Applied Energy Mapping at the Ohio Geological Survey

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Panel 2: Updating the Structure Maps (cont.)

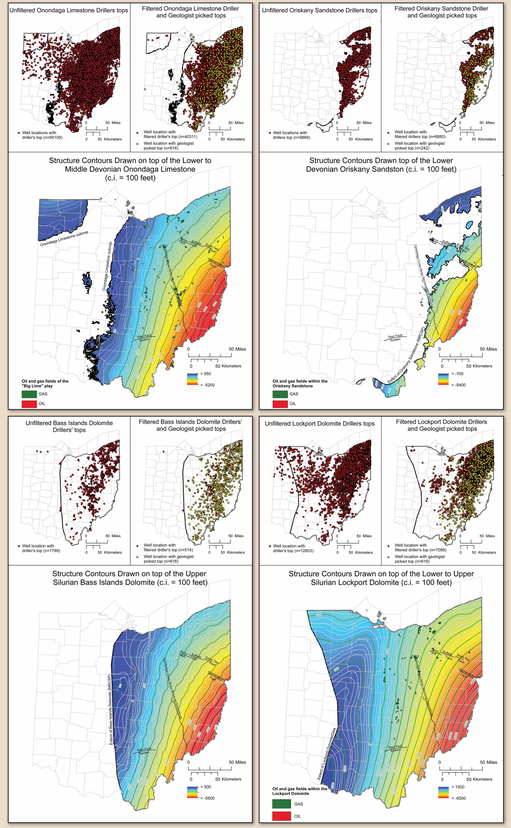
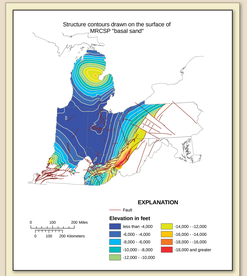
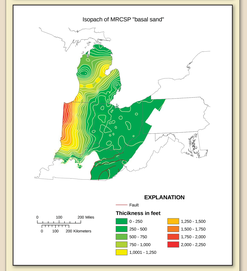


FIGURE 2-4.— After filtering the driller's tops to create a robust data set for Ohio, a new surface is created, edited, and edge matched with corresponding MRCSP Phase II Middle Devonian-Middle Silurian structure contours.





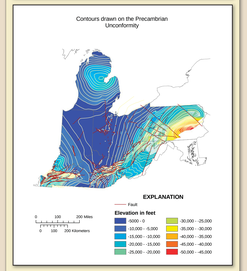


FIGURE 2-5.—Continuing with MRCSP Phase III, regional structure and isopach maps are edited as more data is collected and interpreted (Greb and Solis, 2010; Greb, oral commun., 2010; Baranoski, written commun., 2011).

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Panel 3: Mapping Geothermal Energy Potential—Ohio and MRCSP Region

SUMMARY

- The concentration of geothermal heat in crust is important to understand the potential for geothermal energy and electricity coproduction potential and potential for CO_2 storage.
- Boreholes in deeper Appalachian Basin wells can exceed 100°C and so may have potential for electricity coproduction.
- Shallow Precambrian crust with high thermal gradients may have relatively high heat flow, possibly associated with the uplifted granitic and radiogenic crust.
- High thermal gradients are also inferred for much of Indiana.
- Anomalously low BHT and thermal gradients are inferred for west-central Ohio.

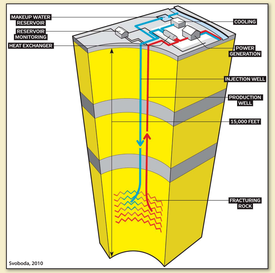


FIGURE 3-1.—In principal, enhanced geothermal systems (EGS) rely on using relatively hot fluids from circulation through fractured hot rock to power electricity generation (MIT, 2006). Improvements in Rankine-cycle power generation, however, have lowered the temperature at which electricity can be produced or coproduced with oil and gas production. Research is also underway to use CO_2 as a working fluid for cogenerating electricity while also sequestering CO_2 and enhancing recovery of oil and gas (McKenna and others, 2005; Pruess, 2006).

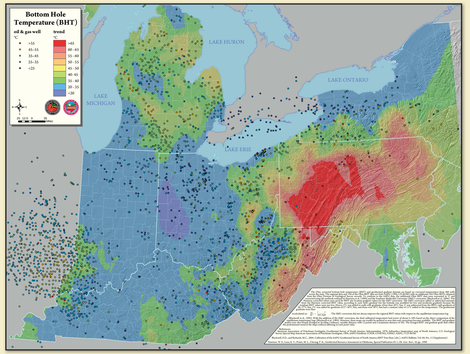
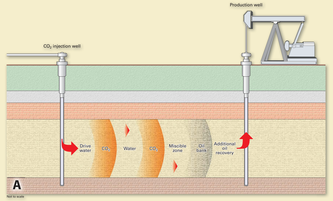


FIGURE 3-4.—Ohio and surrounding environs with BHT data values and the generalized Kreiged BHT surface. The 2,643 data points are from (AAPG, 1994) and 334 new BHT values for Ohio. The BHT data generally reflect the depth of the well with hotter values found in deeper wells.



