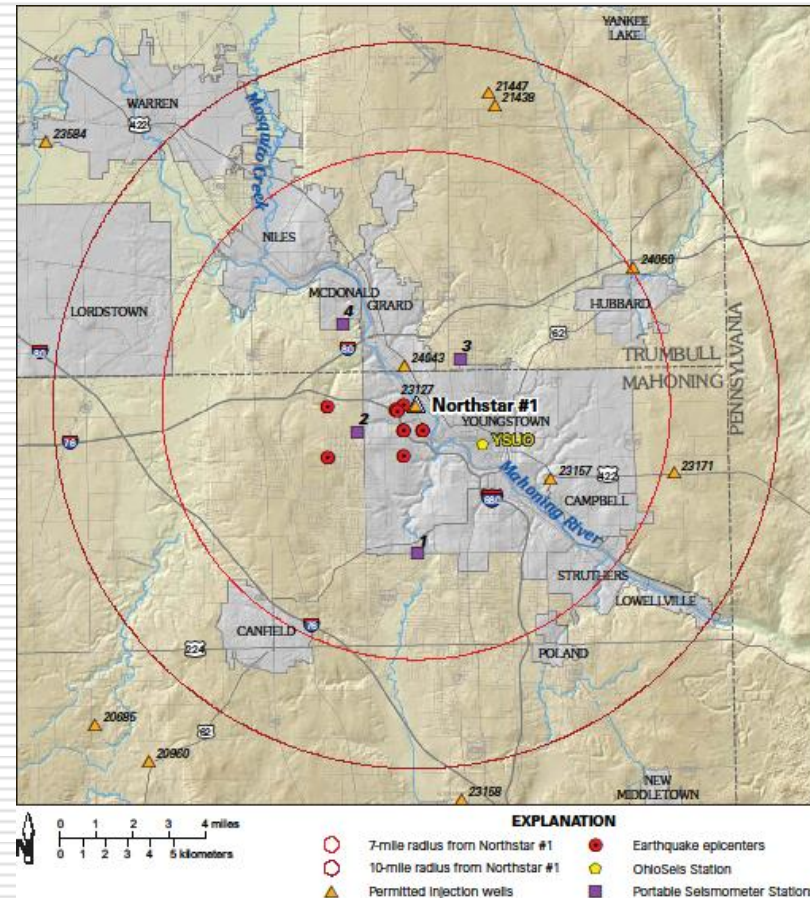


TABLE 5. — *Seismic events in Youngstown, Ohio, area recorded by the Ohio Seismic Network*

DATE	ORIG. TIME UTC	EPICENTER	MAGNITUDE	FELT
Mar. 17, 2011	10:42:20.22	41.11, -80.70	2.1	Not Felt
Mar. 17, 2011	10:53:09.51	41.11, -80.68	2.6	Felt (27 reports)
Aug. 22, 2011	08:00:31.50	41.12, -80.73	2.2	Not Felt
Aug. 25, 2011	19:44:20.99	41.10, -80.71	2.4	Not Felt
Sept. 02, 2011	21:03:26.20	41.12, -80.69	2.2	Felt (few)
Sept. 26, 2011	01:06:09.82	41.11, -80.69	2.6	Felt
Sept. 30, 2011	00:52:37.58	41.11, -80.69	2.7	Felt (300 reports)
Oct. 20, 2011	22:41:09.54	41.11, -80.68	2.3	Not Felt
Nov. 25, 2011	06:47:26.58	41.10, -80.69	2.2	Not Felt
Dec. 24, 2011	06:24:57.98	41.119, -80.694	2.7	Felt (90 reports)
Dec. 31, 2011	20:04:59.03	41.118, -80.693	4.0	Felt (more than 4,000)
Jan. 13, 2012	22:29:33.45	41.11, -80.69	2.1	Not Felt

# SUBSURFACE TESTING

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- After the September seismic events downhole testing was performed on the Northstar #1 injection well
- In October, a tracer survey was conducted and indicated that injection fluids were entering 26 multiple injection zones from 8215 to 8940 feet
- Requirement to plug back the Precambrian with cement
- Division of Oil and Gas Resources Management had performed 35 unannounced inspections at the Northstar #1 injection well from April to December of 2011



