Experimental study on the influence of CO_2 on rock physics properties of a typical reservoir rock with the use of ultrasonic velocity, resistivity and X- ray CT Scanner

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Motivation

- Effect of sub-core scale heterogeneities on fluid distribution pattern in CO_2 - brine system.

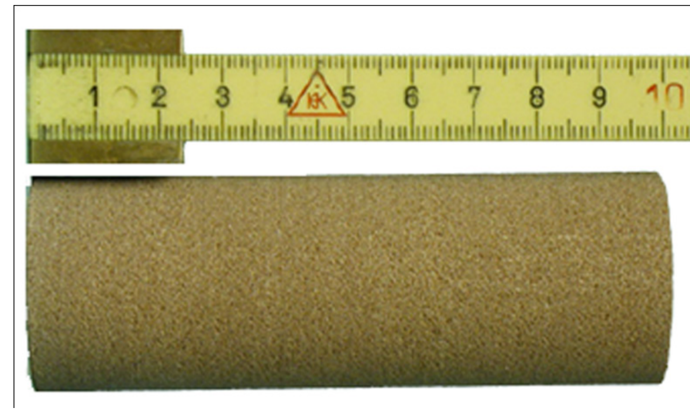
- Evaluate the influence of fluid saturation level and distribution pattern on laboratory measured rock physics properties (ultrasonic velocity, amplitude and resistivity).

- Correlate geophysical measurements with relative saturation of fluids.

Experimental parameters

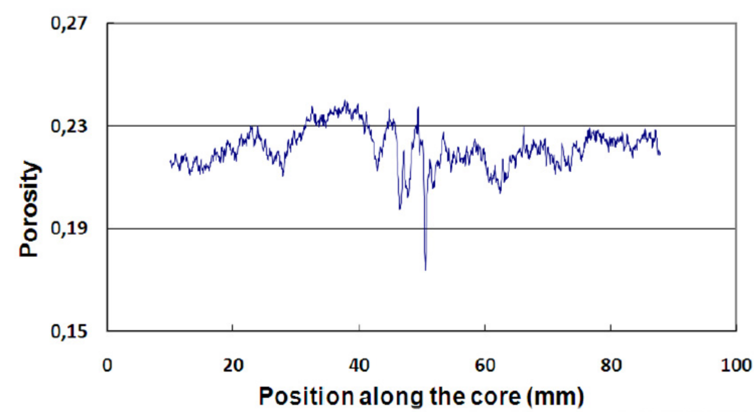
Material properties

- —Rothbach sandstone (moderate layering)
- —Sample #1-drilled perpendicular to layering
- —Sample #2- drilled parallel to layering
- —Length = 100 mm
- —Diameter = 38 mm
- —Porosity = 23%
- —Pore volume (PV) = 26 ml
- —Permeability = 400 mD

