PRELIMINARY RESULTS FROM THE NEWBERRY VOLCANO EGS DEMONSTRATION

Matt Uddenberg,
Susan Petty, Yini Nordin, Trenton Cladouhos

SMU Geothermal Conference
March 13, 2013

AltaRock Energy, Inc. and Newberry Holdings
in partnership with U.S. Department of Energy

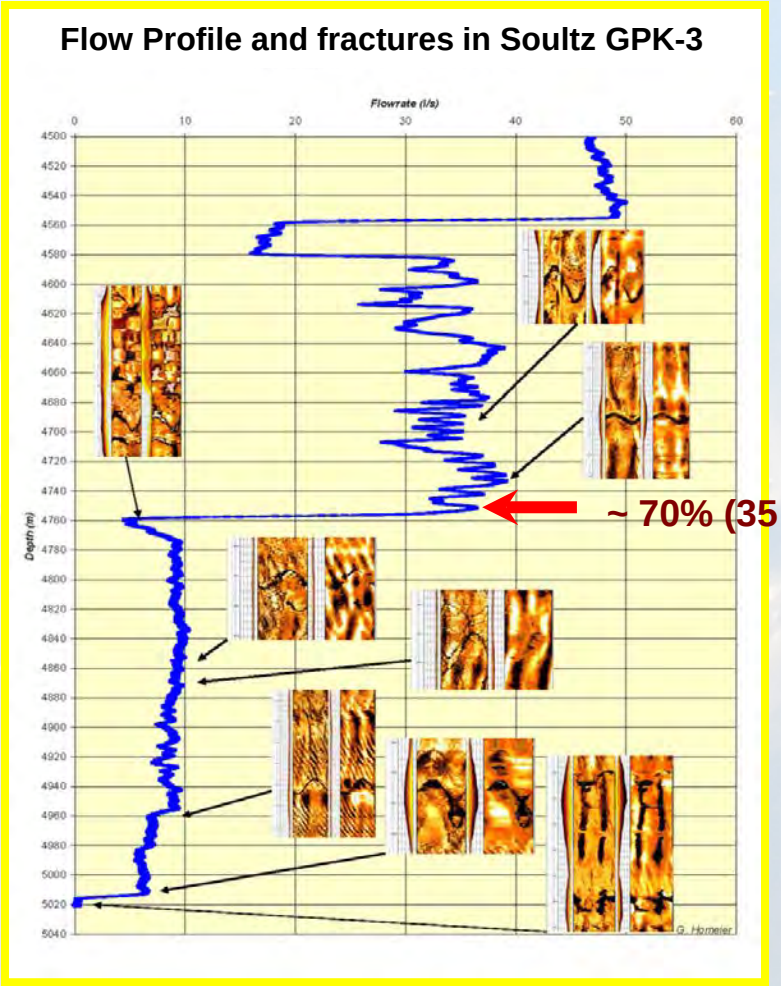
ALTAROCK ENERGY INC

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

Biggest EGS Challenge: Low Flow Rates Per Well

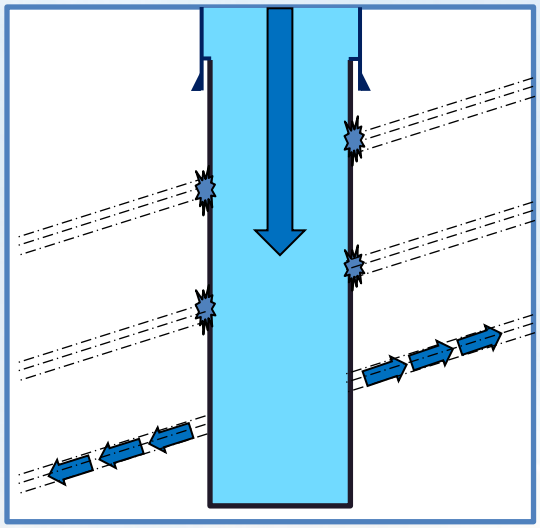
- Most permeable zone in well takes fluid and is stimulated if pressure can be increased
- Remaining zones only take limited amounts of fluid and are not stimulated
- Increasing flow by increasing injection pressure risks induced seismicity
- Single, dominant zone does not provide sufficient heat exchange or flow-rate



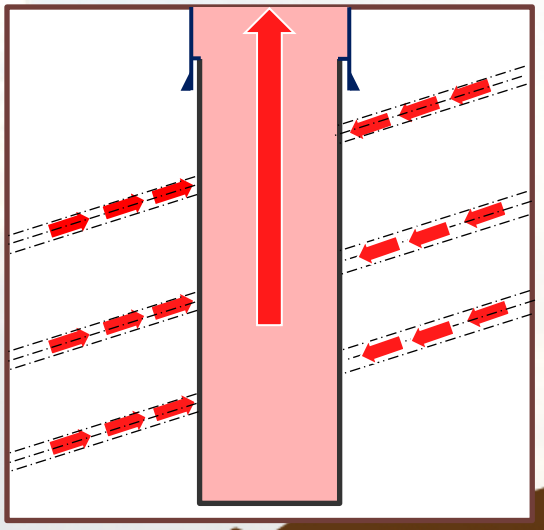
ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

AltaRock TZIM Technology



Diverter Sealing Zones



Thermal Degradation

- TZIM = Thermo-degradable Zonal Isolation Materials, AltaVert®
- Pumped as a particulate slurry
- Near neutral density – follows the flow
- Particles packs off near well-bore face
- Distributed Temperature Sensors monitor fluid exit
- No rig required during treatment