# PORTABLE SEISMIC STATIONS

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- Four highly sensitive, portable seismic stations, on loan from Lamont-Doherty, were deployed in the epicentral area of seismic activity on December 1, 2011
  - Prior to the emplacement of these portable stations, detailed epicenter and surface locations of the previous seismic events were not very accurate
  - The portable stations recorded the December 24th and 31<sup>st</sup> events and were able to calculate accurate epicenters
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# NORTHSTAR #1 INJECTION WELL

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- ❑ After the December 24, 2011 seismic event, the portable seismic data was downloaded and evaluated
  - ❑ On December 30<sup>th</sup>, at the request of the Director of ODNR, D & L Energy shut down the Northstar #1 well
  - ❑ On December 31, 2011, the 4.0 seismic event occurred and the Governor placed an indefinite moratorium on the other three drilled Northstar injection wells and one outstanding Northstar injection permit within a seven mile radius around the Northstar #1 injection well
  - ❑ Additionally, all current Class II injection well permit applications were put on hold
  - ❑ New Class II rules were implemented on October 1, 2012
  - ❑ The first four new Class II permits were issued in November of 2012
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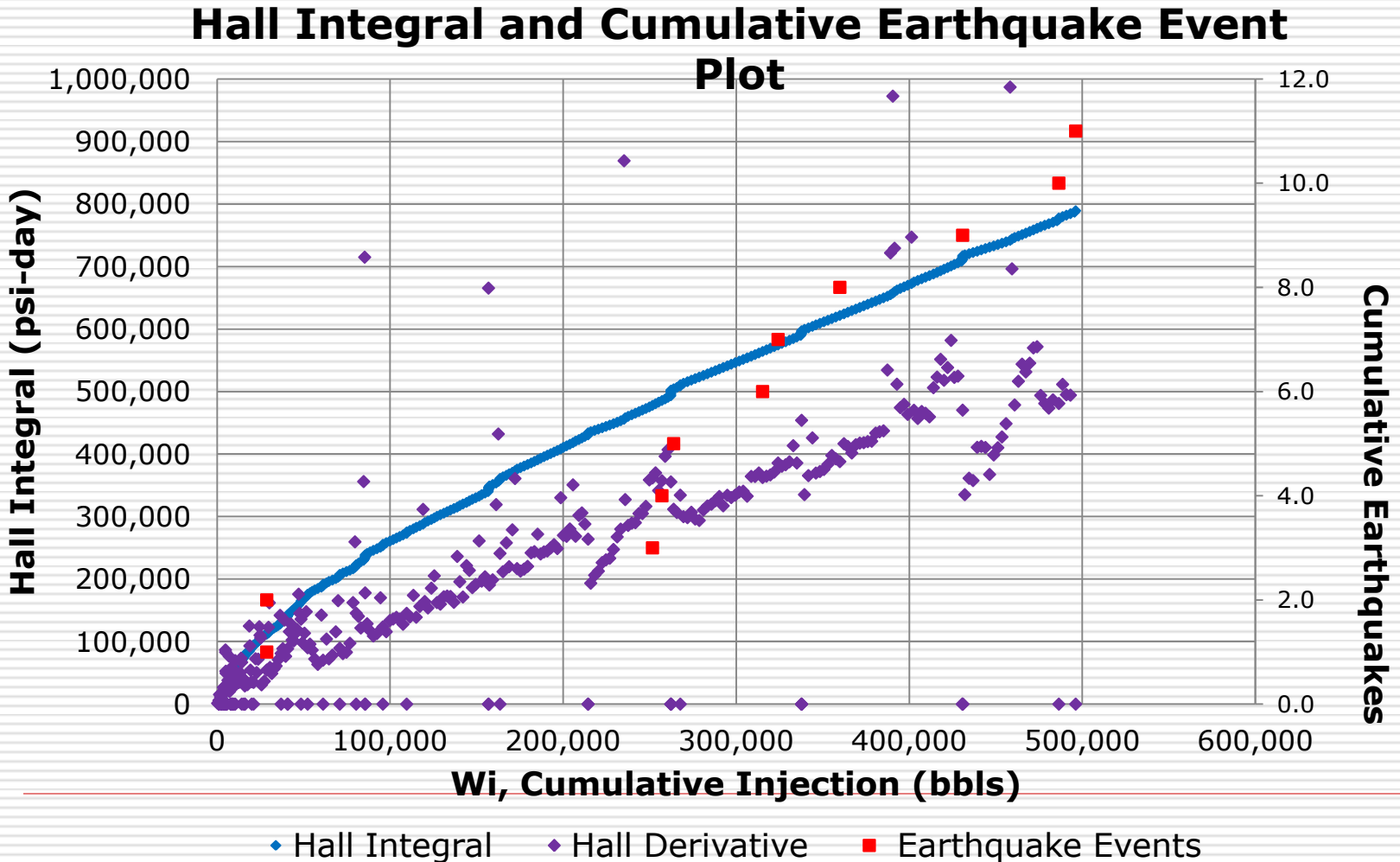