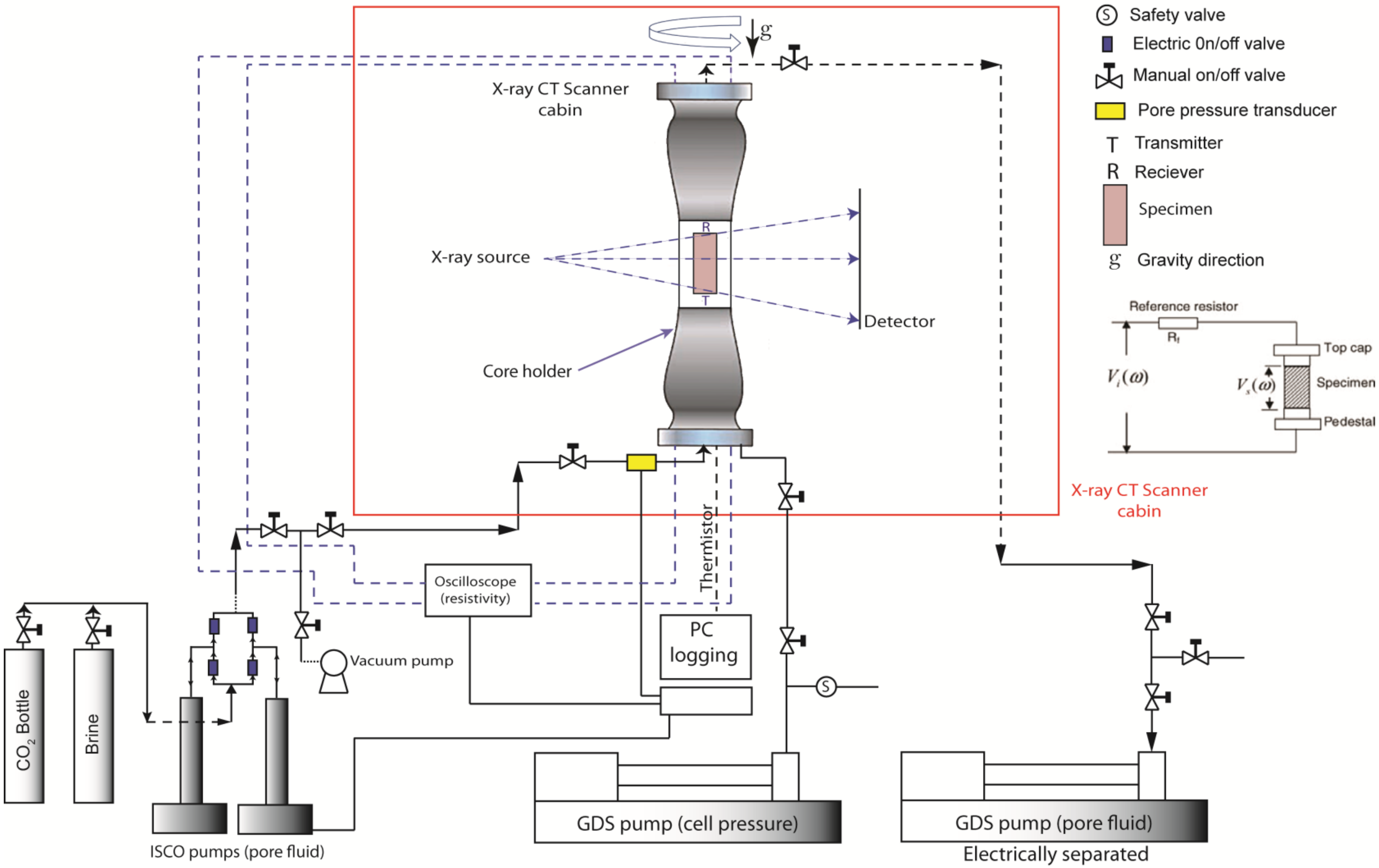


Pore fluids

- —CO2 (liquid), 20 °C and 10 MPa (pore pressure)
- — 25 MPa cell pressure (effective stress = 15 MPa)
- —Brine (50g/l) = (40 g/ L NaCl and 10g/L NaI)
- —Brine Resistivity = 0.16 Ωm



