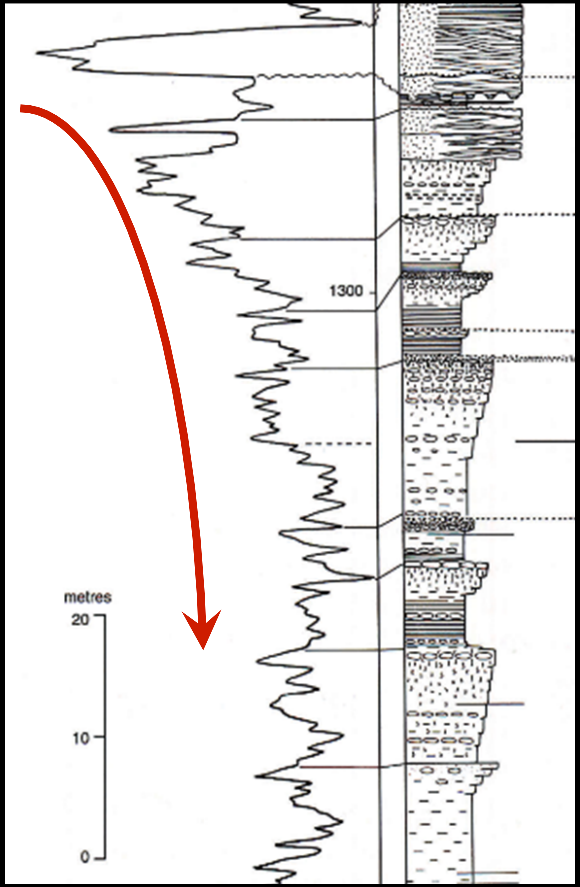
Experimental study to investigate porosity, permeability and velocity development in silt-clay mixtures

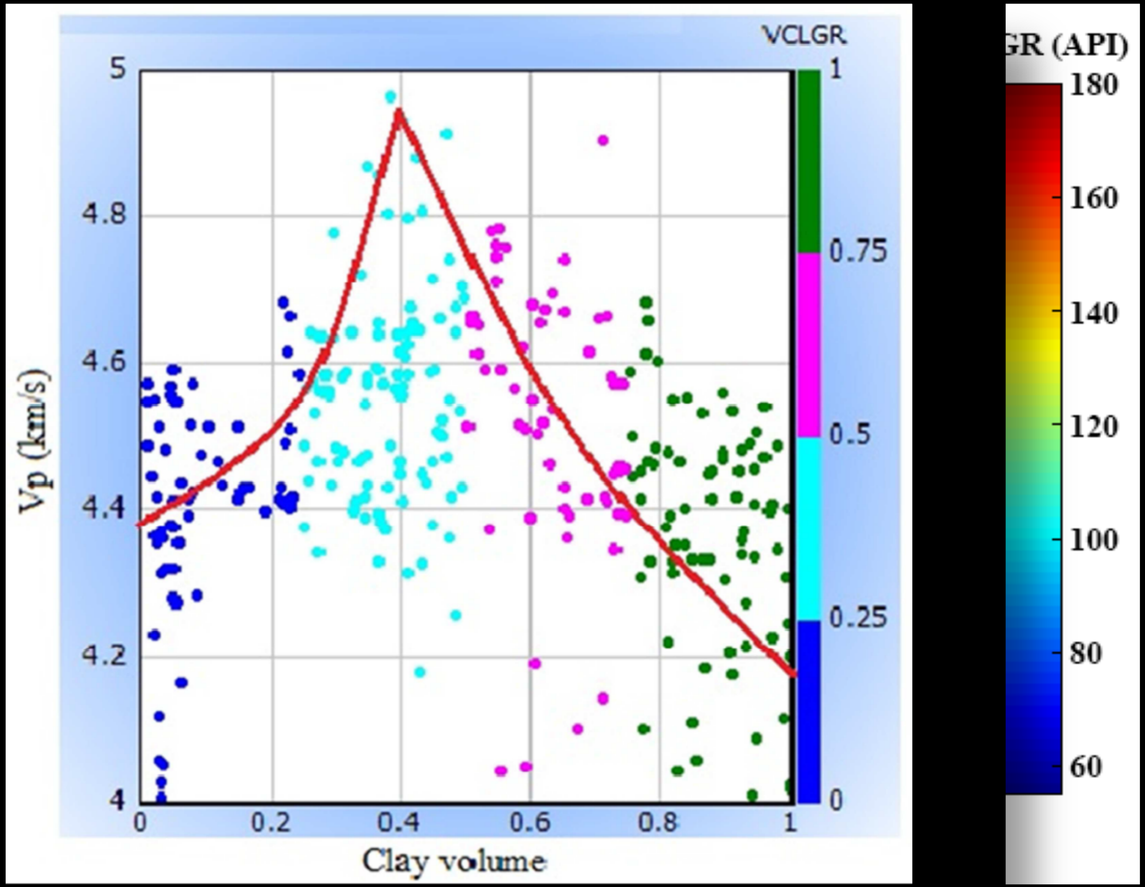
Nazmul Haque Mondol
UiO-NGI

Outline

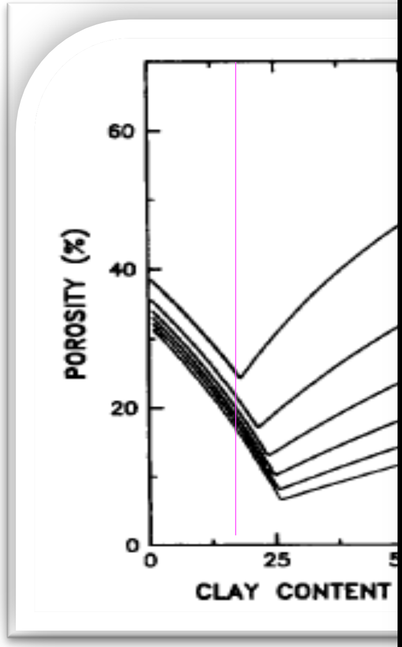
- Background
- Materials and Methods
- Results & Discussion
- Concluding remarks

