CO_2 STORAGE AND SEQUESTRATION POTENTIAL OF DEPLETED OIL FIELDS

GEOFF GALLANT & THOMAS L. DAVIS

<u>CO_2 STORAGE ANALYSES HAVE BEEN CONDUCTED ON SELECT OIL FIELDS</u>

- Assessment of each field is conducted by producing zone
- Carbon storage volumes are calculated based on withdrawn oil or gas volumes and assumes injected CO_2 will occupy this volume. Assessment does not account for diffusion/dissolution of injected CO2 with boundary waters or injection into water bearing areas of the evaluated horizon
- CO_2 storage volumes based on reservoir conditions at expected capacity, with CO_2 density calculated by an equation of state for a given pressure and temperature. The calculation can be accessed here: http://www.energy.psu.edu/tools/CO2-EOS/index.php
- Viability of any given horizon in any given field is based on the following criteria:

<u>Logistical</u>

1. Target reservoir capacity minimum. <u>NOTE: This value should be considered a baseline number of tonnes that can be stored within **depleted hydrocarbon reservoirs** under criteria conditions, and does NOT account for additional storage capacity through dissolution into water-bearing parts of the field or any additional saline aquifer disposal activity within the field area.</u>
    - Kern County annual emissions = ~35-40 million tonnes.
    - Estimated 10% from industrial point sources (Capturable). 4 million tonnes/yr
    - Reservoir must be of sufficient size to be economically viable. Minimum ultimate storage capacity must exceed **<u>2 million tonnes</u>**.
2. Target reservoir proximity to point source.
    - Due to transportation costs, storage reservoir must either be:
        - close to point source (within 30 miles)
        - have access to viable transportation pipeline (re-activated oil/gas pipeline?)
    - Maximum source to storage distance = **<u>50 miles</u>**
3. Target reservoir activity.
    - Target storage reservoir should be either:
        - Depleted (not actively producing)
        - Nearing depletion - is likely to be depleted/rendered operationally defunct within injection time frame (barring EOR benefits from CO_2 injection). Reservoir will not actively produce once reservoir reaches storage capacity (beyond CO_2 cycling for EOR purposes).

<u>Geological Conditions</u>

4. Target reservoir will have adequate pressure at capacity.
    - Reservoir capacity pressure will be in excess of 1100 psi to keep CO_2 as supercritical fluid at capacity.
    - Reservoir capacity pressure will not exceed 80% of discovery pressure. This provides a 20% "buffer" in order to not compromise reservoir seal (either the geological seal or plugged wells penetrating the reservoir).
    - Discovery reservoir pressure must then exceed 1400 psi.
5. Faulting/compartmentalization of reservoir is minimal.
    - Reservoir should not be broken up by numerous faults forming separate sealed compartments.
    - Storage reservoir compartments should exceed at least **<u>160 AC (one quarter of a square mile or section)</u>**.
    - Smaller reservoir compartments should not be considered in order to avoid the potential of over-pressuring the storage compartment and compromising reservoir seal.
6. Reservoir faults not connected to surface or near-surface
    - Faults may provide conduits for vertical migration of highly mobile CO_2 as either a super critical fluid or as a vapor phase from SCF as pressure reduces.
    - Any faults intersecting the storage reservoir should not:
        - extend to surface
        - extend to shallow permeable zones (aquifers) that may have surficial expression
7. Reservoir faults are not seismically active.
    - Seismically active faults can be defined as:
        - Surficial expression and evidence of recent displacement.
        - Subsurface faults (ie "Blind Thrusts") with substantial offset displacements suggesting that fault movement is ongoing or has potential to be ongoing.
    - Storage reservoirs should not be located in fields where faults meet these criteria, or adjacent to faults where injection & re-pressuring or target reservoir may influence seismicity (ie. Oklahoma-type injection-related induced seismicity must be avoided).
8. Reservoir thickness is adequate.
    - Storage reservoir must be of sufficient thickness to accommodate adequate injection rates and ultimate capacity.
    - Target reservoir should be a minimum of **<u>100 feet thick</u>** over storage area (ie. depleted reservoir)
9. Lateral surficial expression of target horizon.
    - Potential lateral migration of CO_2 to the surface must be avoided
    - Target reservoir should not have any surface expression within **<u>3 miles or 3x reservoir depth</u>** from storage area
10. Target reservoir has sufficient overlying (vertical) seal thickness.
    - to avoid vertical migration of stored CO_2, overlying seal should be a minimum of **<u>500 feet thick</u>**
11. Target reservoir has adequate porosity.
    - In order to provide sufficient storage capacity, **<u>porosity should exceed 18%</u>**.
12. Target reservoir has adequate permeability.
    - In order to provide sufficient injection rates, reservoir **<u>permeability should exceed 100 millidarcies</u>**.
    - Reservoir must be able to accept economic injection rates without drastically increasing the injection pressure gradient near the injector to minimize potential leakage within borehole (by compromised cement, induced fracturing, etc.)
    - Reservoirs with demonstrated **<u>production or injection rates of >1,000 Barrels per day</u>** would also demonstrate adequate injectivity
13. Target reservoir does not contain or is in contact with potentially CO_2-reactive materials.
    - Target reservoir does not contain carbonate rocks in sufficient quantities that the expected generation of carbonic acid and dissolution of carbonate reservoir matrix will lead to compromised reservoir conditions such as compaction, loss of porosity, etc.
    - Target reservoir does not contain CO2-reactive minerals (especially expanding clays) that may lead to compromised reservoir conditions such as porosity loss, plugging of pore throats near injectors, etc.
    - Target reservoir fluids do not contain potentially reactive dissolved components that could lead to formation of precipitates and consequent porosity loss and plugging

<u>Drilling/Engineering/Operational</u>

14. CO_2 injection potential for Enhanced Oil Recovery (EOR).
    - Oil reservoir contained low gravity or high viscosity crude that may benefit from increased mobilization from CO_2 injection
    - Production activity from target reservoir would only be maintained and continued through CO_2 injection. Production activity would cease once reservoir reaches capacity or only continue with CO_2 cycling of already injected volume
15. Low well penetration density.
    - Densely drilled reservoirs should be avoided to minimize leakage risk through previously plugged wells
    - Well penetration density should be **<u>less than 100 wells per square mile/section, or 1 well per 6.4 acres</u>**.
16. Well integrity - No "old" wells or badly abandoned wells.
    - Reservoirs with numerous penetrations by wells drilled, and especially abandoned, prior to 1930 should be avoided since well abandonment requirements were inadequate or well was poorly abandoned (consisted of filling hole with bricks, dirt, sump fluids, etc)
    - Wells plugged and abandoned through the use of cavity shots (explosion to create a void or rubble zone) within 1,000 vertical feet of the target storage reservoir
    - Wells without a cement plug across the target reservoir interface, thus providing a conduit to adjacent formations

Each checklist factor is arranged as follows;
✓ for factor that meets criteria
× for factor that does not meet criteria
⊗ for factor that does not meet criteria and is a disqualifying factor for storage reservoir consideration
? for factor that is unknown in regards to criteria

THOMAS L. DAVIS, GEOLOGIST
Ventura, CA
www.thomasldavisgeologist.com
tldavisgeo@gmail.com