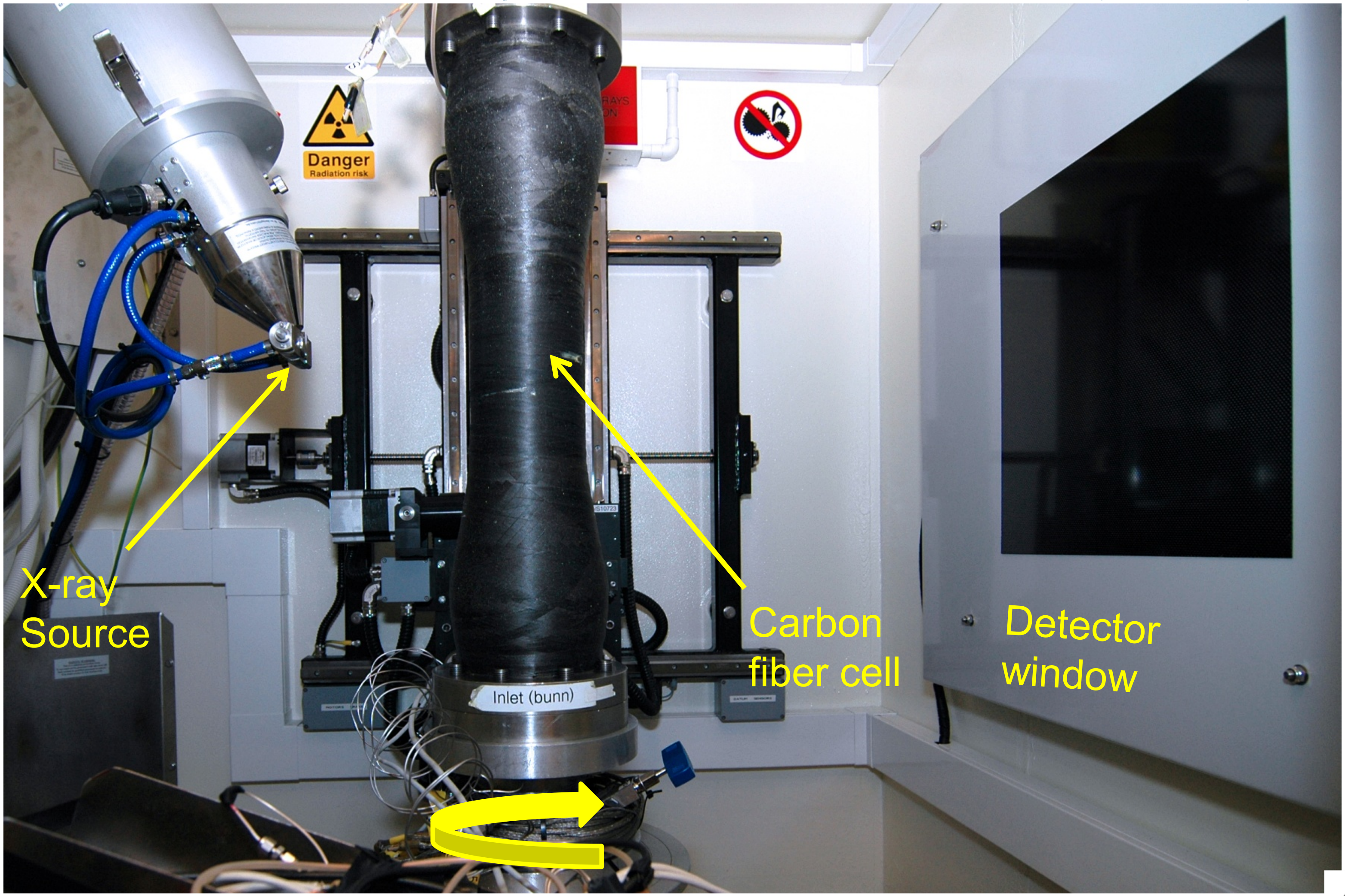
Experimental Setup



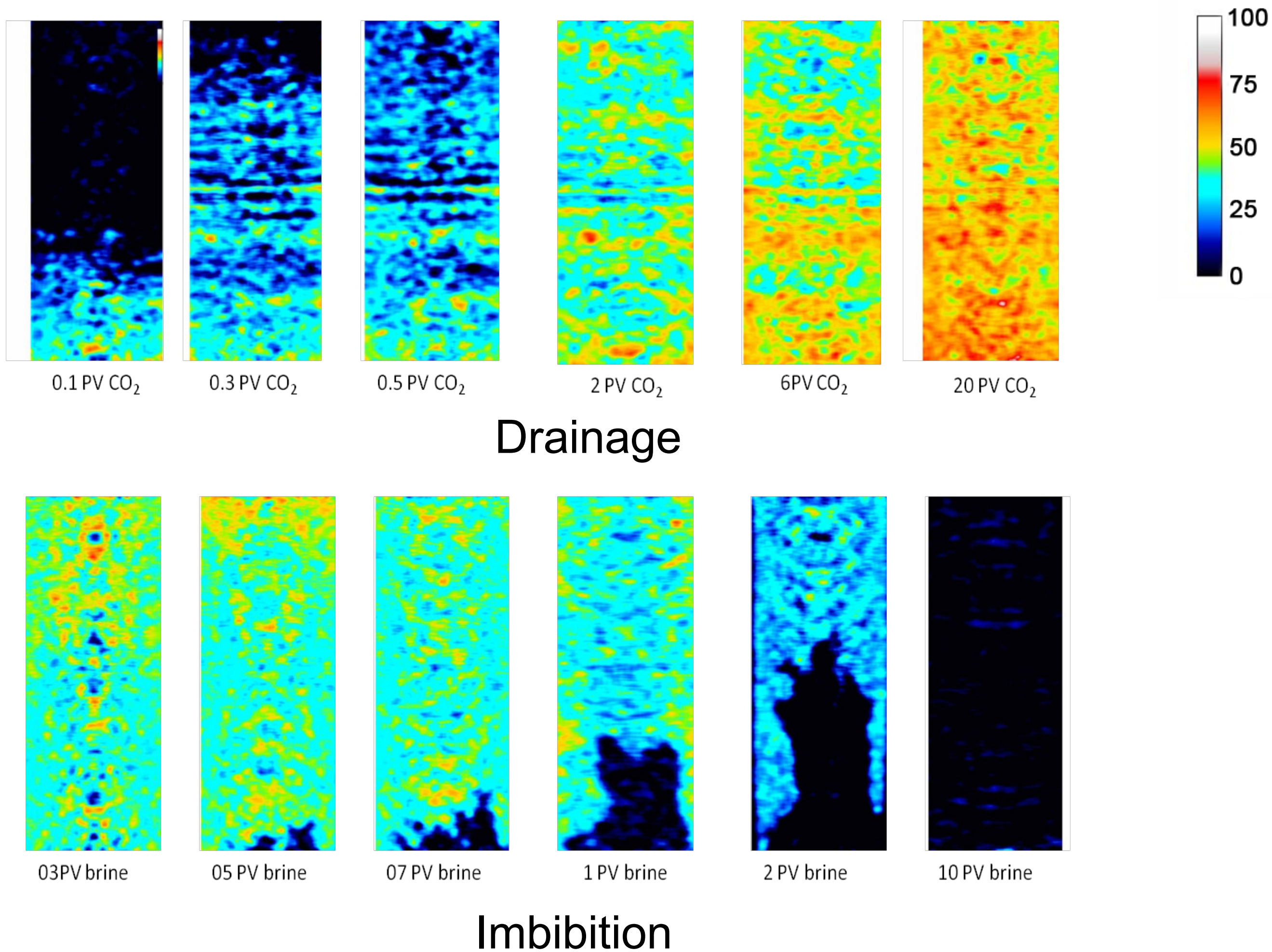
Cartoon of core-holder modified from, Monsen et al., 2005
Resistivity measurement setup Wang et al. 2009