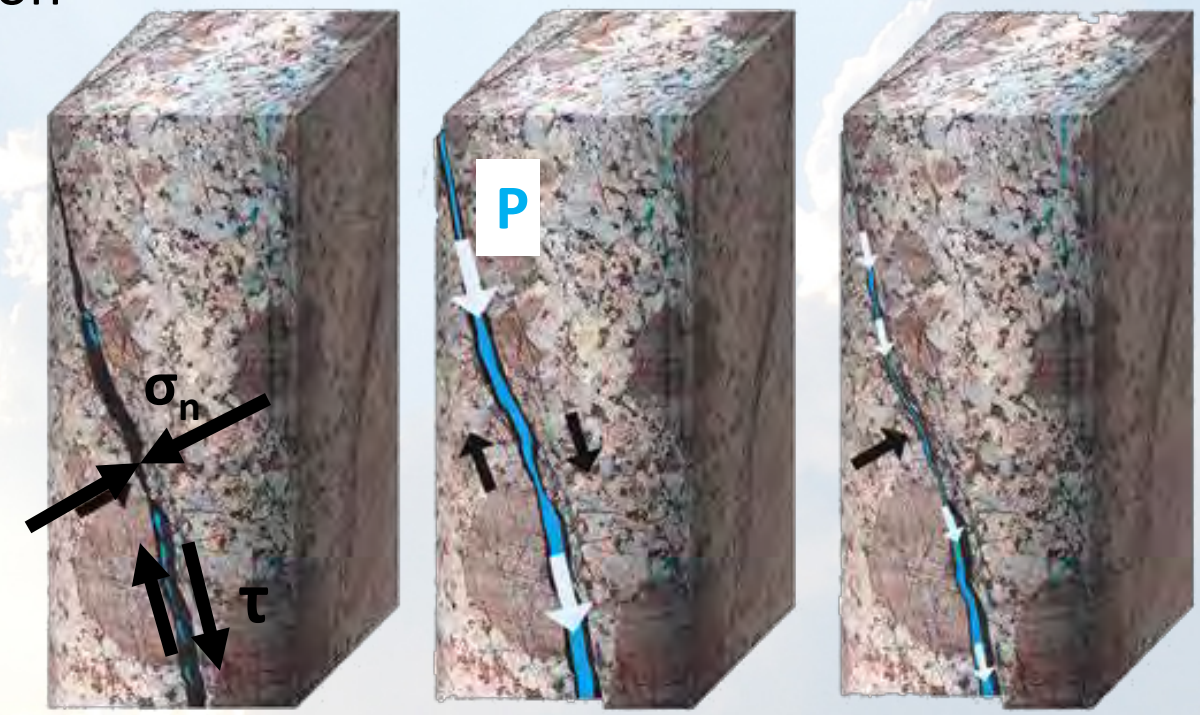
* AltaRock has a portfolio of patent filings protecting its proprietary technology and methods.

ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

Permeability Enhancement in EGS = Hydroshearing*
(not hydrofracking)

- Hydraulic stimulation
- Existing fractures
- $P_f < S_{hmin}$
- Shear failure
- Microseismicity
- Open hole
- Days of pumping @~30-50 l/s (500-700 gpm)



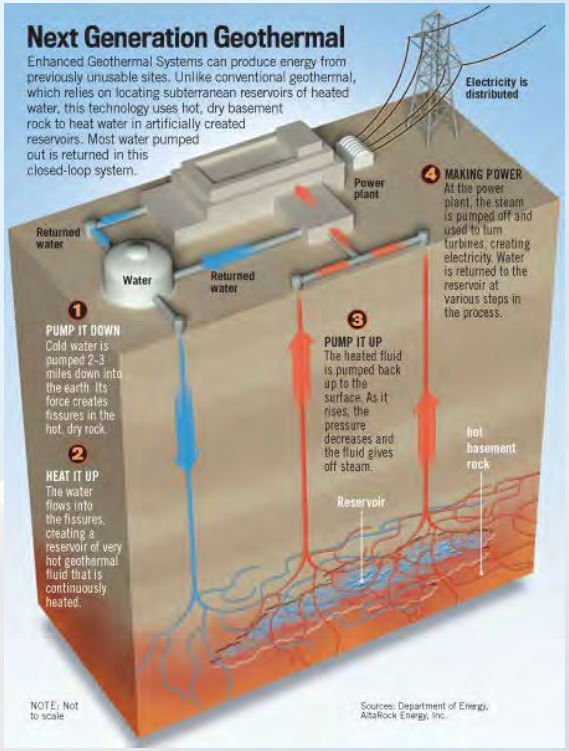
* Cladouhos et al., 2009

ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

Goals of the Newberry EGS Demonstration

- Demonstrate current technology and advances in EGS utilizing AltaRock's proprietary methods and technology*
  - Stimulate and map at least three fracture zones in existing very hot but “dry” well, NWG 55-29 (3066 m deep, 330° C BHT)
  - Demonstrate TZIM for multiple zone stimulation
  - Demonstrate single-well tracer test methods to assess productivity after stimulation
- Drill two production wells into EGS reservoir
- Establish circulation through three-well system
- Demonstrate economic well productivity

