

# **PS CO<sub>2</sub> Injection Monitoring using an Experimental Modular Borehole Monitoring (MBM) System\***

**George J. Koperna<sup>1</sup>, Robert Trautz<sup>2</sup>, Thomas M. Daley<sup>3</sup>, Barry M. Freifeld<sup>3</sup>, and Kevin Dodds<sup>4</sup>**

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<sup>1</sup>Advanced Resources International, Inc. Arlington, VA ([gkoperna@adv-res.com](mailto:gkoperna@adv-res.com))

<sup>2</sup>Electric Power Research Institute, Knoxville, TN

<sup>3</sup>Berkeley Lab, Berkeley, CA

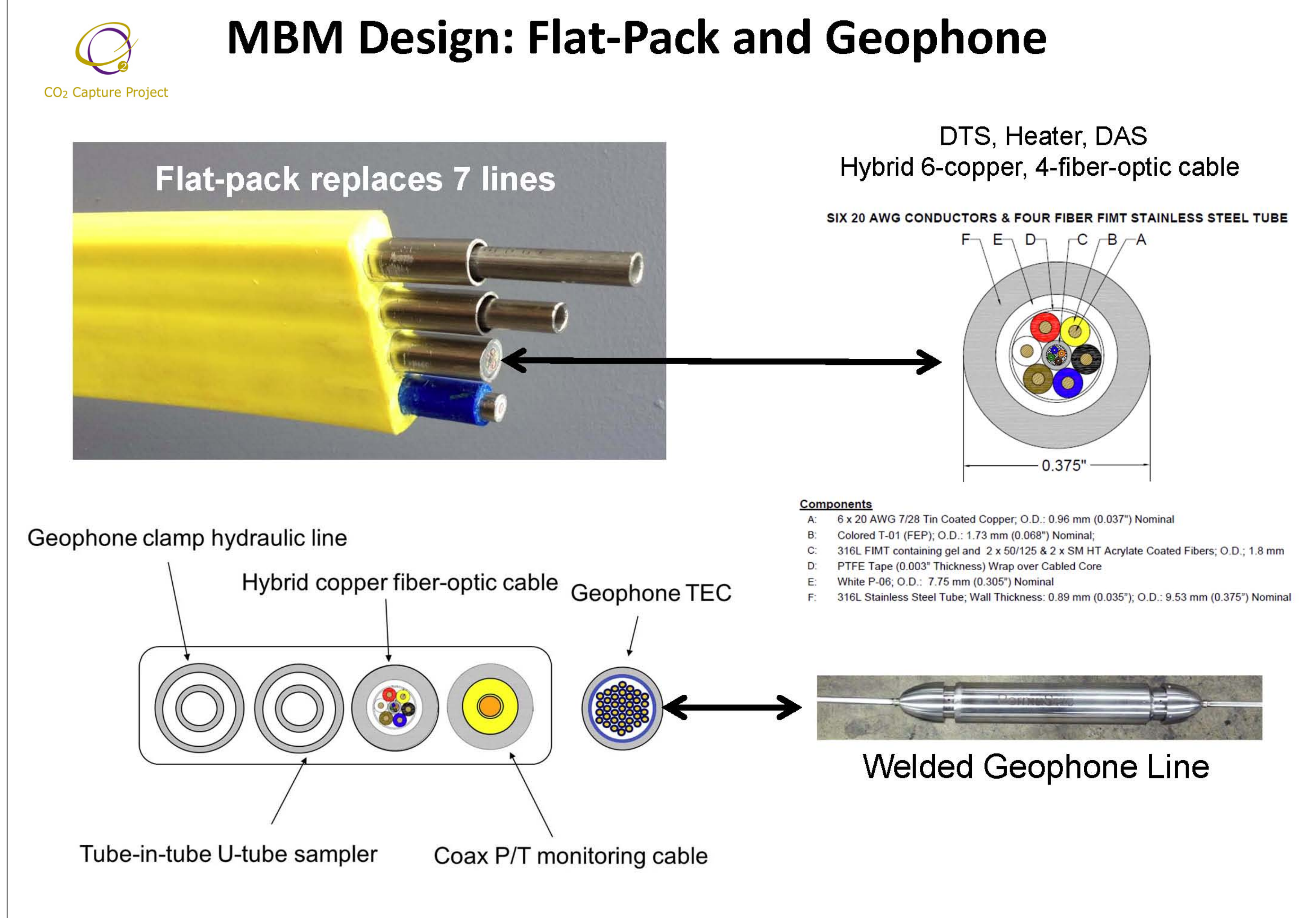
<sup>4</sup>CO<sub>2</sub> Capture Project, Houston, TX ([kevin.dodds@bp.com](mailto:kevin.dodds@bp.com))

