[PS]Characterization of the Helderberg Group as a Geologic Seal for CO_2 Sequestration*

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Abstract

The Midwest Regional Carbon Sequestration Partnership (MRCSP) is one of seven regional partnerships established by the U.S. Department of Energy's National Energy Technology Laboratory (DOE/NETL) to study carbon sequestration as one option for mitigating climate change. This partnership recognizes that both the Devonian Oriskany Sandstone and the Silurian Salina Group offer potential for subsurface carbon dioxide storage in northern West Virginia. The Siluro-Devonian Helderberg Group lies stratigraphically between these two units. Predominantly a carbonate interval with minor interbedded siliciclastics and chert, the Helderberg was deposited in an ancient epeiric sea. Although most previous investigations of this unit have concentrated on outcrops in eastern West Virginia, new information is available from an injection well drilled along the Ohio River at First Energy's R. E. Burger electric power plant near Shadyside, Ohio. Geophysical, seismic and core data from this well have been combined with existing outcrop information to evaluate the Helderberg Group's potential as a geologic seal. The data collected have shown that only secondary porosity remains and permeability, if it exists, most likely occurs along faults or within fractures.

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Head, J.W., 1974, Correlation and Paleogeography of Upper Part of Helderberg Group (Lower Devonian) of Central Appalachians: AAPG Bulletin, v. 58/2, p. 247-259.

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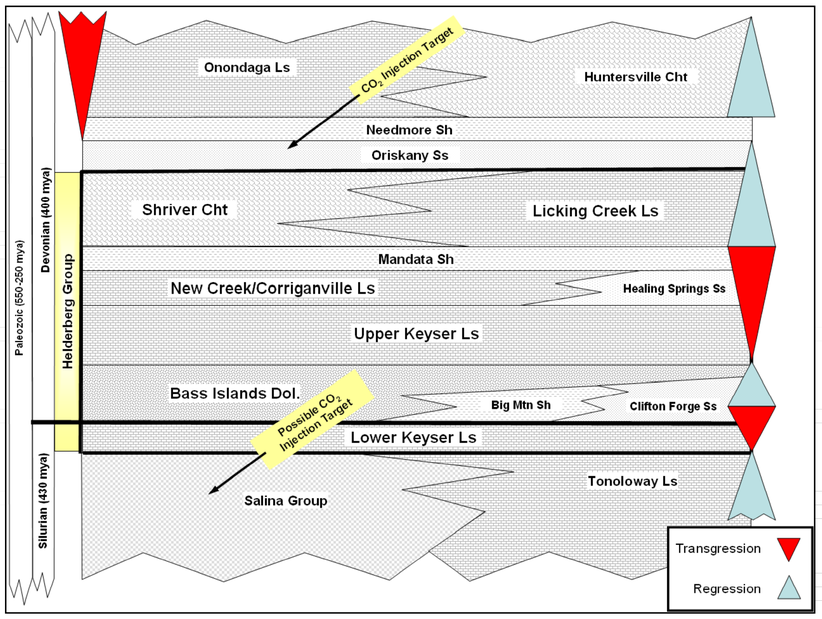
Abstract