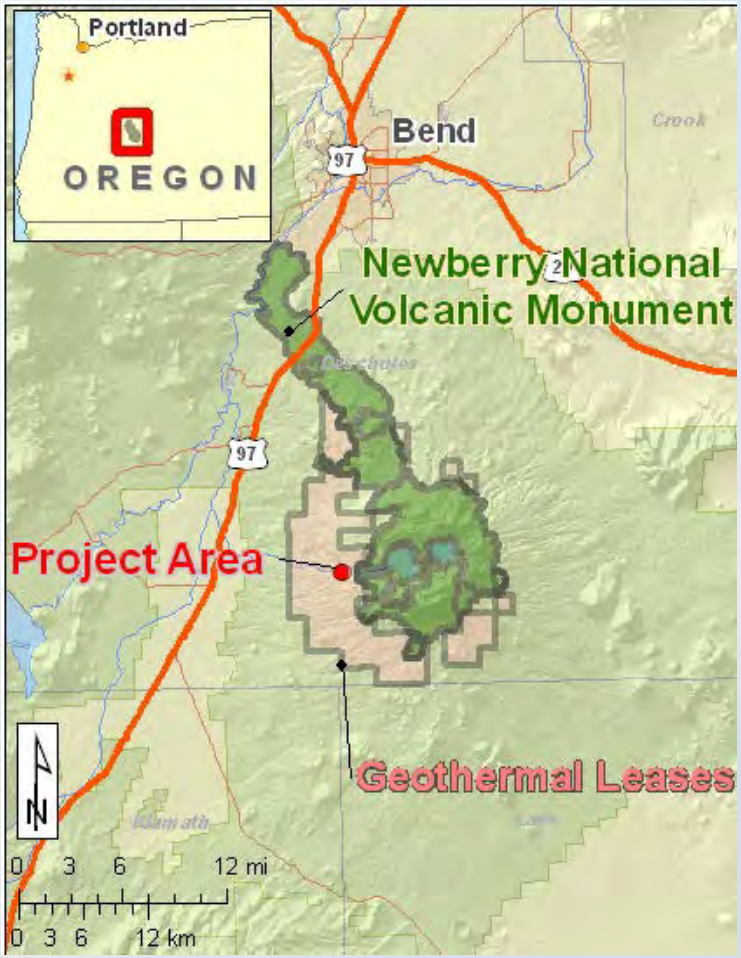


ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

Newberry EGS Demonstration Timeline

- Phase I (2010-2011)
  - Historical data review
  - Injection testing, BHTV and PTS logging
  - Hydrological testing and monitoring
  - Stimulation planning and modeling
  - Public outreach
  - Seismology (*Induced Seismicity Mitigation Plan*)
  - Permitting (*Environmental Assessment*)
- Phase II (2012-13)
  - MSA boreholes and equipment Installation
  - Stimulation & flow test of NWG 55-29
  - Drill and test production wells
- Phase III (2014)
  - Conceptual modeling of full-scale Development