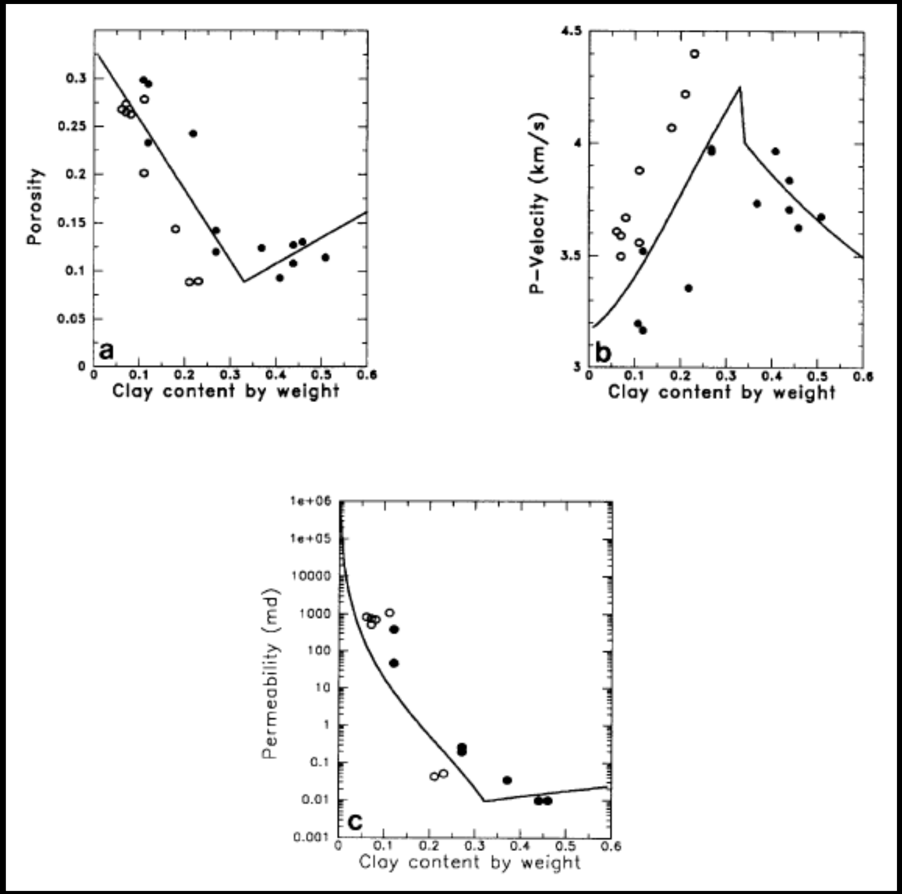
Background


1300
metres
20
10
0

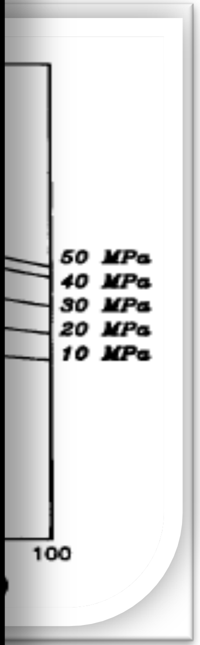

VCLGR
Vp (km/s)
Clay volume
GR (API)
180
160
140
120
100
80
60

Ideal packing model



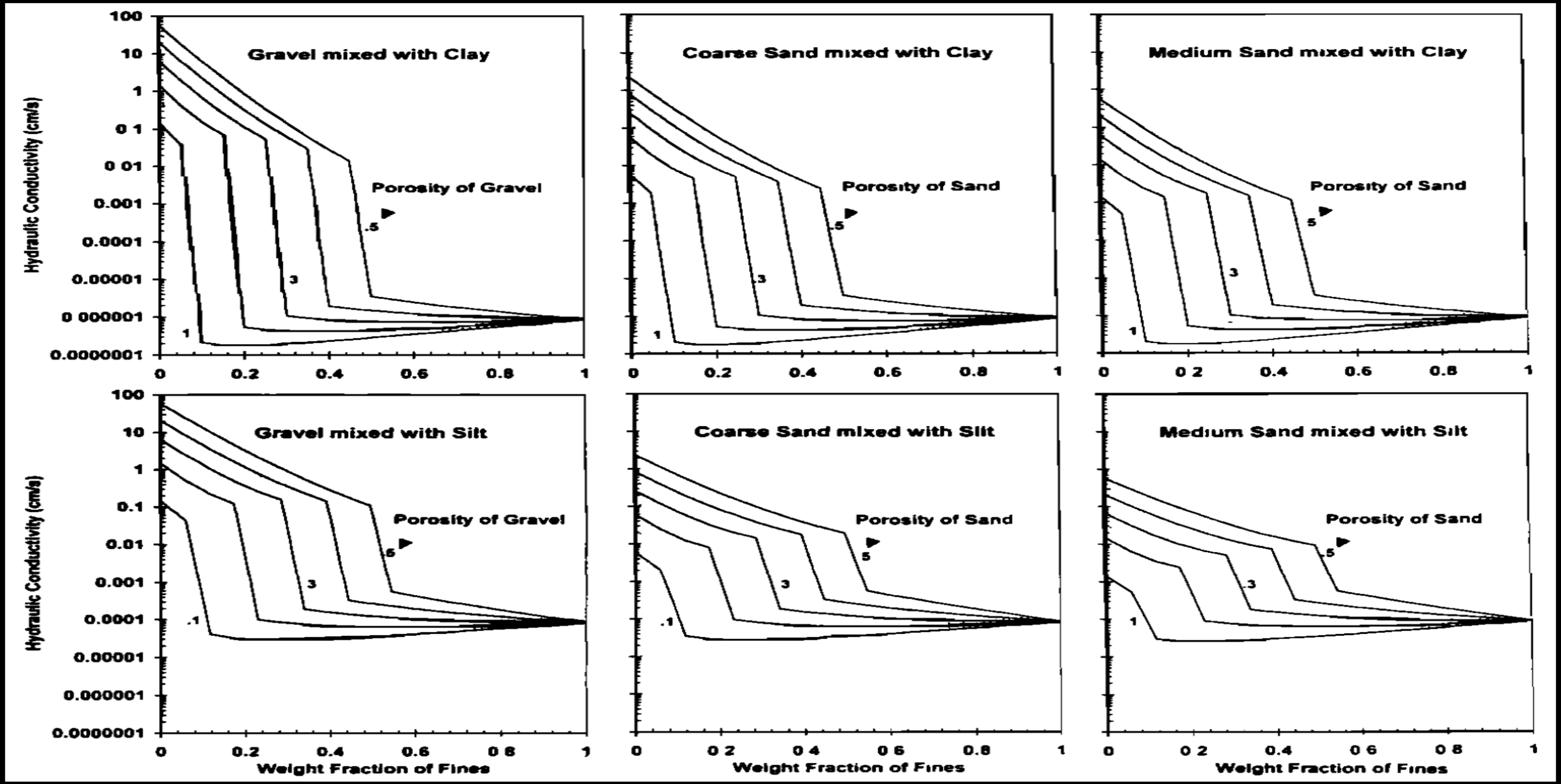


Marion et al., 1989



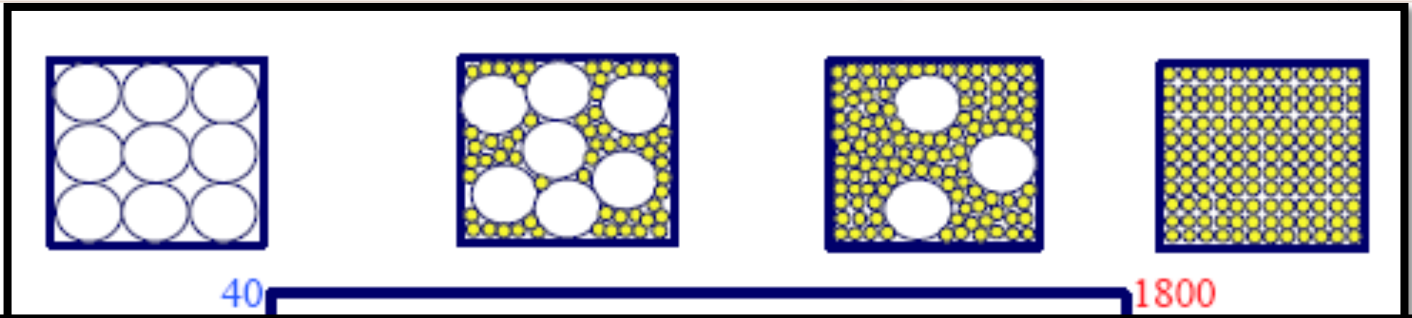
Marion et al., 1992

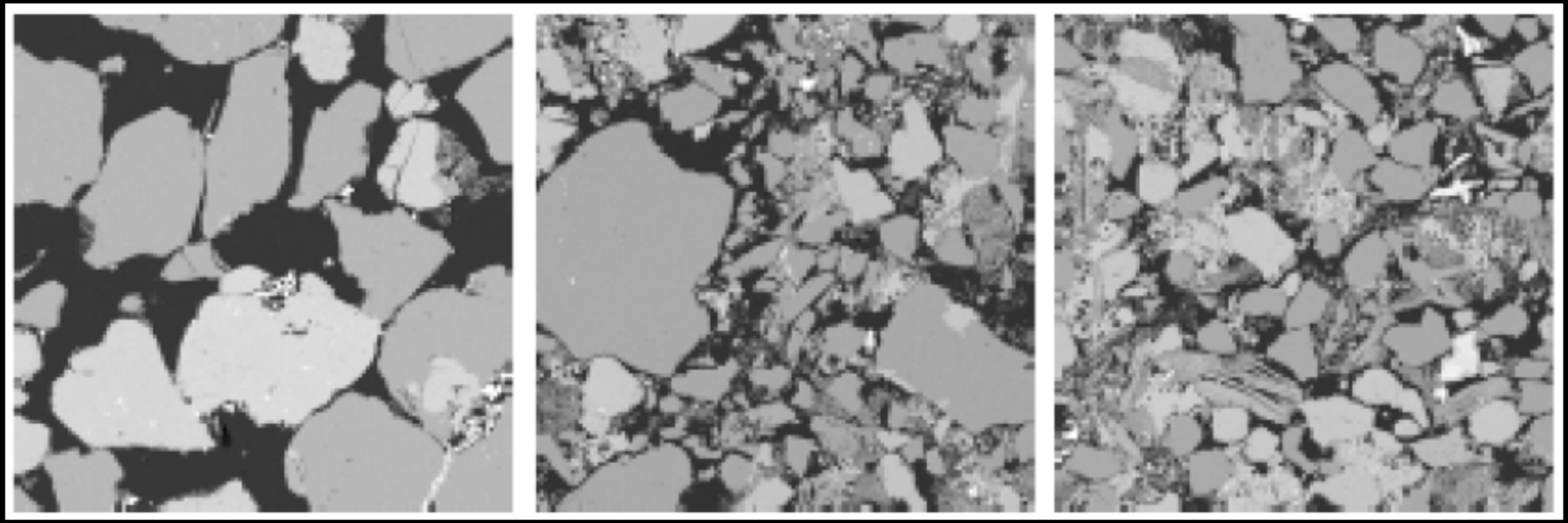
Fractional packing model