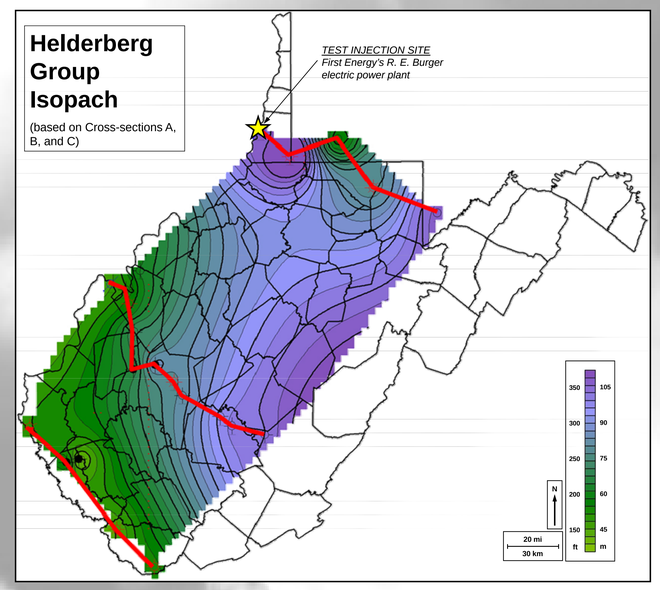
The Midwest Regional Carbon Sequestration Partnership (MRCSP) is one of seven regional partnerships established by the U.S. Department of Energy's National Energy Technology Laboratory (DOE/NETL) to study carbon sequestration as one option for mitigating climate change. This partnership recognizes that both the Devonian Oriskany Sandstone and the Silurian Salina Group offer potential for subsurface carbon dioxide storage in northern West Virginia. The Siluro-Devonian Helderberg Group lies stratigraphically between these two units. Predominantly a carbonate interval with minor interbedded siliciclastics and chert, the Helderberg was deposited in an ancient epeiric sea. Although most previous investigations of this unit have concentrated on outcrops in eastern West Virginia, new information is available from an injection well drilled along the Ohio River at First Energy's R. E. Burger electric power plant near Shadyside, Ohio. Geophysical, seismic, and core data from this well have been combined with existing outcrop information to evaluate the Helderberg Group's potential as a geologic seal. The data collected have shown that only secondary porosity remains and permeability, if it exists, most likely occurs along faults or within fractures.

Stratigraphic Chart

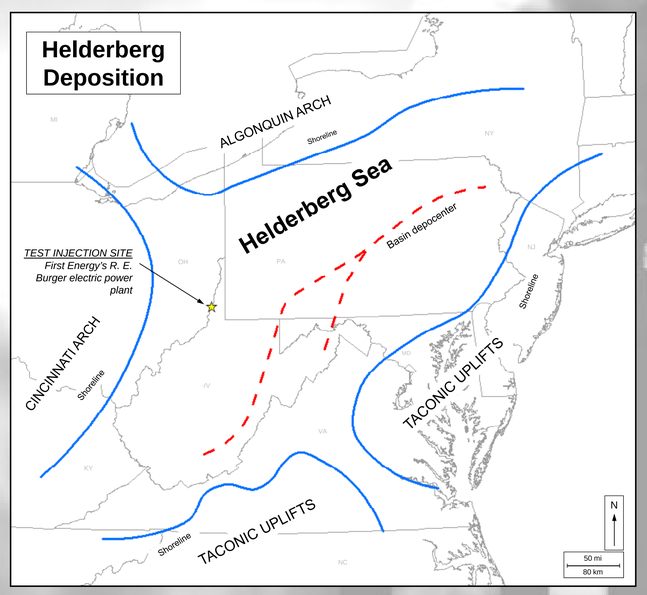
Extensive work on this predominantly carbonate formation has been done at outcrops in eastern West Virginia and has allowed the Helderberg to be subdivided into individual formations from top to bottom respectively: Shriver Chert, Licking Creek Limestone, Mandata Shale, New Creek /Corriganville Limestone, Upper Keyser Limestone, Bass Islands Dolomite, and Lower Keyser Limestone.