## **Abstract**

The U.S. Southeast Regional Carbon Sequestration Partnership (SECARB) Anthropogenic Test is a demonstration of CO<sub>2</sub> capture from a coal-fired power plant, transport, geologic storage and monitoring technologies. Starting in August 2012, up to 550 metric tons of CO<sub>2</sub> have been captured and injected underground per day. Operations will continue for two years and monitoring will be deployed through 2017. One of the goals of the project is to test experimental monitoring technologies and, as part of this effort, the project team installed an innovative tubing deployed modular borehole monitoring (MBM) system designed at Lawrence Berkeley National Laboratory and supported by CO<sub>2</sub> Capture Project (CCP) as a field trial project. The MBM was designed with the aim of deploying a robust flexible monitoring package that maximizes the data collected in a single-well monitoring system while minimizing installation risks. This system includes U-tube reservoir fluid sampler, heat-pulse cable with fiber-optic distributed temperature sensor (DTS), a geophone array for borehole seismic acquisition and discrete downhole pressure/temperature sensors at the level of the storage reservoir. The MBM system was installed in the project's monitoring well in March 2012, all of the components were tested, and baseline measurements were performed prior to the onset of CO<sub>2</sub> injection. This baseline effort included the acquisition and characterization of reservoir fluid samples, testing of the heat-pulse/DTS system, a continuous record of reservoir pressure and the acquisition of baseline vertical seismic profiles using the borehole geophone array. This paper will present the results of the baseline and injection-phase monitoring efforts to date using the MBM.

## ABSTRACT

The Southeast Regional Carbon Sequestration Partnership (SECARB) Phase III Anthropogenic Test is a demonstration of CO<sub>2</sub> capture from a coal-fired power plant, transport, geologic storage and monitoring technologies, injecting a maximum of 550 metric tons of CO<sub>2</sub> per day into the Paluxy formation in the Citronelle dome. Operations will continue for two years and monitoring will be deployed through 2017. A goal of the project is to test experimental monitoring technologies deployed and installed in an innovative Modular Borehole Monitoring (MBM) system designed at Lawrence Berkeley National Laboratory. The MBM was designed to deploy a robust flexible monitoring package that maximizes the data collected in a single-well monitoring system while minimizing installation risks. The system includes U-tube reservoir fluid sampler, heat-pulse cable with fiber-optic distributed temperature sensor (DTS), a geophone array for borehole seismic acquisition, and discrete downhole pressure/temperature sensors at the level of the storage reservoir. The MBM system was installed in March 2012 and all of the components were tested and baseline measurements were performed prior to the onset of CO<sub>2</sub> injection. This baseline effort included the acquisition and characterization of reservoir fluid samples, testing of the heat-pulse/DTS system, a continuous record of reservoir pressure and the acquisition of baseline vertical seismic profiles using the borehole geophone array.

