MMV Support for SECARB Phase II Field Demonstration Projects

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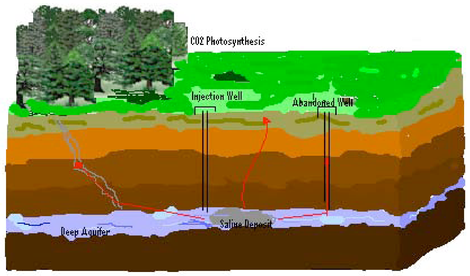
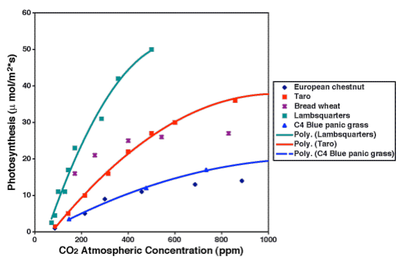
Identify Emerging Technologies to Fill MM&V Gaps

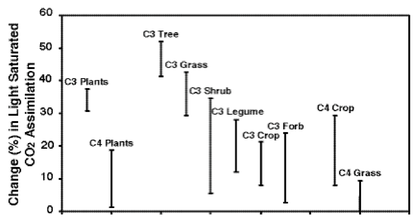
- Review of techniques applicable to quantification of CO_2 (reservoir, groundwater, soil, atmosphere).
- Identification of novel measurement techniques.
- Evaluation of instrumentation required for pipelines.
- Development of an MM&V relational database.
- Background on spatial and temporal variations of CO_2 (atmospheric and soil gas).



Major MM&V Challenge - Accurately Identifying and Quantifying CO_2 Seepage

- Coefficients of variation of natural CO_2 flux (seasonal and diurnal variations) over limited areas have been found in the range of 25 - 85%.
- A large number of samples are required to achieve an accurate measurement with an acceptable precision.
- CRDS and tracers with portable GC, GC/MS measurement frequency will be limited until market-driven forces become active.

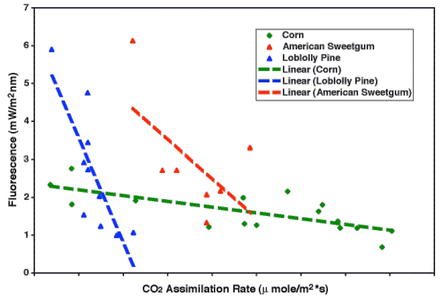




Photosynthetic response to elevated CO_2 concentrations in various C_3 and C_4 Plants; greenhouse simulations, growth chambers and open-top chambers (left panel)[1,2] and free air CO_2 enrichment (FACE) conditions (right panel).[3]

Use of Fluorescence to Monitor Enhanced Plant Growth and Locate Seeps (concept in development)

- Chlorophyll fluorescence - carbon dioxide fixation
  - climate change
  - terrestrial sequestration.
- Instruments commercially available (lab and field).
- Measurements less complicated than traditional photosynthesis measurements (leaf respiration).
- Fluorescence inversely correlated to plant carbon assimilation.[4,5]
- More CO_2 incorporated into the plant reduces fluorescence as the rate of electron transport is lowered.



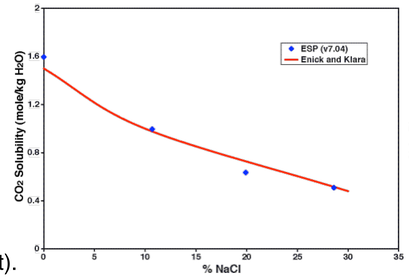
Support Field Validation MM&V

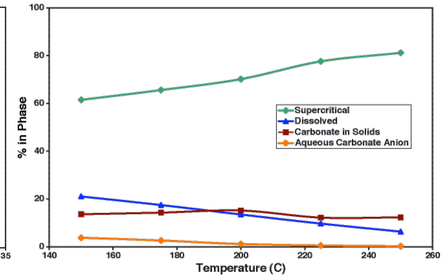
- Down-selection of conservative tracers for ECBM (Black Warrior project).
- Physical properties[6] (solubility, vapor pressure, Mw, B.P., M.P.) of fluoro-carbon (and other) molecules that have been employed in oil recovery and sequestration studies were compared with anticipated seam conditions (150 psi, 50˚C).
- CO_2 within the thin coal seam will exist in the vapor phase.
- Desired tracer has limited solubility, is already in the gas phase and will exhibit minimal adsorption on the coal.
- Down-selected tracer candidates will be analyzed using coal from actual core samples.

Tracer	MW (g/mol)	B.P. (°C)	Density (kg/L) STP	Solubility in H20 STP ln(x_1) (mole fraction)
CO_2	44	-78.5	0.00198	-1.311
CH_3F	34	-78.4	0.5786	-6.725
CH_2F_2	52	-51.6	0.909	-7.301
SF_6	146	-63	0.0066	-12.186
SF_5	196	-21		
C_2F_6	138	-79	1.59 (-78°C)	-13.786
C_3F_8	188	-36.7	0.0082L	-14.395 (15°C)
PCB	200	-6	1.724	-12.814
PDCB	300	45	1.62	-12.31 to -21.52 (see text)
PMCP	300	50	1.707	-12.31 to -21.52 (see text)
PMCH	350	75	1.788	-12.31 to -21.52 (see text)
PDCH	400	102	1.828	-12.31 to -21.52 (see text)
PECH	400	101.7	1.788	-12.31 to -21.52 (see text)
PTCH	450	127	1.888	-12.31 to -21.52 (see text)
iPPCH	450	130		-12.31 to -21.52 (see text)
nPPCH	450	130		-12.31 to -21.52 (see text)

Support Field Validation MM&V

- Thermodynamics - model validation activities.
- Environmental Simulation Program (ESP, OLI Systems Inc.)[7]
  - interphase (solid-liquid-vapor) and intraphase equilibria (redox, co-precipitation)
  - extensive unit operations.
- Model accurately predicts CO_2 solubility in brine and phase behavior.[8]
- Survey calculations based on the work of Kaszuba, et al.[9]
- Solids predicted (200˚C, 200 bar) magnesite ($MgCO_3$), siderite ($FeCO_3$), $CaMg_3(CO_3)_4$, SiO_2, $KAl_3(OH)_6(SO_4)_2$.
- Magnesite, analcime ($NaAlSi_2O_6{\cdot}H_20$), and smectite (clays) were observed.
- Work on incorporating kinetics into the model is in progress.





References

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Acknowledgements

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