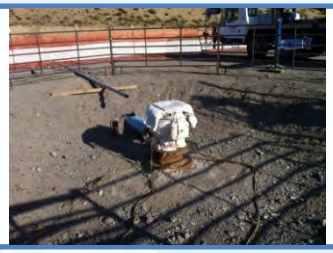


ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

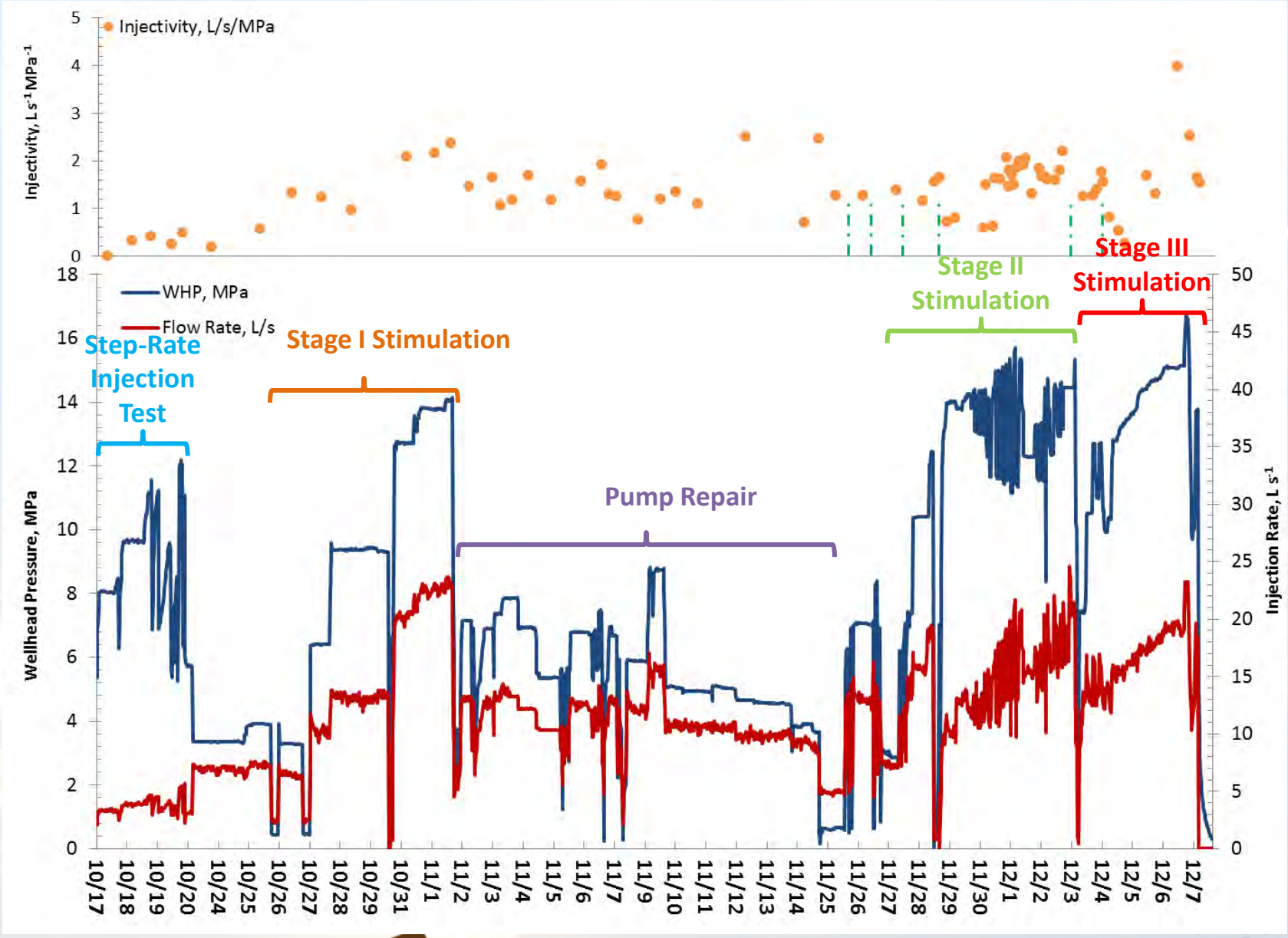
Newberry Stimulation Site Preparation

Wellhead



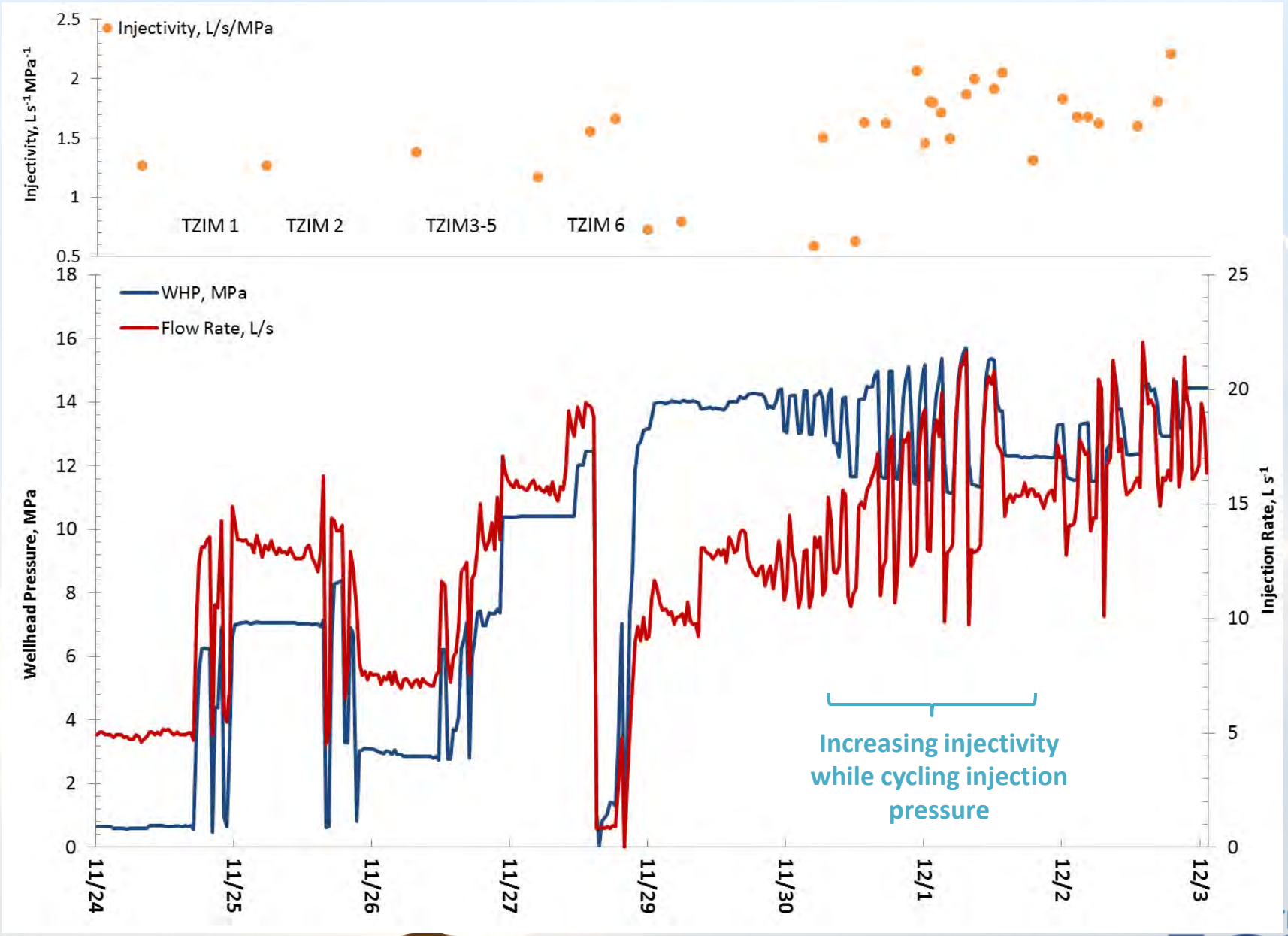
MSA

Piping and Pumps



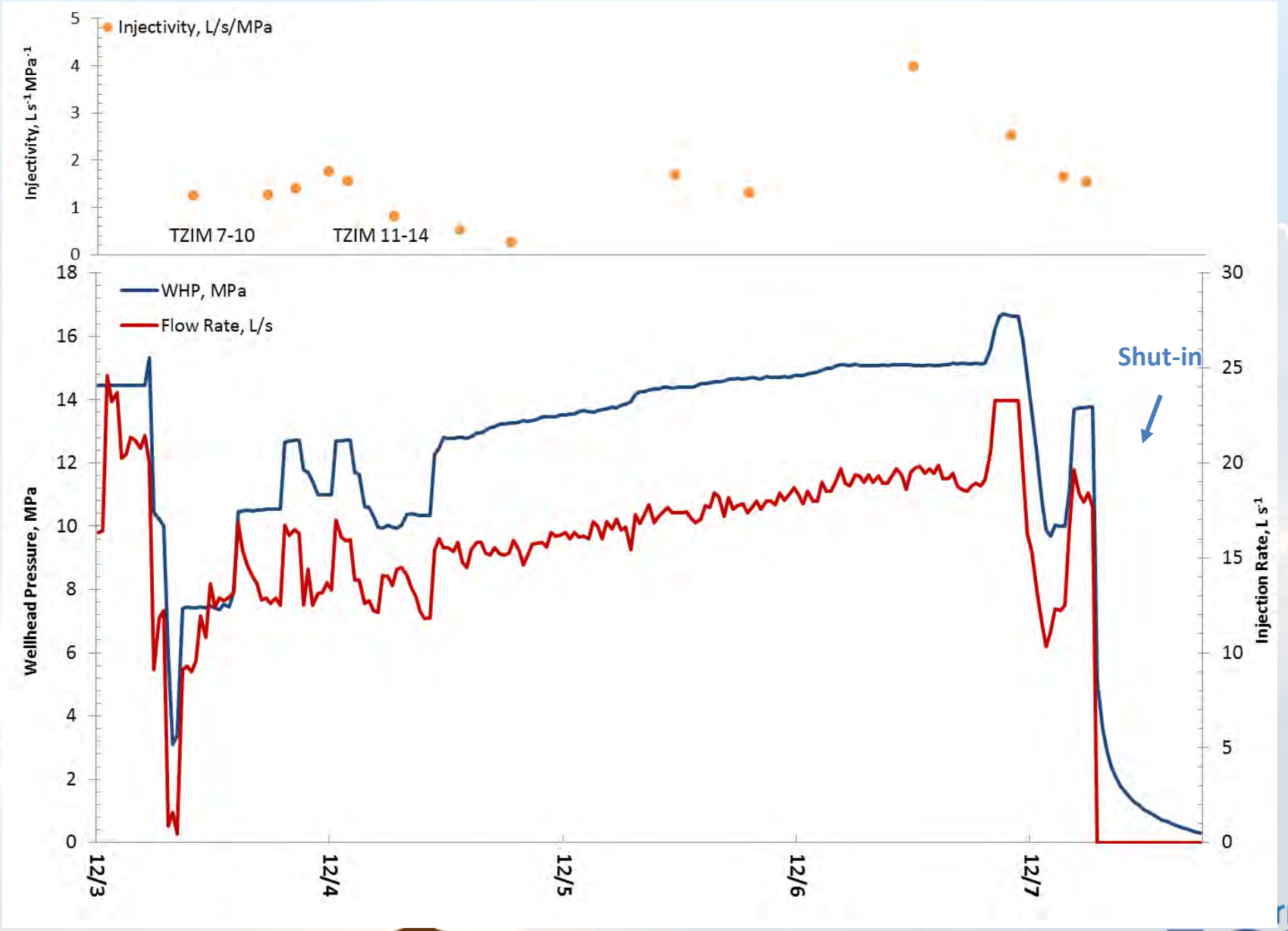
ALTAROCK ENERGY INC

EGS Enhanced Geothermal Systems DEMONSTRATION



ALTAROCK ENERGY INC

EGS Enhanced Geothermal Systems DEMONSTRATION



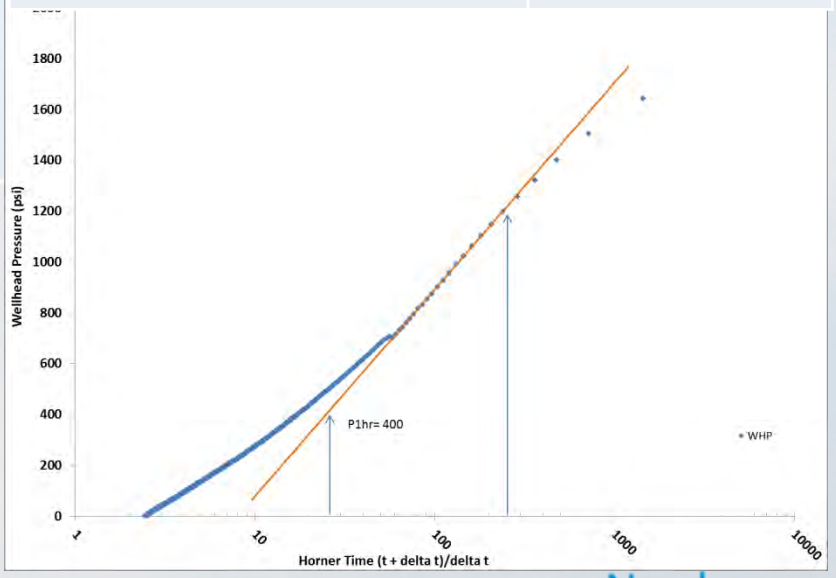
ALTAROCK ENERGY INC

EGS Enhanced Geothermal Systems DEMONSTRATION

Pressure Fall-off Test

- Injection shut-off on 12/7/12
- Pressure fall off monitored and analyzed with Horner plot
- Results are prior to TZIM degradation, thus previous two zones may still be blocked
- Transmissivity calculated to be 6.46×10^{-13} m^3 (2,147 md-ft)

Pre-stim permeability	**1×10^{-17} m^2**
Predicted shear enhanced permeability (LBNL TOUGH model)	2×10^{-15} m^2
Fall-off analysis permeability*	3.2×10^{-15} m^2