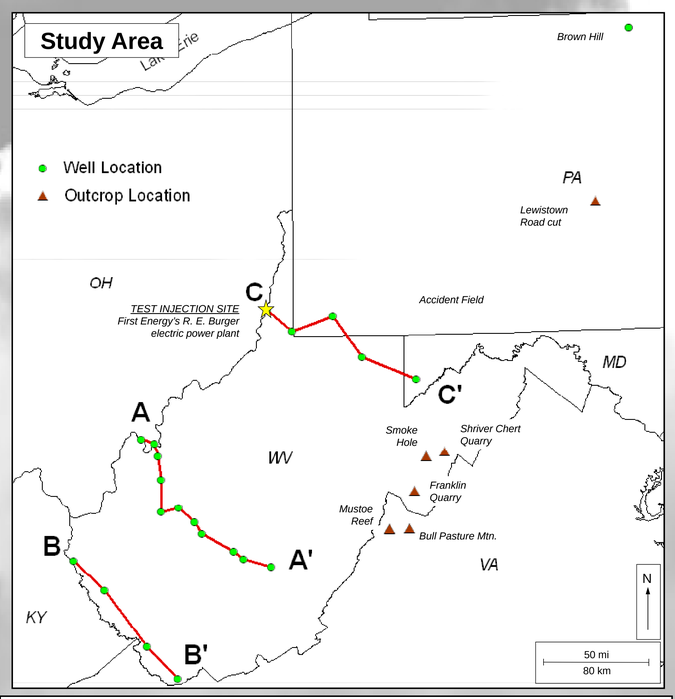
Shriver Chert - siliceous chert, highly deformed and fractured.
Licking Creek Ls - silty/sandy/shaly limestone, interbedded chert, interfingers with Shriver Chert.
Mandata Sh - terrigenous/calcareous shales, mudstones, poorly exposed. First of the "black shales" to be deposited. High TOC in some areas.
New Creek / Corriganville Ls - interbedded micritic and coarsely crystalline Ls, abundant crinoids, upper section contains chert beds.
Keyser Ls (U/L) - lithology varies; micritic, argillaceous, coral-stromatoporoid buildups, pelletal, fossiliferous, stylolitic.
Bass Islands Dolomite - argillaceous, thinly laminated, sparsely fossiliferous dolomite and dolomitic limestone.



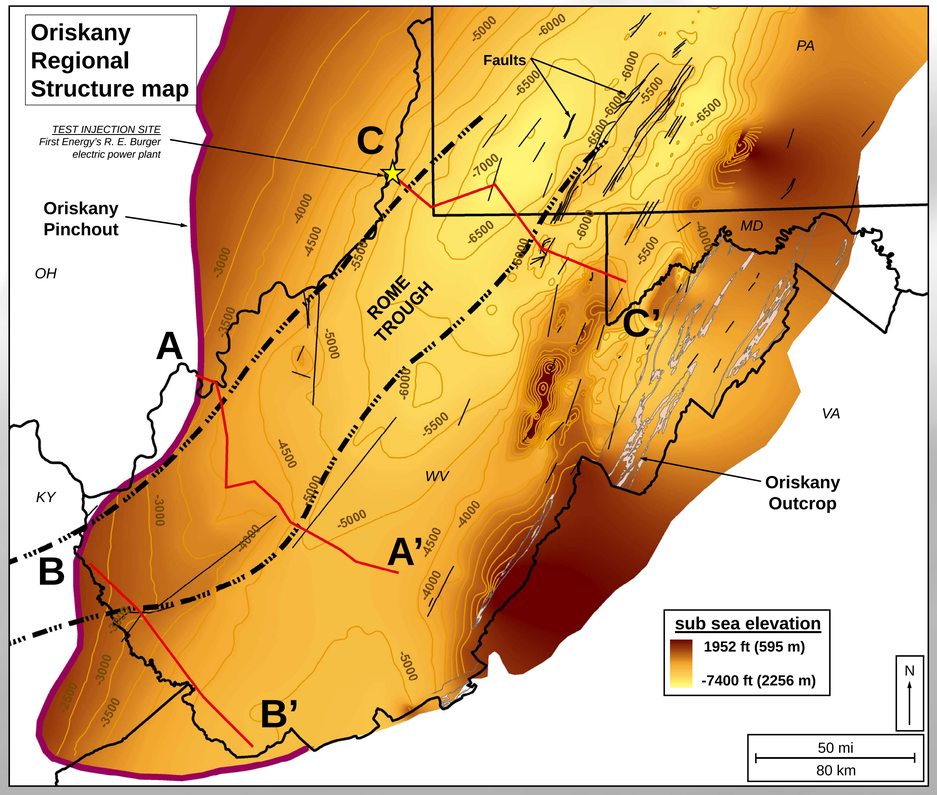
During Helderberg deposition, subsidence was slow - approximately 0.4 - 0.5 in (1.0 - 1.3 cm) per 1,000 years. This resulted in thickening toward the basin center and was associated with extensive normal faulting throughout the entire basin. Although the eastern flank of the Rome trough is well defined by dramatic breaks in slope, the western flank contains multiple offset types, including rotational faults, which in some cases resulted in uplift. As a result, the western flank is not as well defined and becomes even less so moving north toward the Burger site.