Koltermann and Gorelic, 1995

Bimodal mixtures

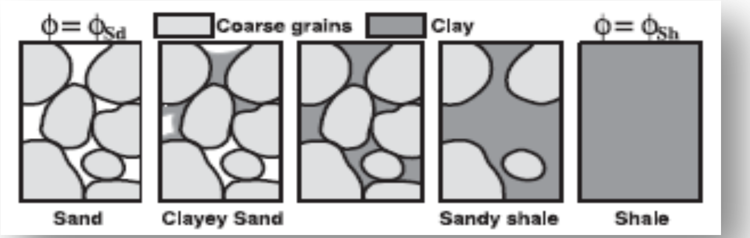


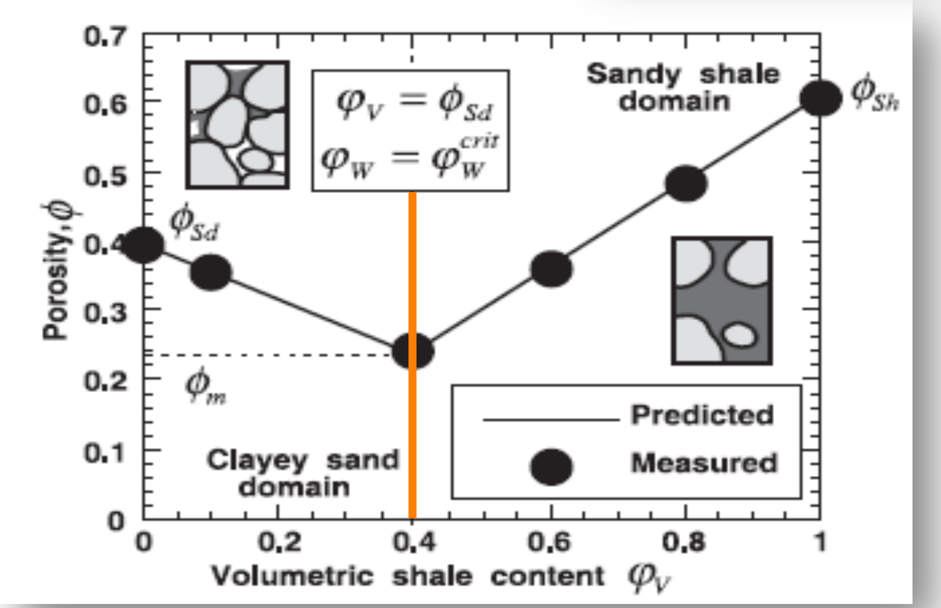


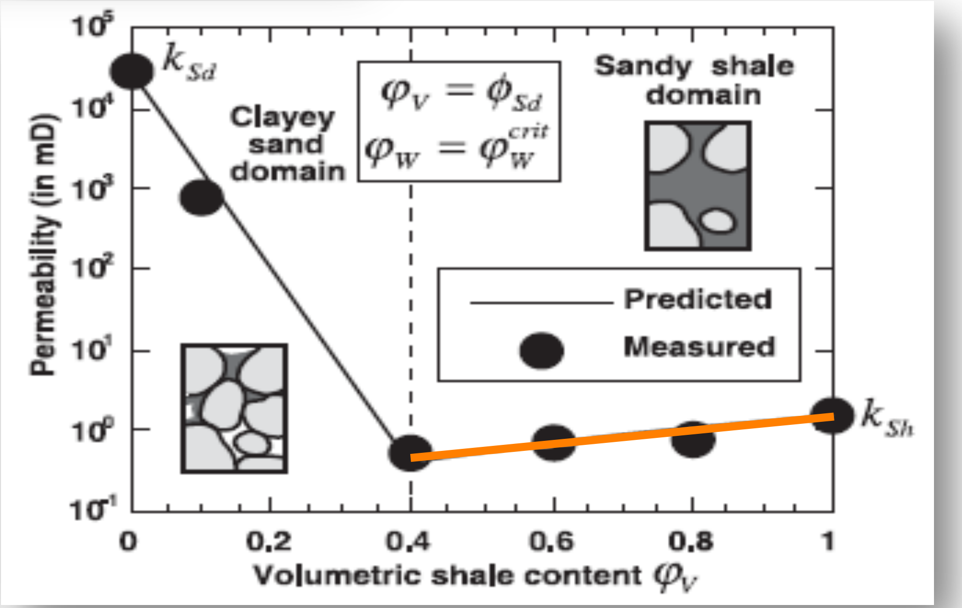
Gutierrez et al., 2001

al., 2001

Porosity-permeability-clay content

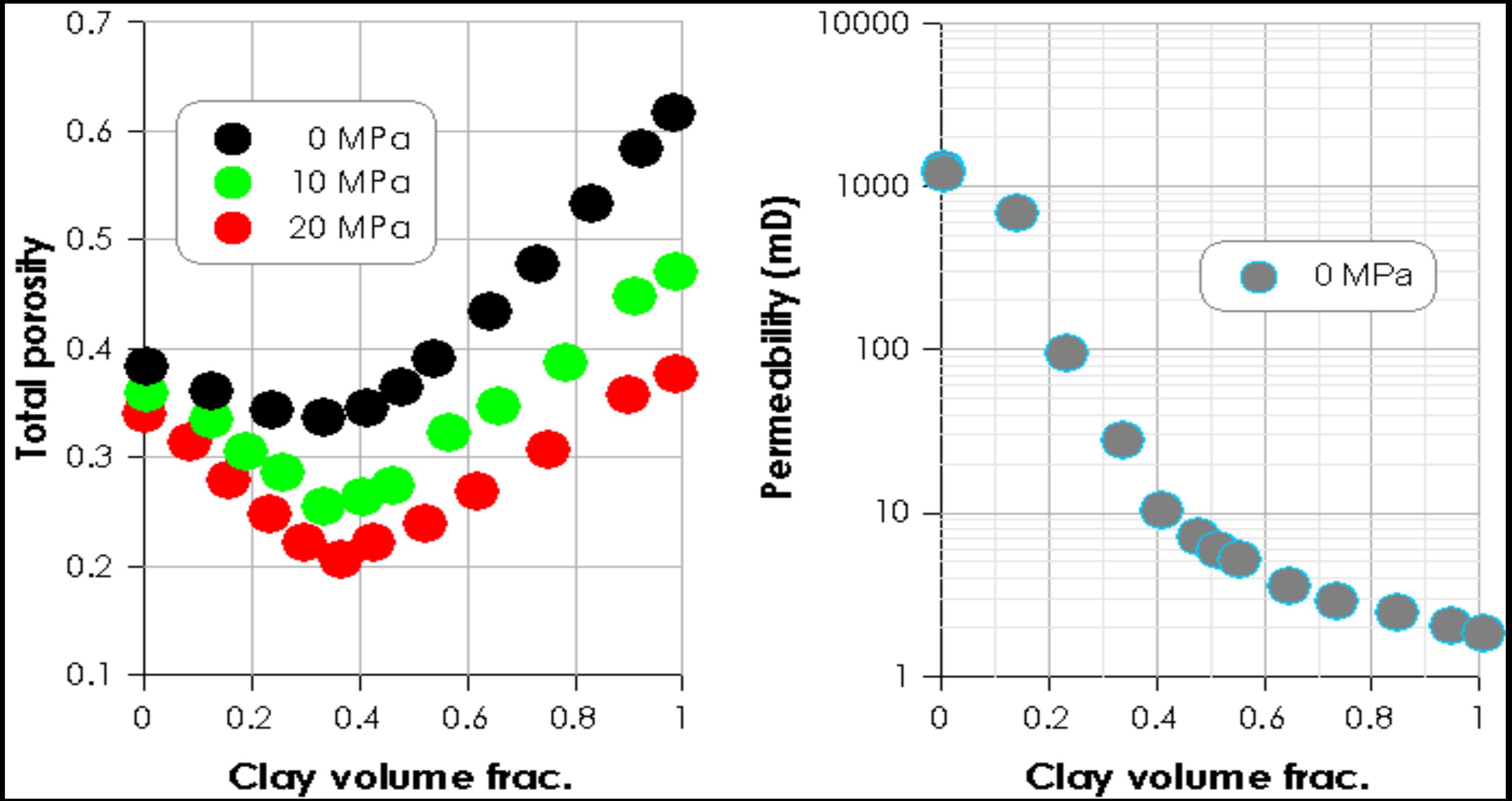






Revil et al., 2002

Porosity-permeability-clay content



Dvorkin & Gutierrez, 2002