# EVALUATION OF THE DATA

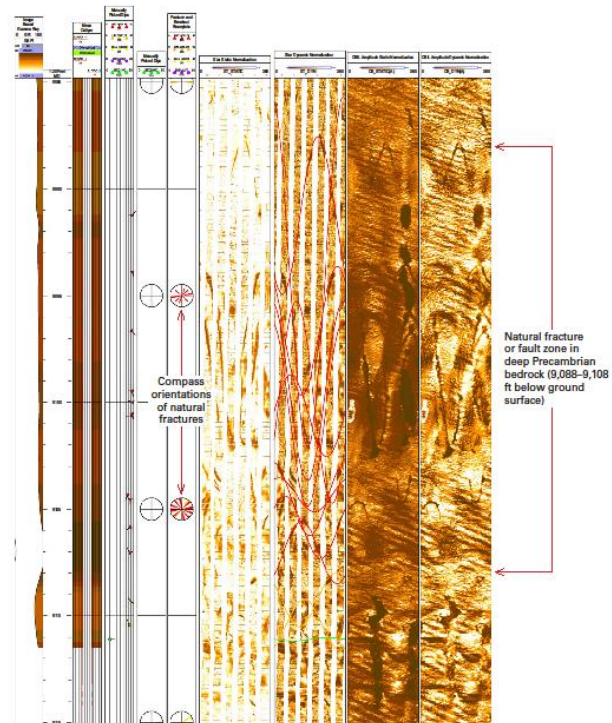
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- ❑ Evaluations done by Lamont-Doherty on the seismic data indicates there may be a unknown fault within the Precambrian rocks near the Northstar #1 injection well
  - ❑ Injection from the Northstar #1 well may have communicated with this potential fault and caused the seismic activity
  - ❑ Data continues to be collected and evaluated
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# U.S. EPA REGION VI EVALUATION



# ACOUSTIC AND RESISTIVITY IMAGE LOG



# MEETINGS

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- Meetings have been held with the operators of these five injection wells in the Youngstown area and proposals have been submitted to ODNR for review to address the seismicity issues and will be reviewed with ODNR's administration
  - Final determinations as to the status of these injection wells will be made with the public's safety as a top priority
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# CONCLUSIONS OF THE REPORT

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- ❑ Very difficult for all conditions to be met to induce seismic events
  - ❑ There are 144,000 Class II injection wells in operation in the U.S. and less than 20 incidents of alleged induced seismicity
  - ❑ Number of coincidental circumstances appear to make the compelling argument for the recent Youngstown-area seismic events may have been induced
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# COINCIDENTAL CIRCUMSTANCES?

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- ❑ Seismic events started three months after the Northstar #1 well started injecting
  - ❑ Events were clustered around the well
  - ❑ Potential evidence of open fractures or high permeability zones within the Precambrian rocks
  - ❑ Portable seismic stations were able to more accurately determine the surface and subsurface distances and depths of the seismic epicenters
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# CONTINUED RESEARCH

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- ❑ Additional data is being collected and analyzed by experts
  - ❑ Additional testing may be warranted to confirm preliminary findings
  - ❑ Decisions must be based upon sound scientific information
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# CHANGES TO THE UIC PROGRAM

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- ❑ Ohio's new Class II UIC rules went into effect on October 1, 2012
  - ❑ These new rules can: prohibit drilling into the Precambrian rocks for Class II injection, possible collection of original downhole reservoir pressures, pressure fall-off testing, potential for conducting seismic surveys or seismic monitoring, minimum geophysical logging suite, automatic shut-off switches on injection pumps, continuous annulus pressure monitoring, and in depth geologic evaluation
  - ❑ Rules are applied on a well-by-well basis – conversion vs. new well and depths of injection formations
  - ❑ Ohio will continue to be proactive in its approach to induced seismicity
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# QUESTIONS

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