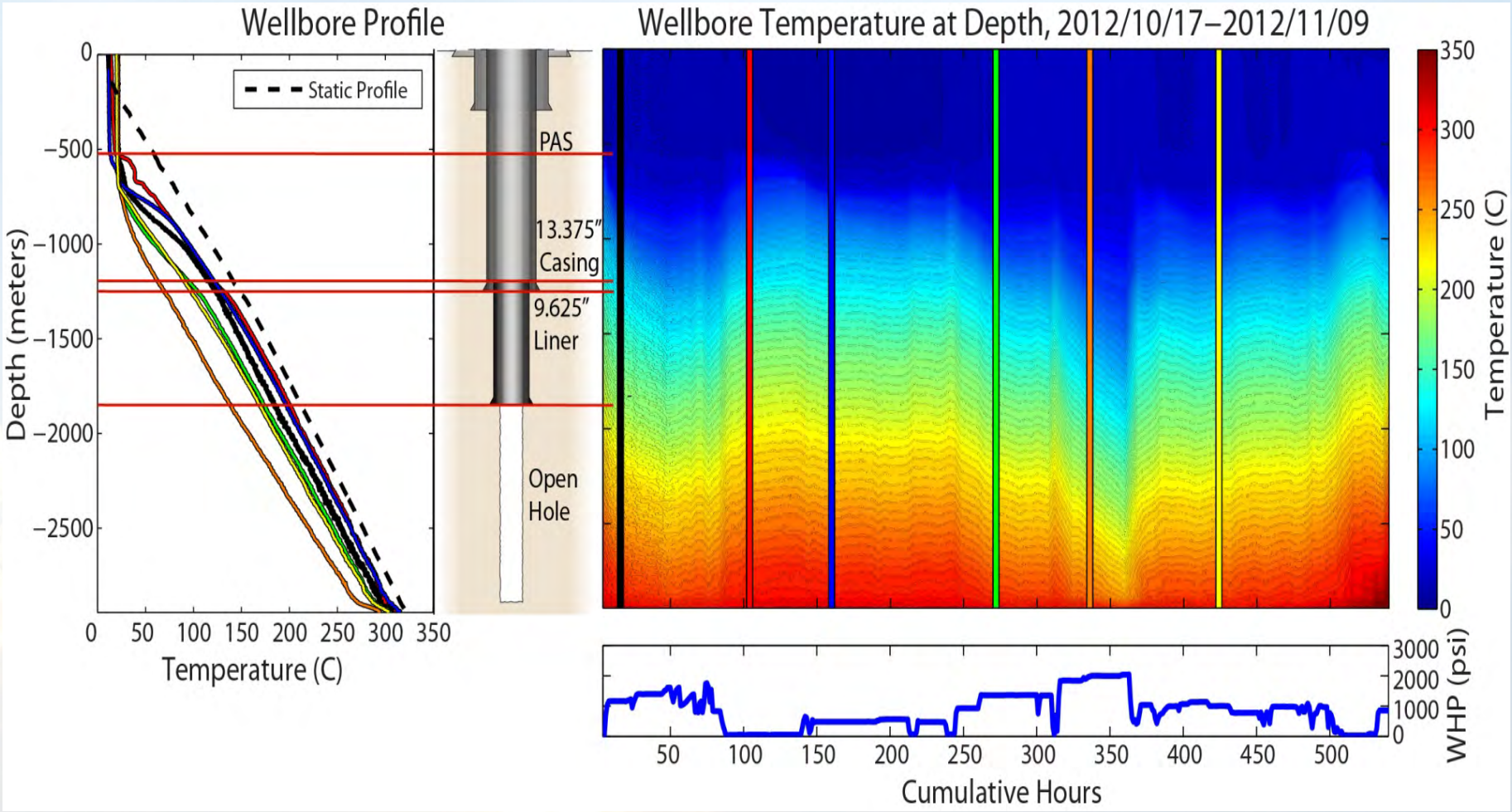


*Assuming 200m reservoir height as presented in Cladouhos et al. 2011

ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

DTS results: Newberry EGS

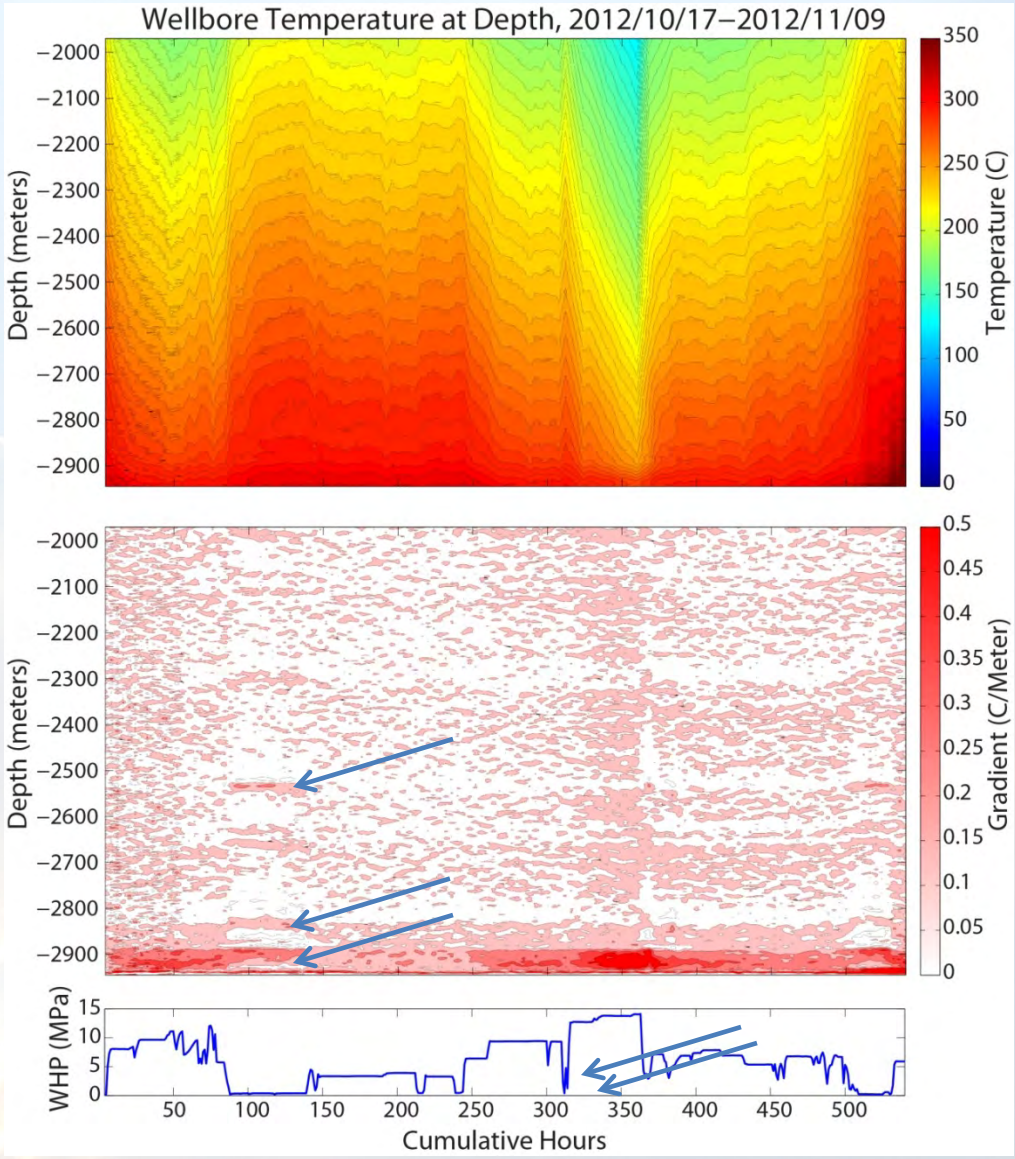


ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

Stage 1 Openhole

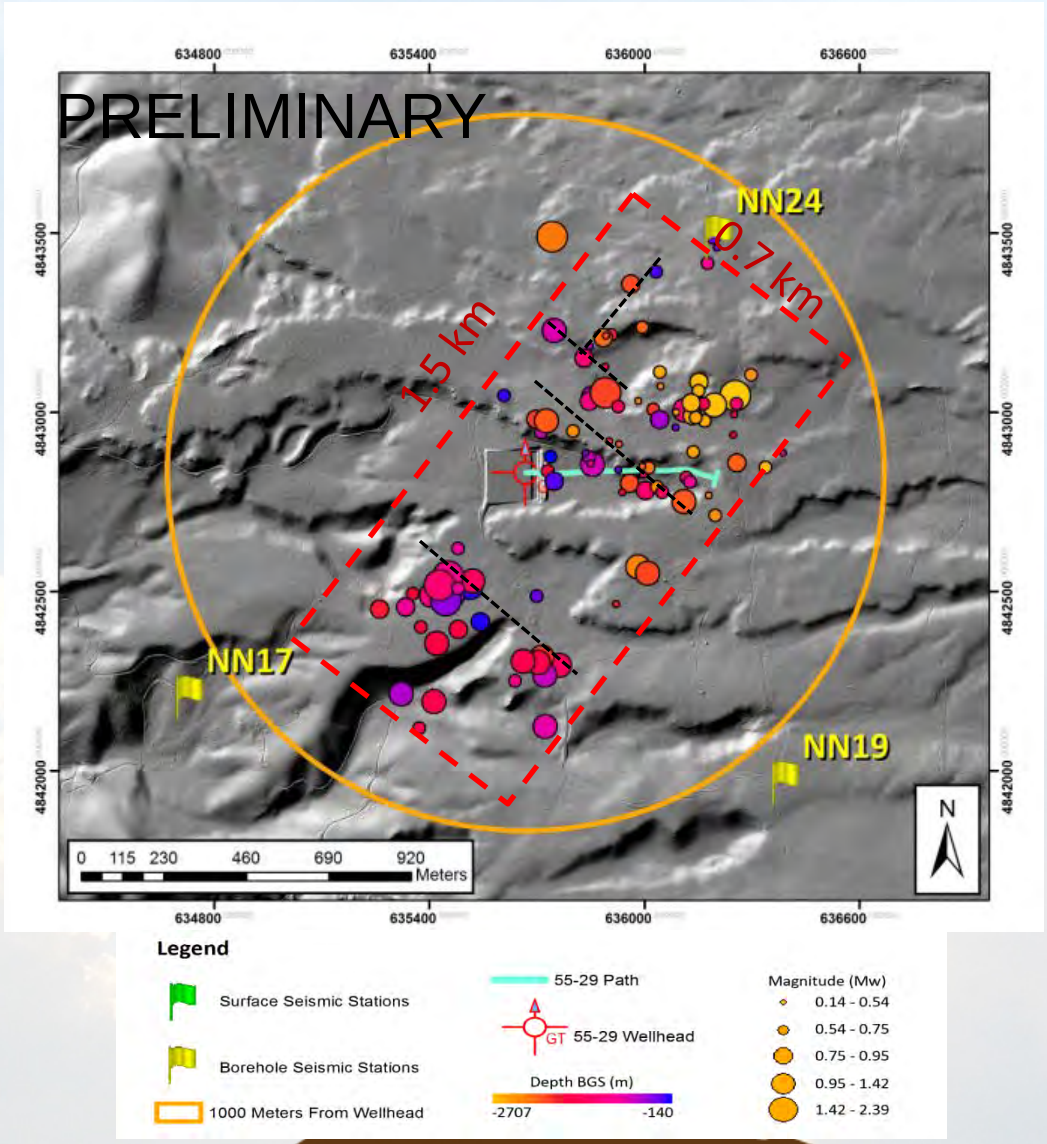
- Two or more permeable zones between 2880 m and 2950 m are taking majority of the injected fluid
- The deep zones from 2880 to 2950 m are stimulated at pressures above 10 MPa
- Darker red color after higher pressures indicates improvement – zones take for fluid and therefore cool more
- Other small permeable zones exist around 2550m, 2670m and 2850m