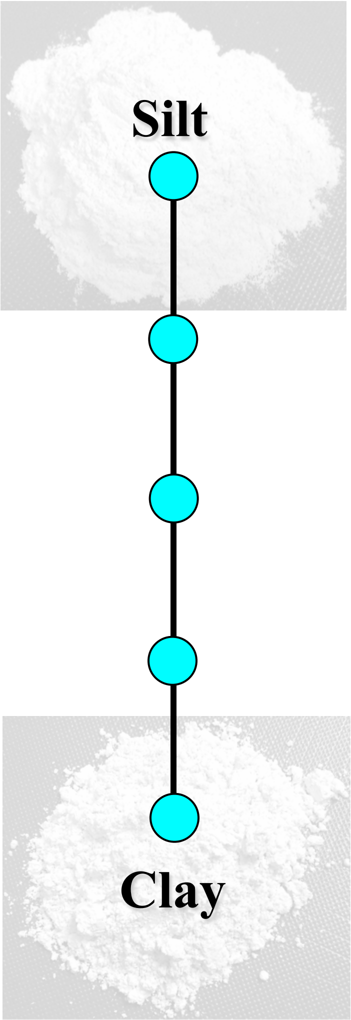
Objectives

- Porosity, permeability and velocity development in mechanically compected silt-clay mixtures.
- Relationship between microfabric and rock properties.

Outline

- Background
- Materials and Methods
- Results & Discussion
- Concluding remarks

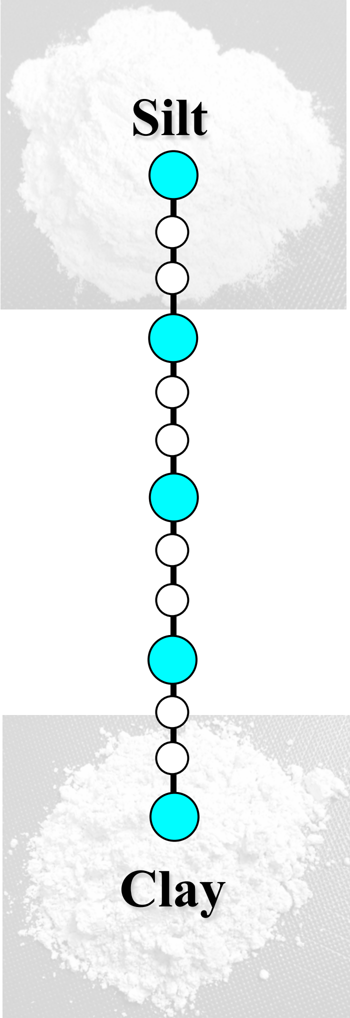
Sample selection



Silt (100%)
Silt (75%), Clay (25%)
Silt (50%), Clay (50%)
Silt (25%), Clay (75%)
Clay (100%)

Synthetic Brine

Sample selection



- ✓ Silt (100%)
- Silt (92.5%), Clay (7.5%)
- Silt (85%), Clay (15%)
- Silt (75%), Clay (25%)
- Silt (65%), Clay (35%)
- Silt (52.5%), Clay (42.5%)
- Silt (50%), Clay (50%)
- Silt (42.5%), Clay (57.5%)
- Silt (35%), Clay (65%)
- Silt (25%), Clay (75%)
- Silt (15%), Clay (85%)
- Silt (7.5%), Clay (92.5%)
- ✓ Clay (100%)