Experimental setup

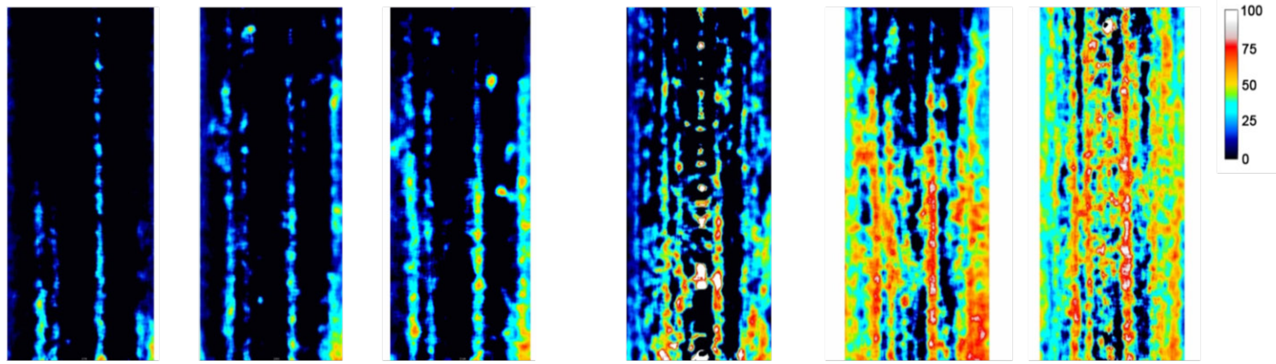
Large cabinet XT H 225/320 LC industrial X-ray and CT system