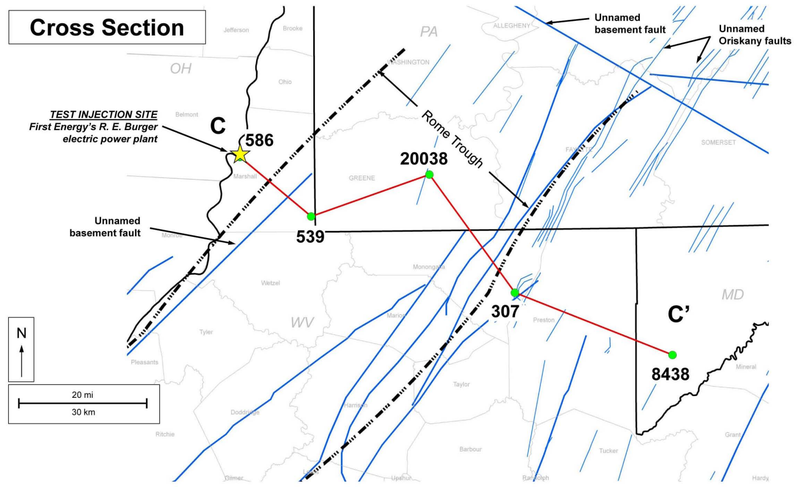
The Helderberg Sea was bounded to the southeast by the Taconic uplifts which provided intermittent influxes of clastics, to the west and northwest by the Cincinnati and Algonquin Arches, respectively, and by the Adirondack Dome to the northeast. Inlets were present on all four sides, but it is not clear if all of these led to the open ocean. At least one major connection to open ocean must have existed during early deposition of the Helderberg, however, in order to allow for adequate influx of nutrients during the deposition of this normal marine limestone deposit.

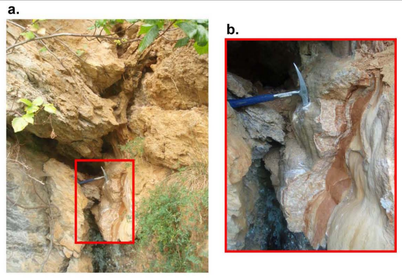


Map view of study area, cross sections and sample locations. First Energy's R.E. Burger electric power plant, approximately four miles (6.4 km) south of Shadyside, Ohio in the Businessburg 7.5' U.S.G.S. quadrangle, is one of the pilot sites for carbon dioxide injection in Phase 2 of the MRCSP (Fig. 2). Located on the west side of the Ohio River across from Moundsville, WV, the site sits on a floodplain where the elevation is 690 ft (210 m) above mean sea level.