Synthetic Brine

Specimen detail

Clay

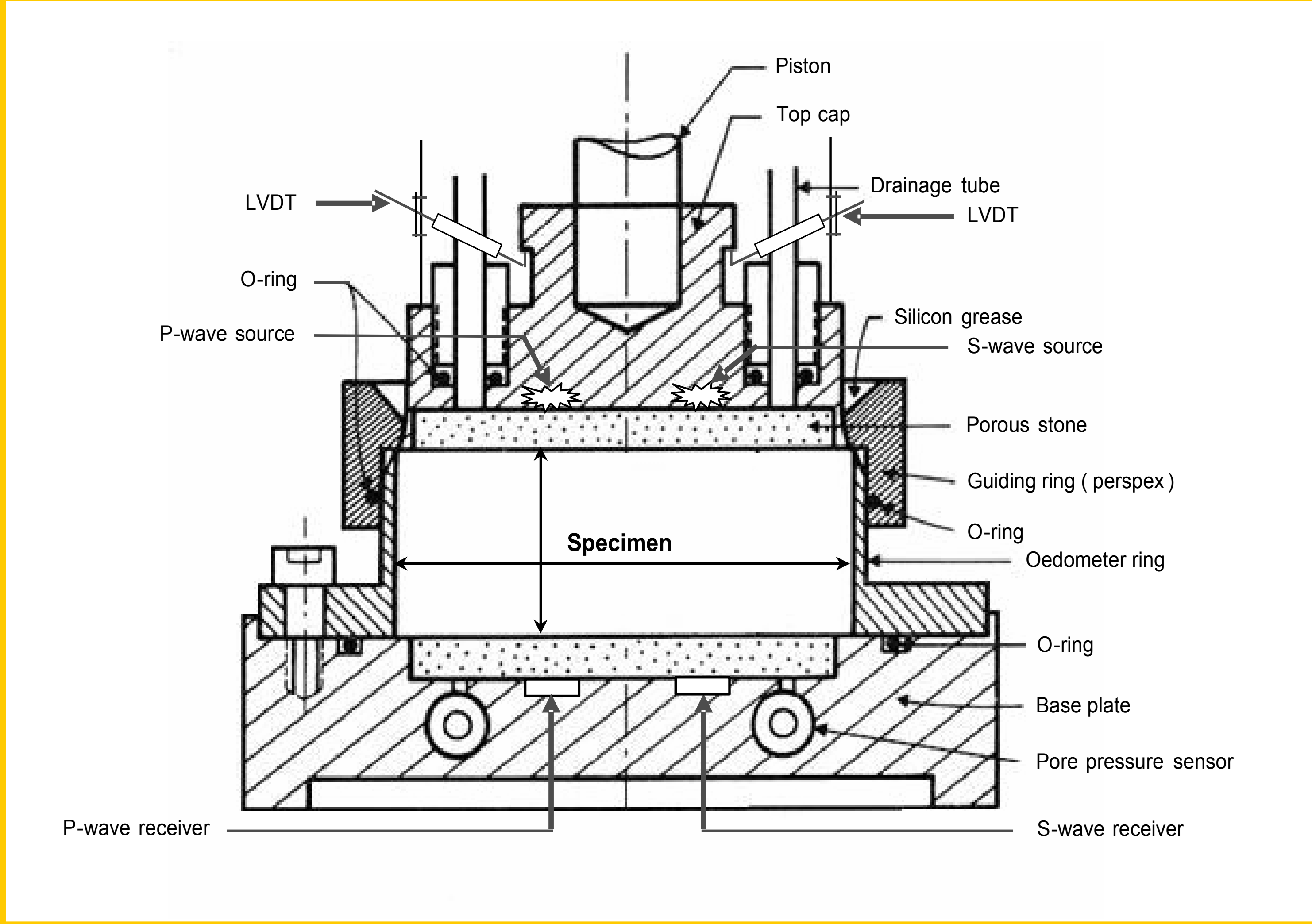
Kaolinite 81%
Illite/Mica 14%
Microcline 5%

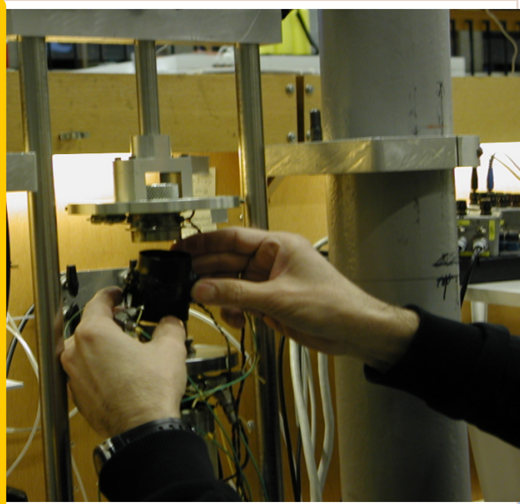
Silt

Quartz 99%

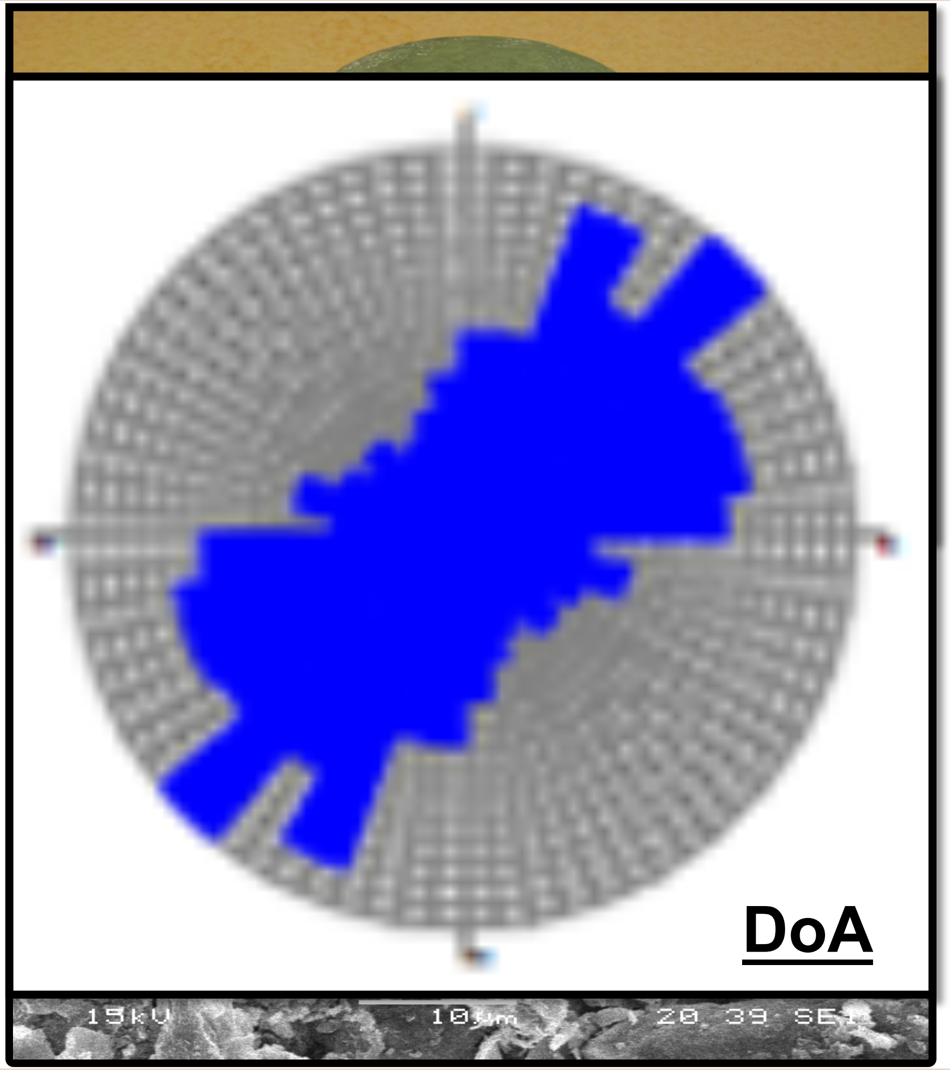
Lithology	Grain size (mm)
Sand	2.0-0.063
Silt	0.063-0.0039
Clay	< 0.0039