Sample #1: **Fluid injected perpendicular to layering**

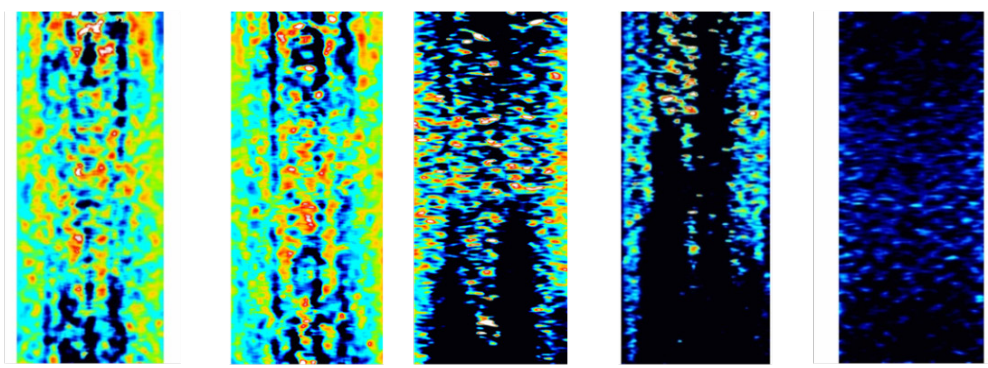


Sample #2: **Fluid injected parallel to layering**



0.1 PV CO_2 | 0.3 PV CO_2 | 0.5 PV CO_2 | 2 PV CO_2 | 6 PV CO_2 | 20 PV CO_2

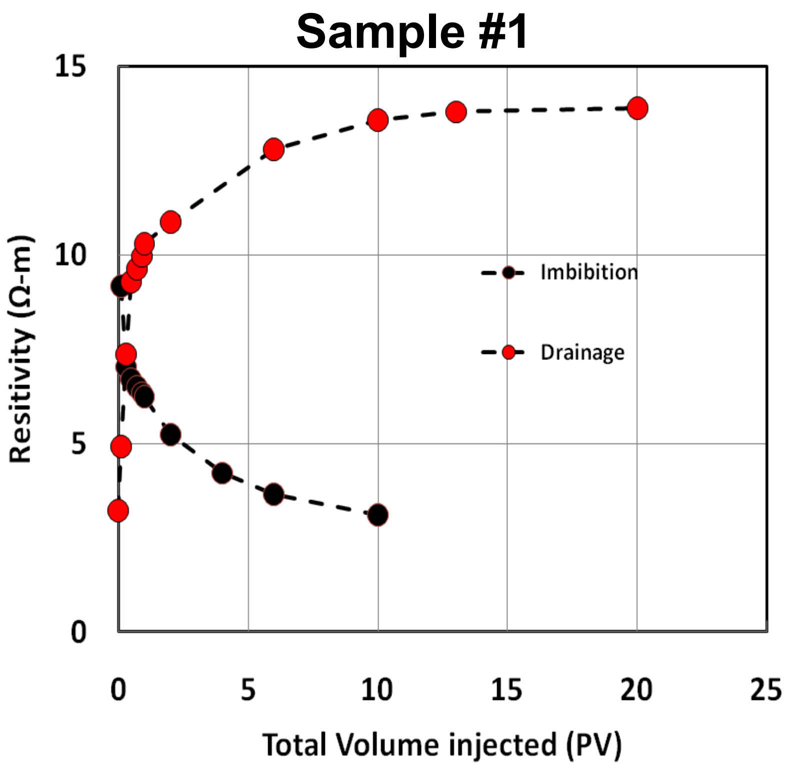
Drainage

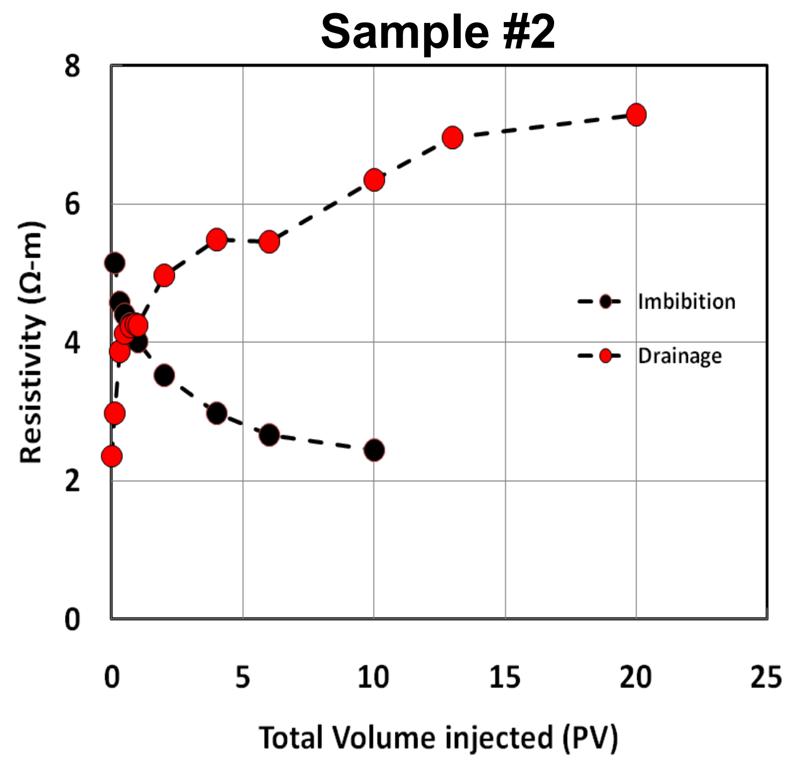


0.1 PV brine | 0.5 PV brine | 1 PV brine | 2 PV brine | 10 PV brine

Imbibition

CO_2 induced resistivity change





$$3.2\ \Omega m \xrightarrow[Sco_2\ (53\ \%)]{20\ PV\ CO_2} 13.9\ \Omega m$$

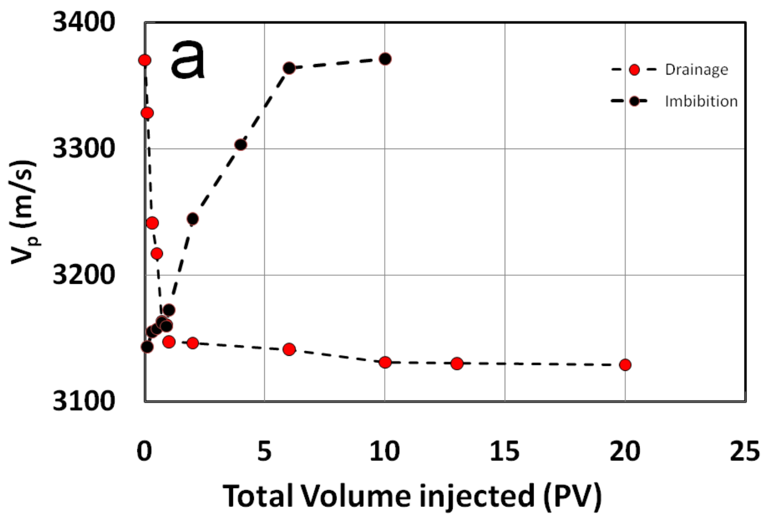
↑ 335 %

$$2.36\ \Omega m \xrightarrow[Sco_2\ (\sim 40\ \%)]{20\ PV\ CO_2} 7.29\ \Omega m$$