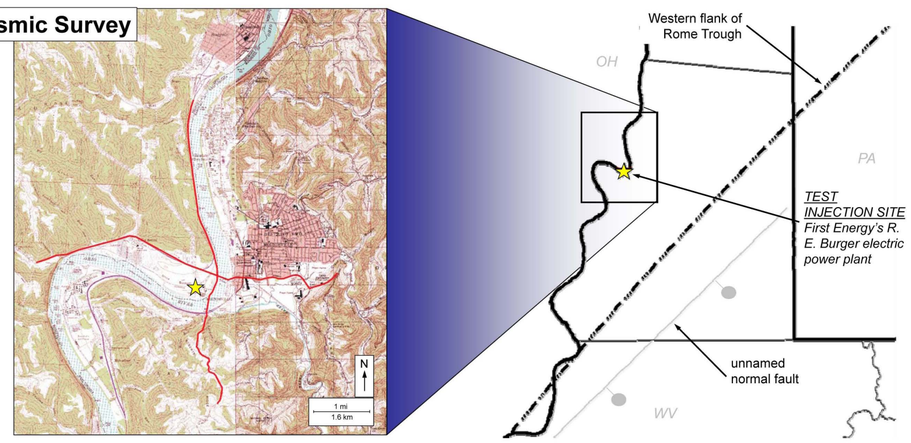
Cross Section



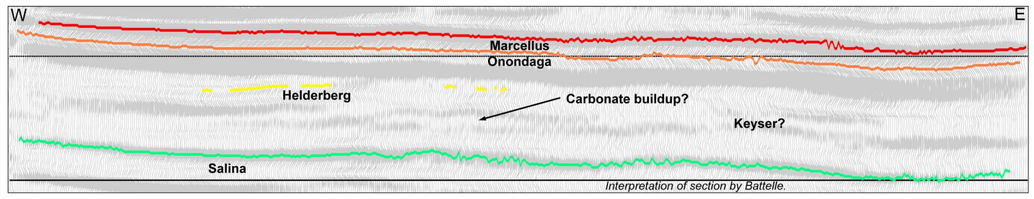


Permeability may still exist within the fractures unless these have been subsequently filled with secondary calcite or other minerals. Karsting occurs in the Helderberg and sizeable calcite veins have been documented in the eastern outcrop belt. (**a.** solution cavity/calcite vein at Bull Pasture Mountain, VA. **b.** close up view)

Seismic Survey

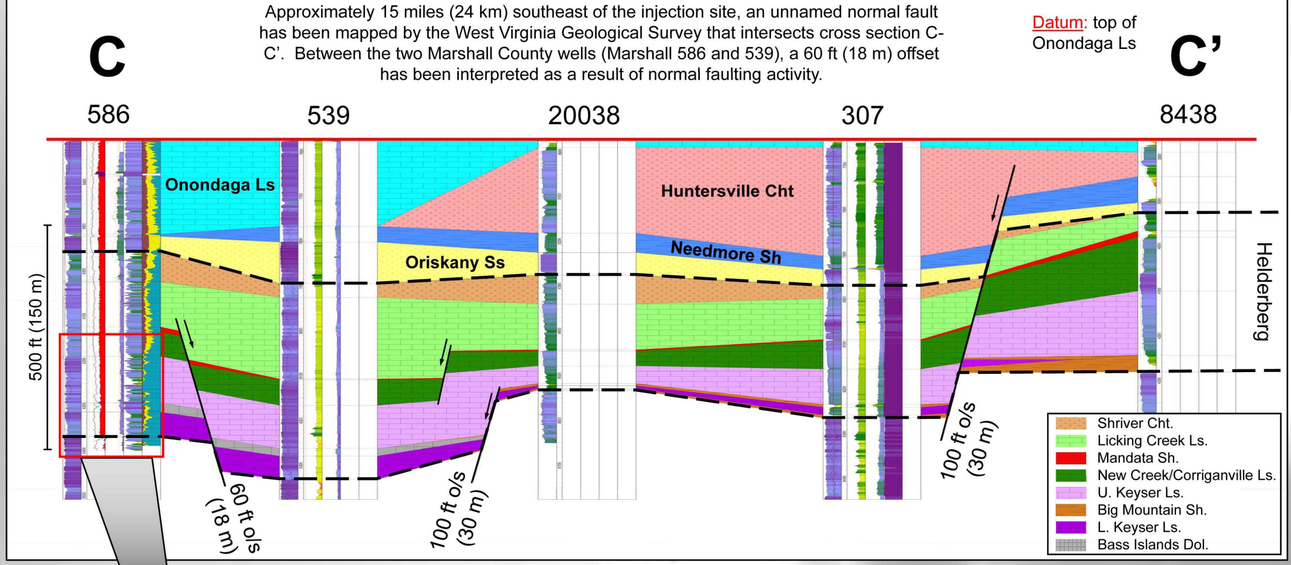


Battelle ran a five-mile (eight km) long seismic survey across the study area and no major normal faults were apparent. Interestingly, their east/west seismic line shows what could be a two to three mile (3.2 - 4.8 km) wide carbonate buildup.