Rock mechanical testing

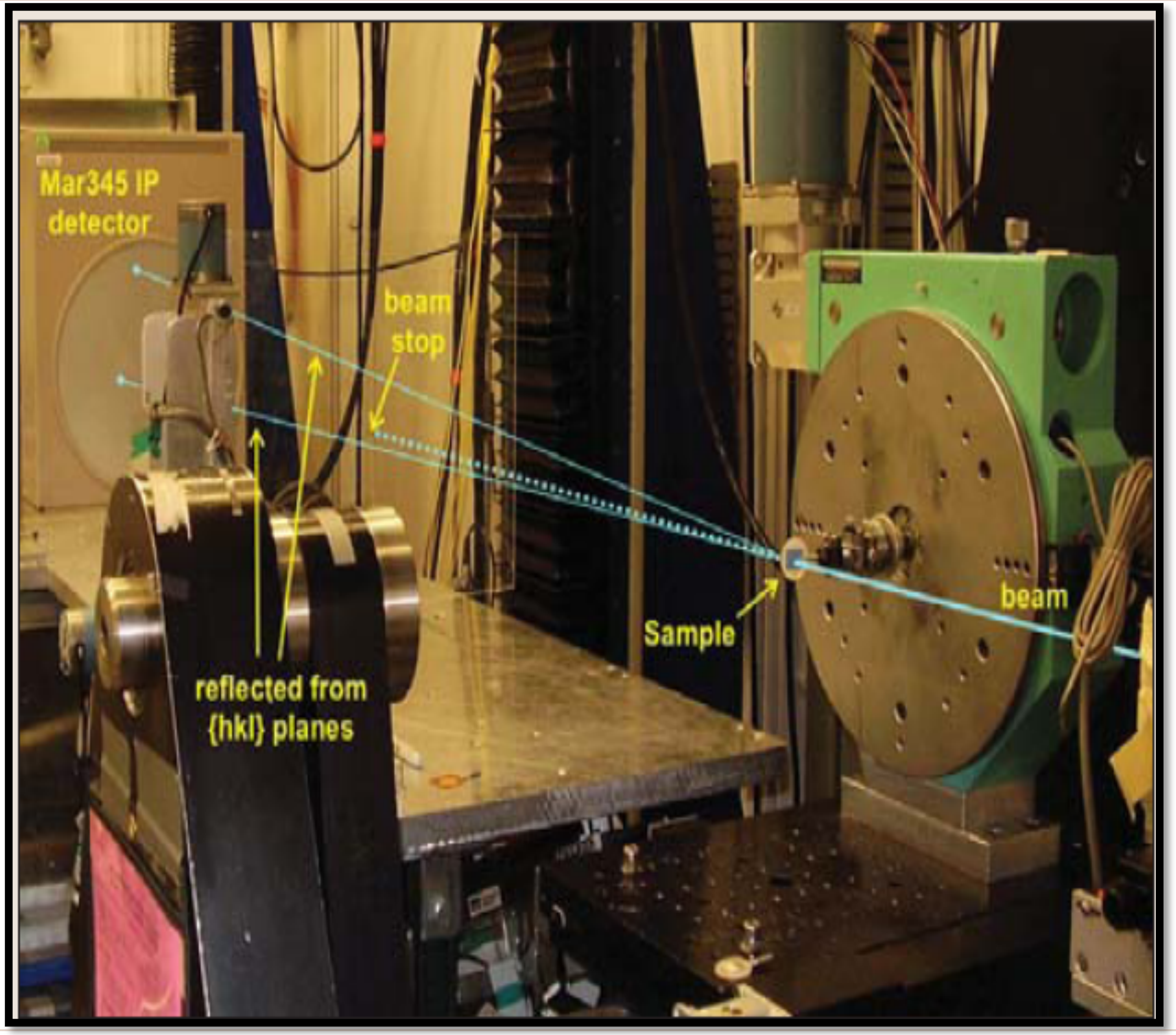


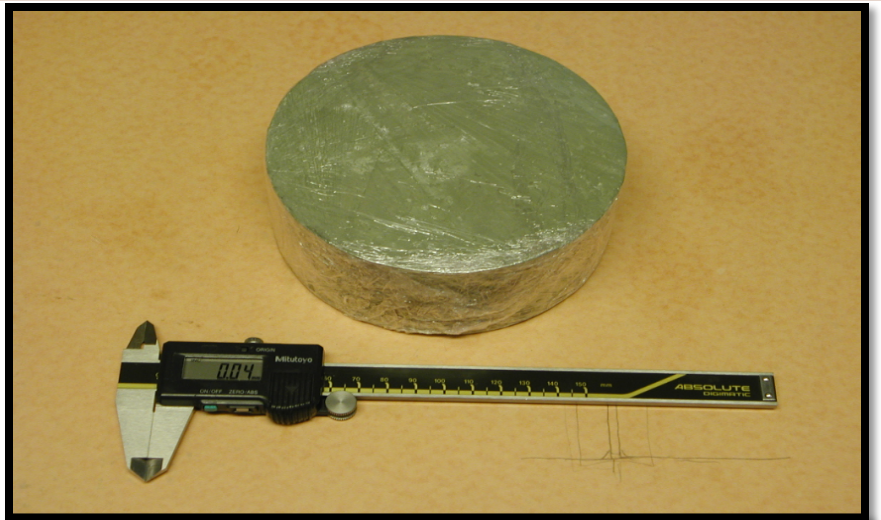