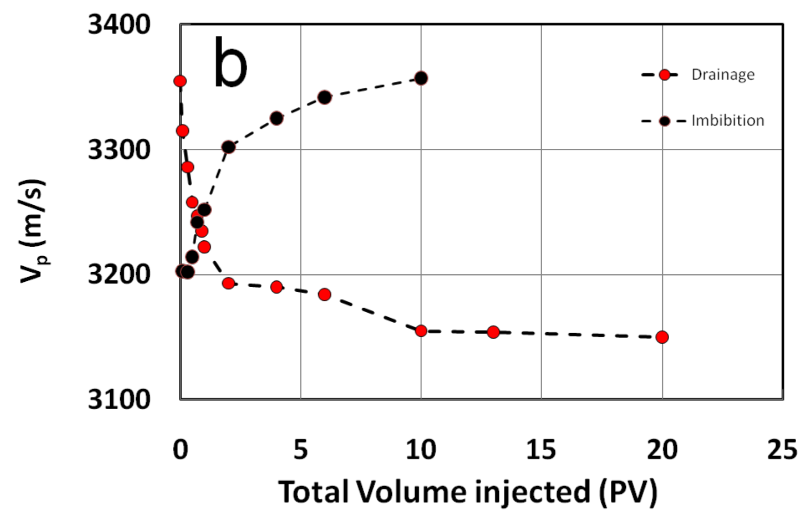
↑ 200 %

CO_2 induced velocity change

Sample #1



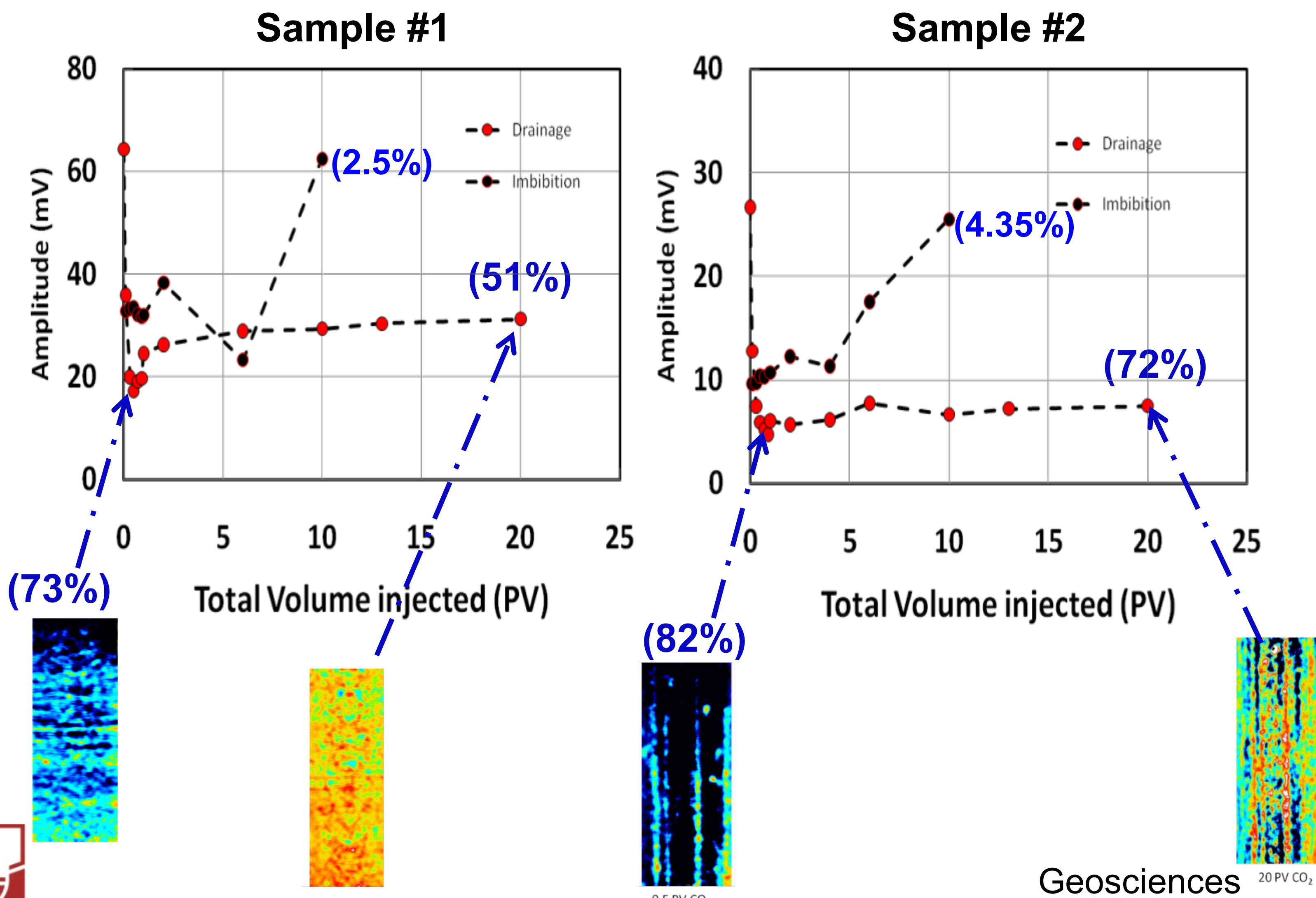
Sample #2



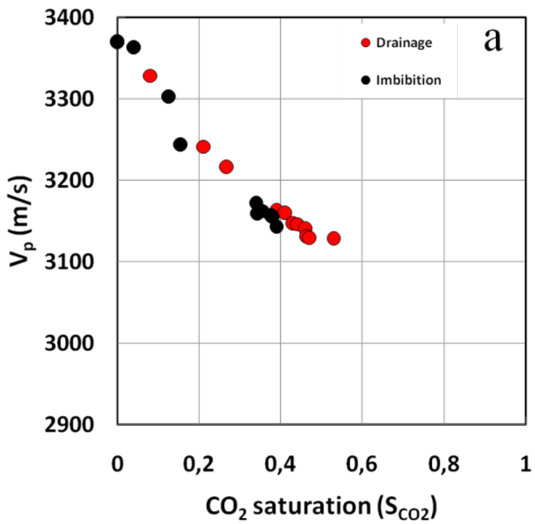
V_p decrease of by 7.2%

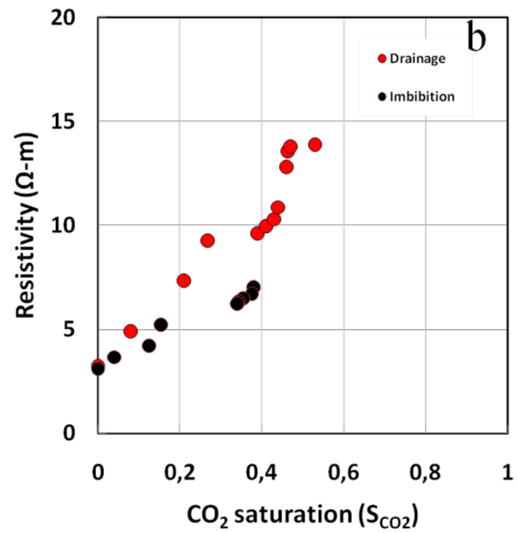
V_p decrease of by 6.25%

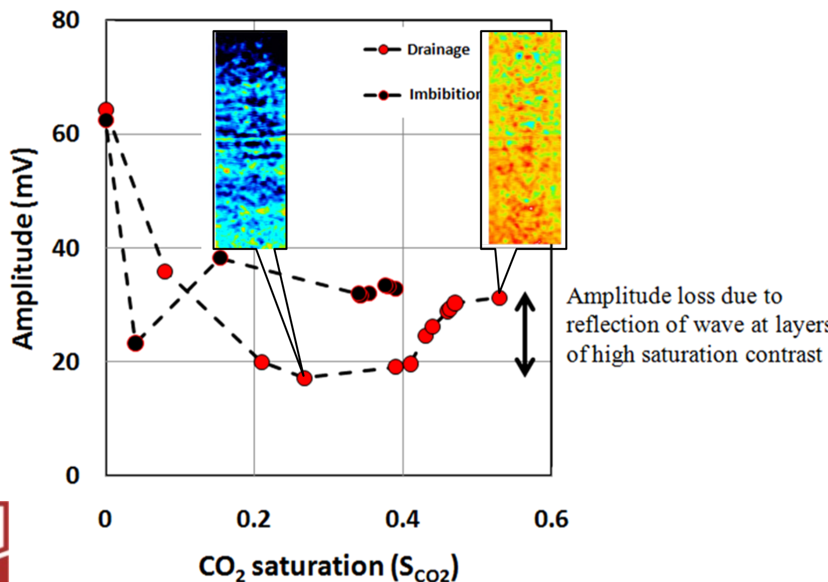
CO_2 induced amplitude change

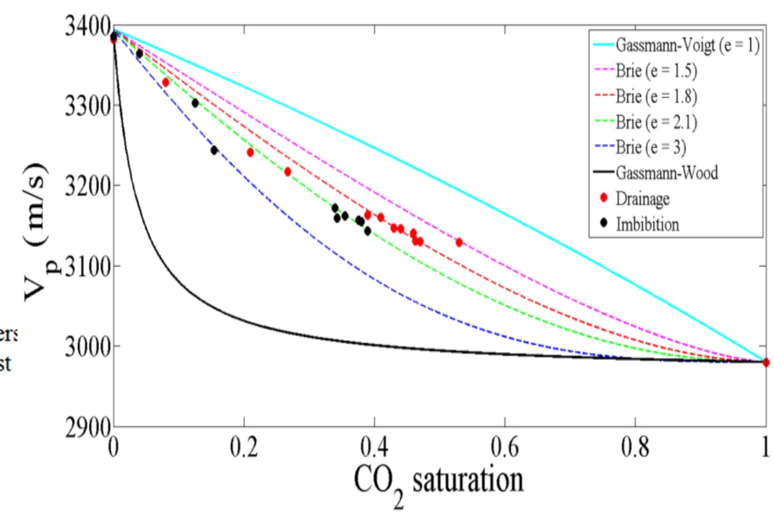


Sample #1: **Fluid injected perpendicular to layering**









Conclusions

- Fluid distribution patterns were dictated by the variation in porosity/ permeability in both samples.
- Distribution and sweeping efficiency of CO_2 was affected by the injection direction relative to the layering in the samples.
- The sensitivity of P-wave velocity and amplitude to changes in CO_2 saturation above 40% was very limited.
- The resistivity and amplitude were significantly affected by the fluid distribution patterns and saturation history (hysteresis) than P-wave velocity.
- The amplitude and resistivity were also more sensitive to minor changes in pore fluid composition: effective to detect low level (residual) CO_2 $\rightarrow$monitoring leakage into overlying formations?
- The amplitude variation was dependent on the relative orientation of fluid distribution heterogeneities relative to the direction of wave propagation.

Thank you!

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