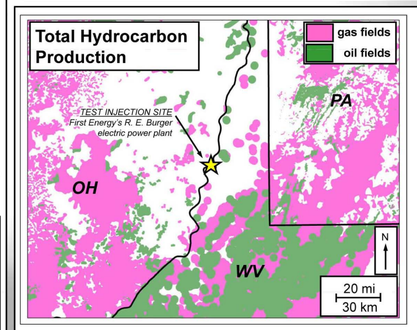


Approximately 15 miles (24 km) southeast of the injection site, an unnamed normal fault has been mapped by the West Virginia Geological Survey that intersects cross section C-C'. Between the two Marshall County wells (Marshall 586 and 539), a 60 ft (18 m) offset has been interpreted as a result of normal faulting activity.

Datum: top of Onondaga Ls

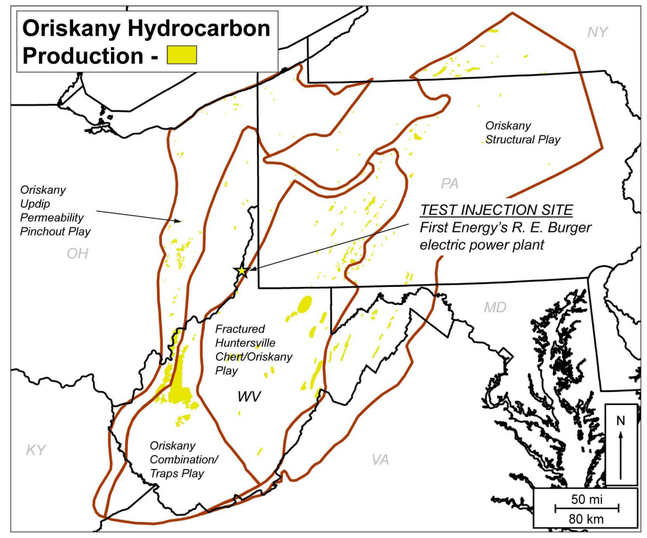


Total Hydrocarbon Production



The nearest hydrocarbon production is over two miles (3.2 km) to the north of the target well.

Oriskany Hydrocarbon Production -



The possibility that fractures have been sealed with calcite exists, although there are no structural hydrocarbon traps in the area that might help prove this.