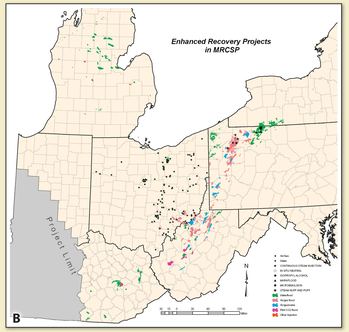


FIGURE 3-2.—(A) Graphic illustration of CO_2-enhanced oil recovery (EOR) process and (B) locations of regional, enhanced-recovery projects (Riley and others, 2010).

DOE Enhanced Oil Recovery/CO_2 Injection

CO_2 injection may also enable enhanced recovery of the nation's "stranded" oil resources (Randolph and Saar, 2010). DOE's program focuses on evaluating possible candidate locations for future CO_2 injection-enhanced oil recovery, utilizing CO_2 from industrial sources, as well as geologic sources. DOE is also investigating CO_2 as a working fluid to coproduce electricity in conjunction with enhanced or secondary oil-and-gas recovery.

CO_2 Injection Offers Considerable Potential Benefits

The EOR technique that is attracting the most new market interest is CO_2-EOR. First tried in 1972 in Scurry County, Texas, CO_2 injection has been used successfully throughout the Permian Basin of West Texas and eastern New Mexico, and is now being pursued to a limited extent in Kansas, Mississippi, Wyoming, Oklahoma, Colorado, Utah, Montana, Alaska, and Pennsylvania.

For more information about enhanced oil recovery research, visit the U.S. Department of Energy website: **http://fossil.energy.gov/programs/oilgas/eor/.**

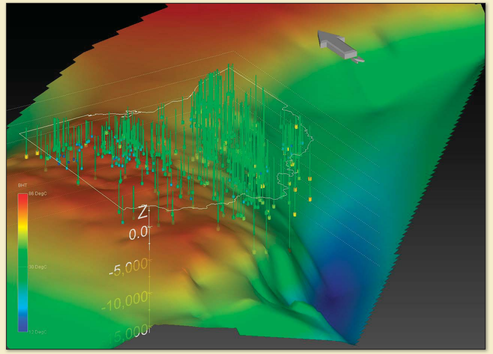


FIGURE 3-3.—Ohio and surrounding environs Precambrian surface with color-coded barrels that indicate corrected BHT observations in 3-D perspective. The straws show well locations and observation depths. Also shown is the Precambrian subsurface interpolated from 406 wells that contact or penetrate the Precambrian basement. BHT data and rock property data constrain the regional geothermal gradient, heat flow, and geothermal conditions at depth. These data will help to evaluate where geothermal energy, CO_2 injection, enhanced recovery, and electricity coproduction may be viable.

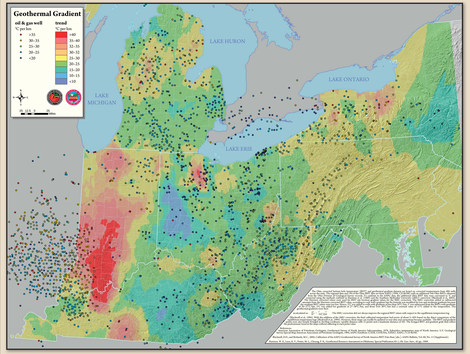


FIGURE 5.—Ohio and surrounding environs with geothermal gradients (dT/dz) from BHT data values and the generalized kriged geothermal gradient surface. Whereas the BHT data generally reflect the depth of each well, with hotter values found deeper, the gradient reflects the steepness of the temperature increase with depth.

The heat flow and thermal state of the crust and lithosphere is largely deduced from the thermal gradients, rock thermal conductivities, and estimates of the subsurface concentrations of radioactive elements according to:

$$q_s = -K\frac{dT}{dz} = q_m + bD \qquad (1)$$

where q_s is the surface heat flow in [W/m2], K is the thermal conductivity in [W/m°K] and dT/dz is the thermal gradient. The surface heat flow is due to crustal heat generation sources, bD, where b is the thickness of the heat-producing layer and D is heat production in [W/m2] and q_m is heat entering the crust from the mantle. The temperature solution to (1), assuming exponentially decreasing crustal heat production, then is:

$$T = T_0 + \frac{q_m}{K}z + \frac{\rho H_r h_r^2}{K}\left(1 - e^{-z/h_r}\right) \qquad (2)$$

where hr is a length scale [m] for the decrease of Hc [W/m3] with depth z [m] (Turcotte and Schubert, 1982).

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