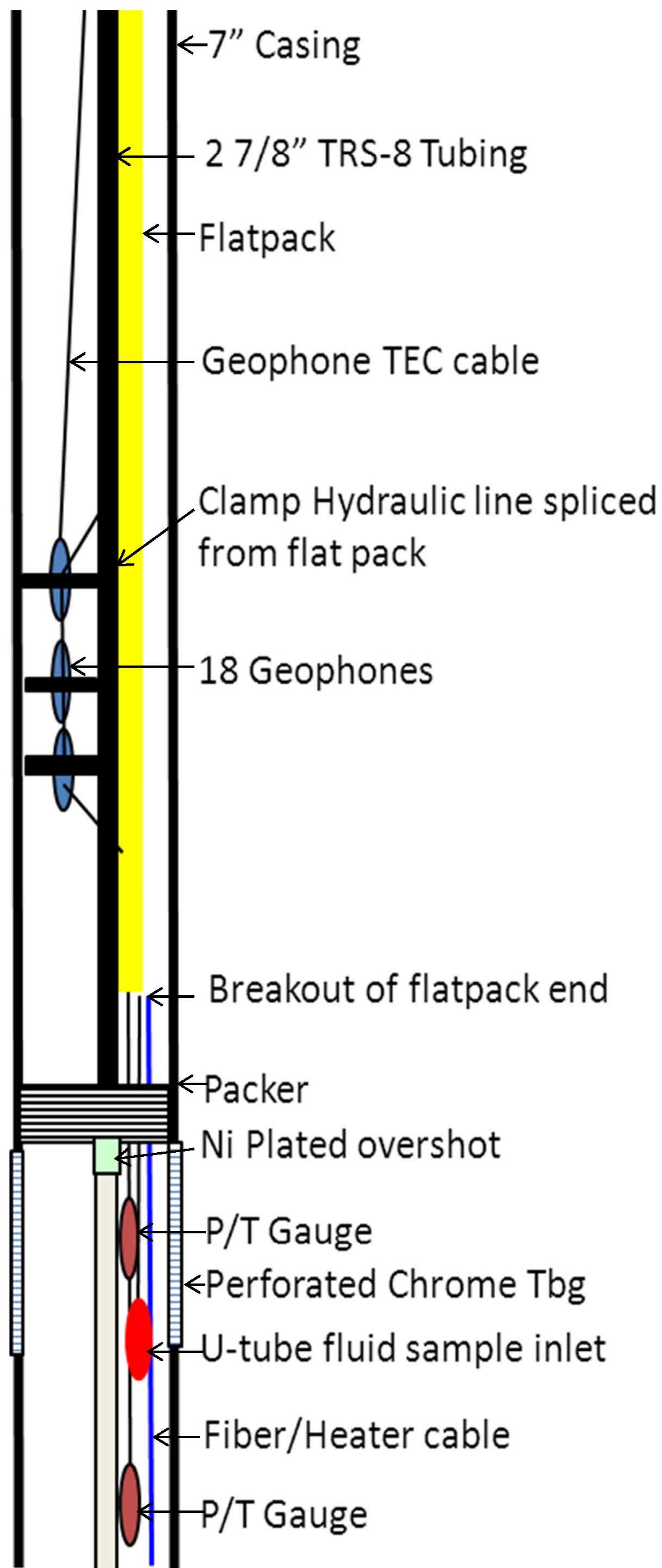


## RUN-IN DATA

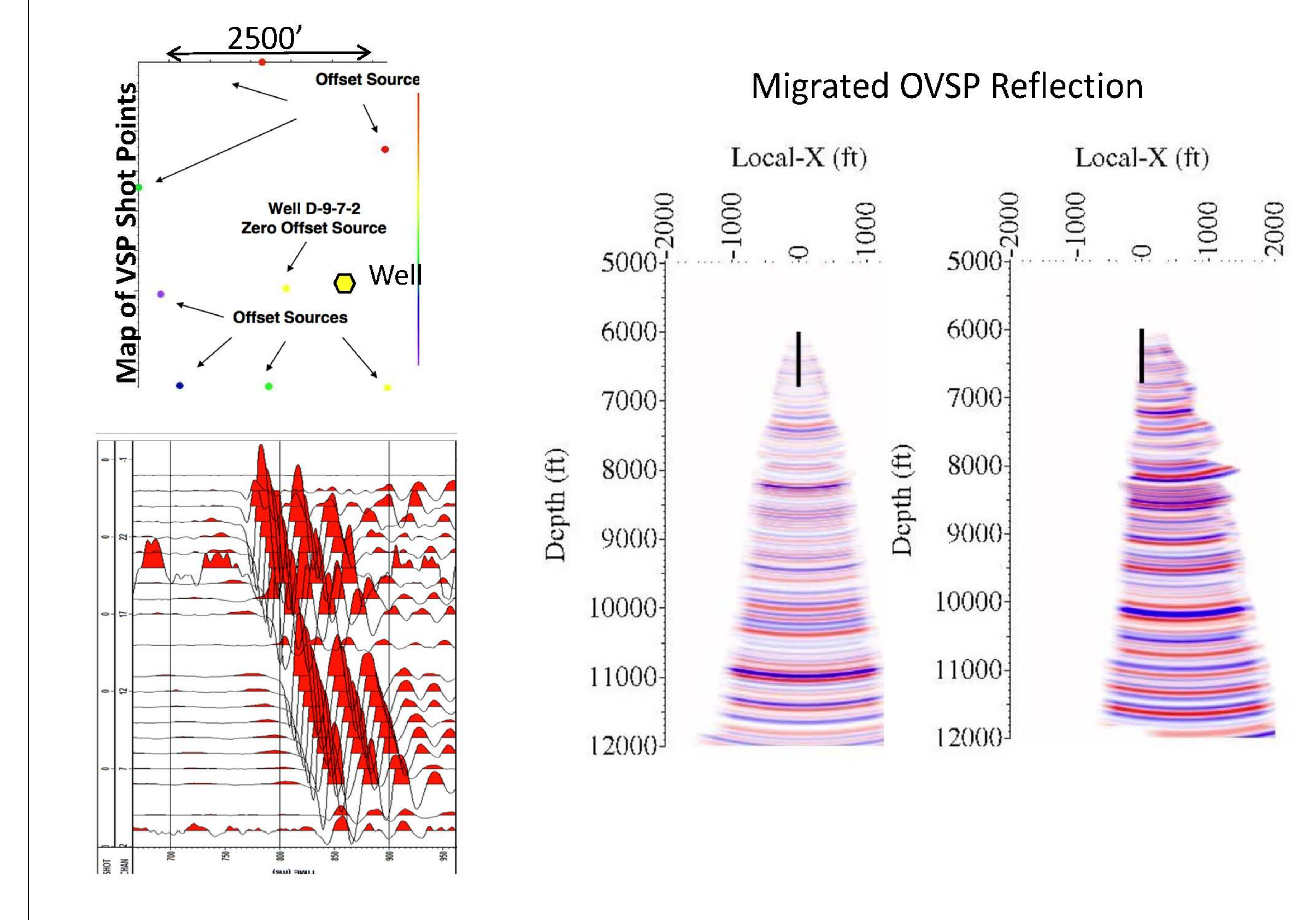
Deployment is facilitated by bundling the 7 control lines in a polypropylene-jacketed flatpack, using a non-rotating off-center overshoot to couple the uphole, dual-mandrel hydroset packer assembly. The bottom of the packer was landed at a depth of ~9,400 feet (2,865 m) and the entire completion depth was 9,850 feet (3,002 m), requiring 4 – 24 hour-a-day operations to install.



## MBM COMPONENT WELL DIAGRAM



## MBM Geophone Array: Baseline VSP



## MBM COMPONENTS

The components are designed for long-term operation in a CO<sub>2</sub> environment. The backbone of the MBM system consists of (i) integrated 9 mm fiber-optic (FO) sensor array consisting of a single-mode fiber for acoustic monitoring of flow and active seismic imaging of the CO<sub>2</sub> plume; (ii) a multi-mode fiber for performing Distributed Temperature Sensing (DTS) embedded within copper conductors for performing heat-pulse interrogation of the near-wellbore environment to determine the thermal conductivity of the near-wellbore (fluid, casing and rock) system where changes in saturation can be indication of CO<sub>2</sub> migration, thereby integrating combining geophysical and hydrological monitoring that take advantage of the benefits of commercial grade telecom fibers including longevity (50 year life span), reliability, low cost and widespread availability with 1 foot resolution; (iii) tube-in-tube U-tube sampler for collection of deep reservoir fluid sampled; and (iv) coaxial cable for monitoring of pressure and temperature data.

- Fiber Optic Cable being the sensor: provides very large receiver array
- Complete wellbore coverage for every source firing
- Dynamically change the sensor/antenna length to any value greater than one (1)
- High fold with walk-away / 3-D VSP
- Identification of lateral variations in lithology for Well-Placement and Landing ERD wells
- 3-D Velocity and Anisotropy

## ACKNOWLEDGEMENT

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