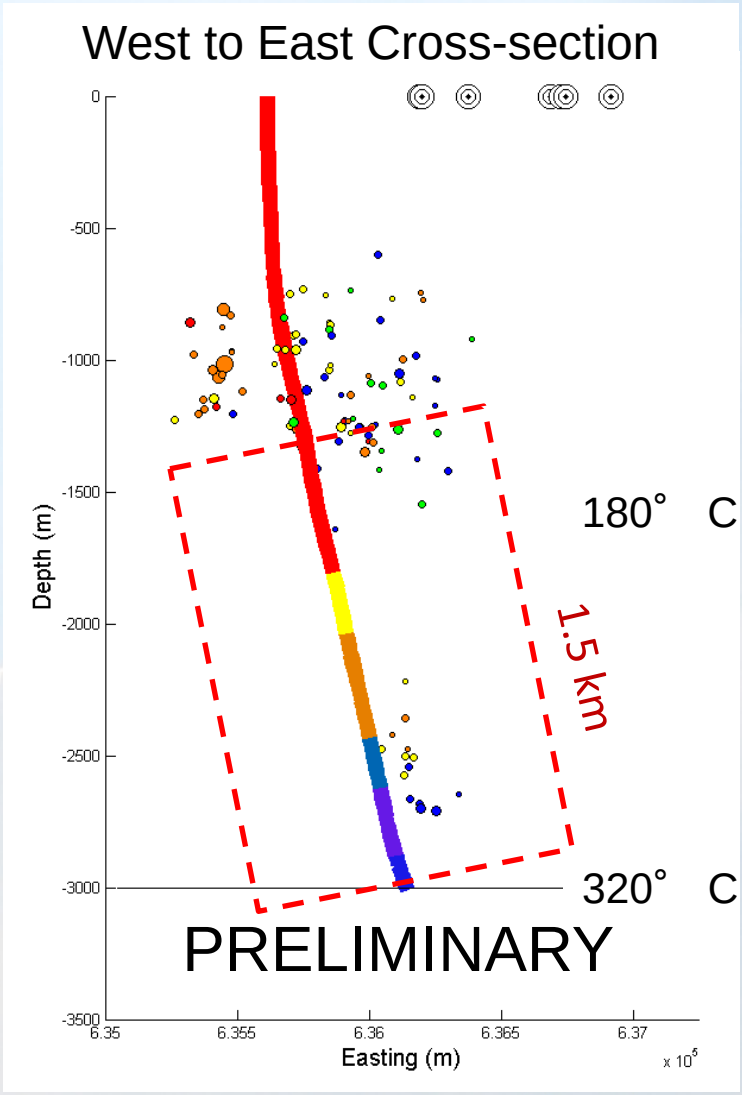


ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

EGS Reservoir



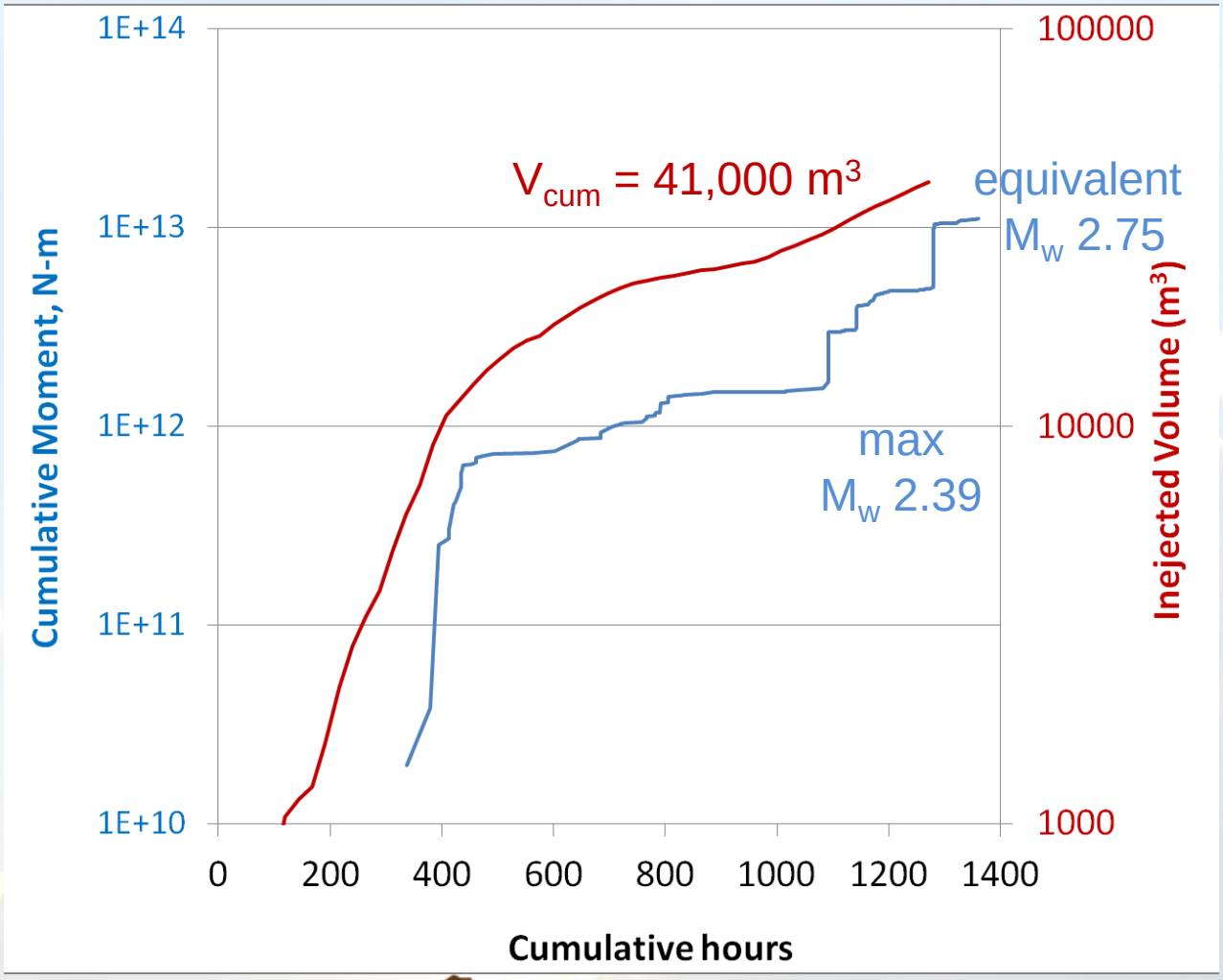


$V_{stim} \approx 1.5\ km^3$

ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

Injected Volume and Cumulative Moment



Comparison

GPK2
22,680 m^3
equiv M_w 3.4

Basel
11,500 m^3
Max M_w 3.4

ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

Future Work

- Conduct post TZIM degradation injectivity and fall-off analysis
- BHTV and fluorimeter run
- Flow well to recover tracer
- Pass phase 2.1 DOE Go/N Go
- Design well course from stimulation seismicity
- Drill first production well (2013)
- Conduct 7-day connectivity test
- Stimulate production well, if needed
- Plan and drill second production Well
- Conduct 30-day multi-well connectivity test

ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION

Newberry EGS

Enhanced Geothermal Systems DEMONSTRATION

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Acknowledgement: This material is based upon work supported by the Department of Energy under Award Numbers DE-EE0002777 to AltaRock.

Disclaimer: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

ALTAROCK ENERGY INC

Newberry EGS Enhanced Geothermal Systems DEMONSTRATION