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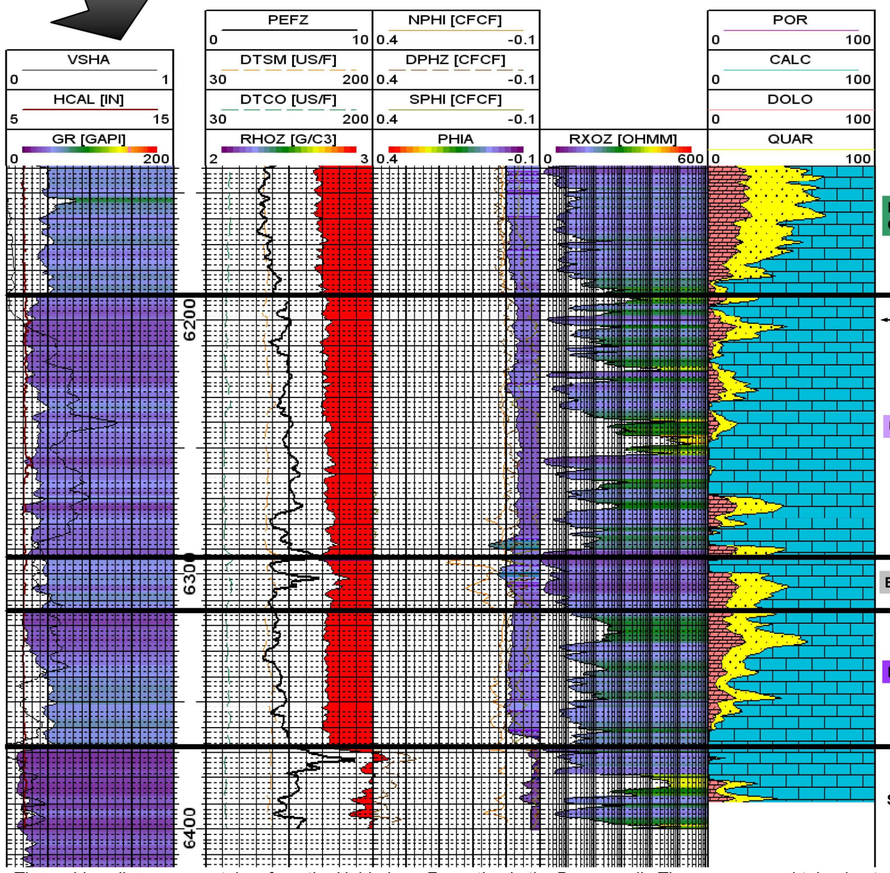
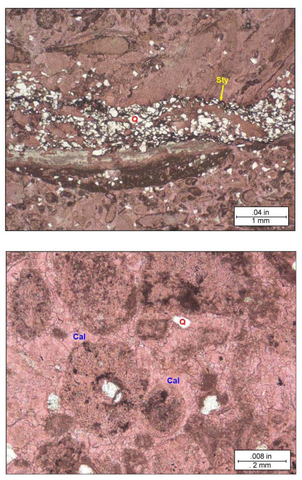




Q-Quartz, Cal-Calcite and Sty-Stylolite.

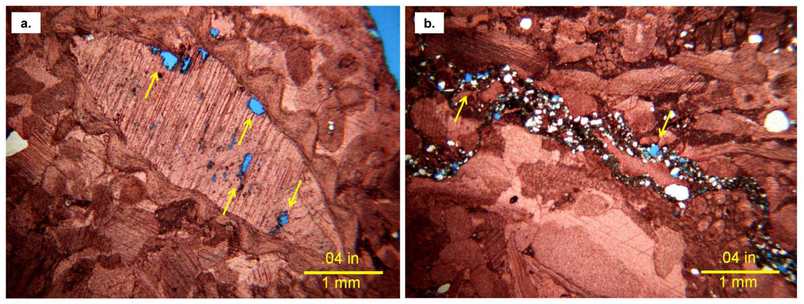
Three sidewall cores were taken from the Helderberg Formation in the Burger well. The cores were obtained out of what we interpreted to be the Shriver Chert (6000 ft (1,830 m)), the Upper Keyser Limestone (6200 ft (1890 m)), and the Lower Keyser Limestone (6350 ft (1935 m)). Descriptions for all three are identical: Limestone, grey, very fine grained, microcrystalline, very fossiliferous. One thin section was made from the Upper Keyser Limestone sidewall core and the description is as follows: grainstone with fossil fragments (mollusks and echinoderms) as principle allochems, calcite cement and no pores visible.

Conclusion

Most studies of the Helderberg have taken place along the outcrop belt from West Virginia to New York. As a result, little work had been done in our area of interest prior to this study. Compared to the eastern outcrop belt, the structure in the immediate study area is relatively simple; however, any structural variations that do exist must be taken into account when considering injection of *any* substance into the subsurface.

An attempt to inject carbon dioxide into the Burger Well was made in early December, 2008. Injection pressure proved to be higher than anticipated, so only a small amount of carbon dioxide was sequestered. Although the initial data showed sequestration potential, attempts to inject CO_2 at higher pressures proved futile due to low permeability in the target formations.

Thin Sections



Thin section analysis suggests that most primary porosity has been filled during early cementation; however; secondary, intragranular porosity (a) remains in addition to porosity along stylolites (b). Samples taken from the Keyser Ls. at Bull Pasture Mountain in VA.

References

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