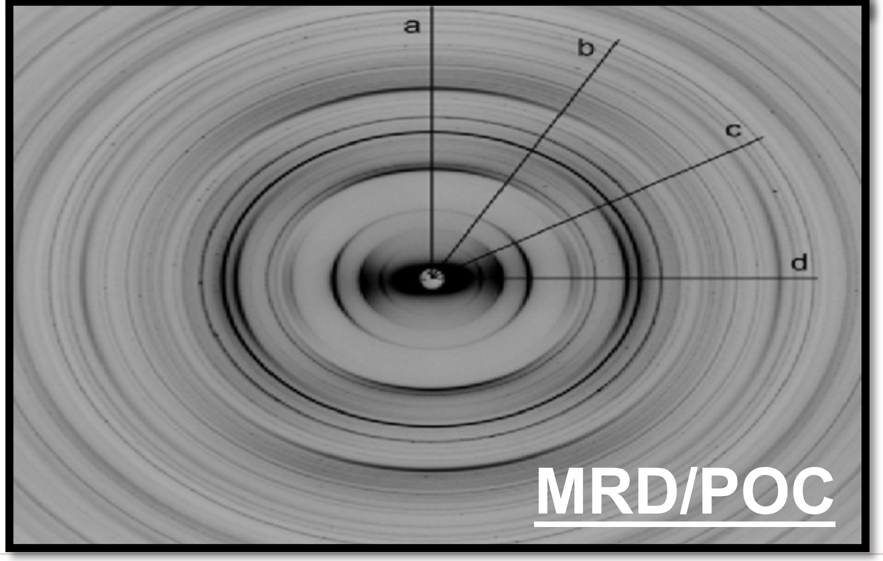
SEM image analysis



X-ray syncroton image analysis



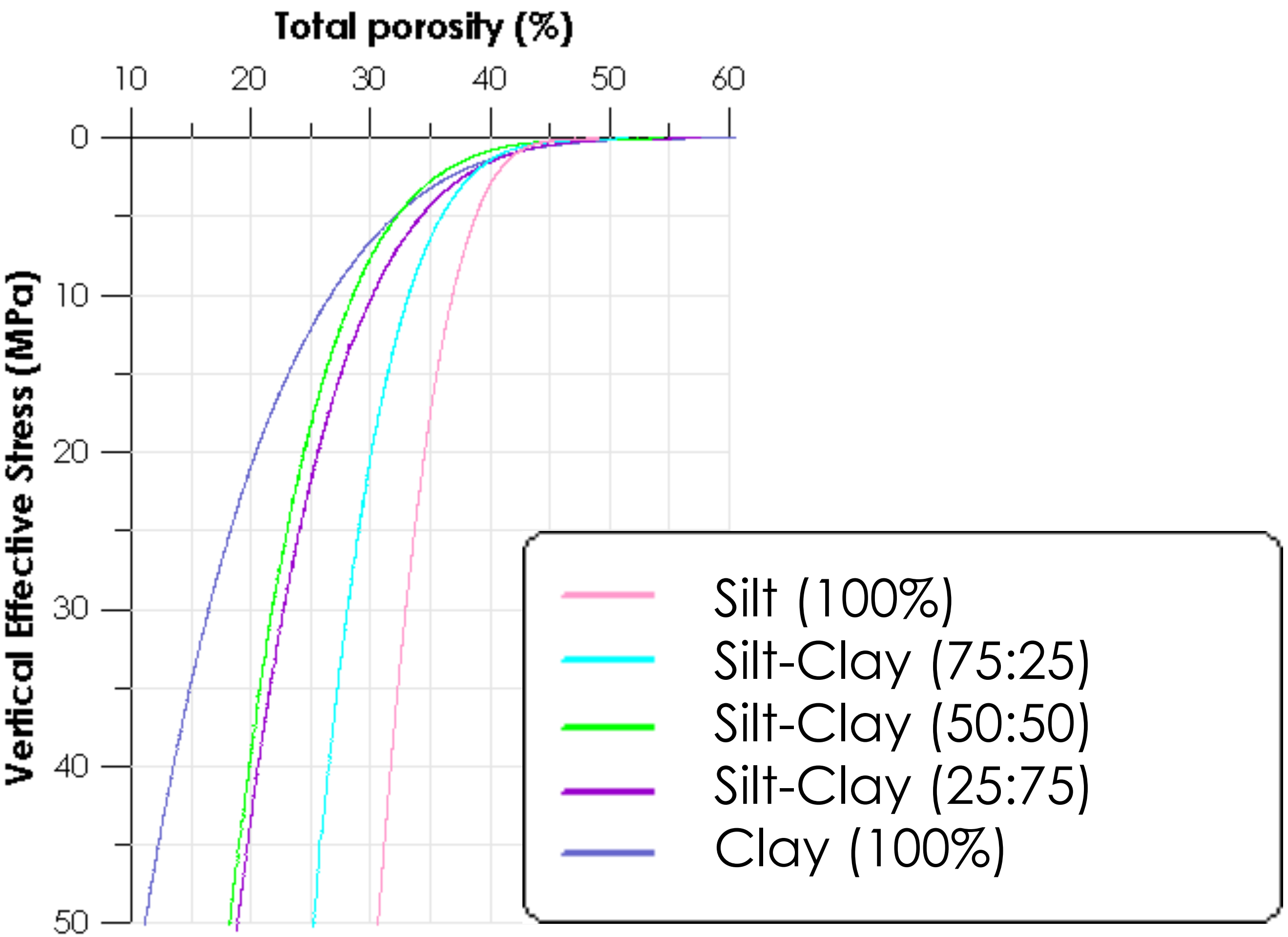




Outline

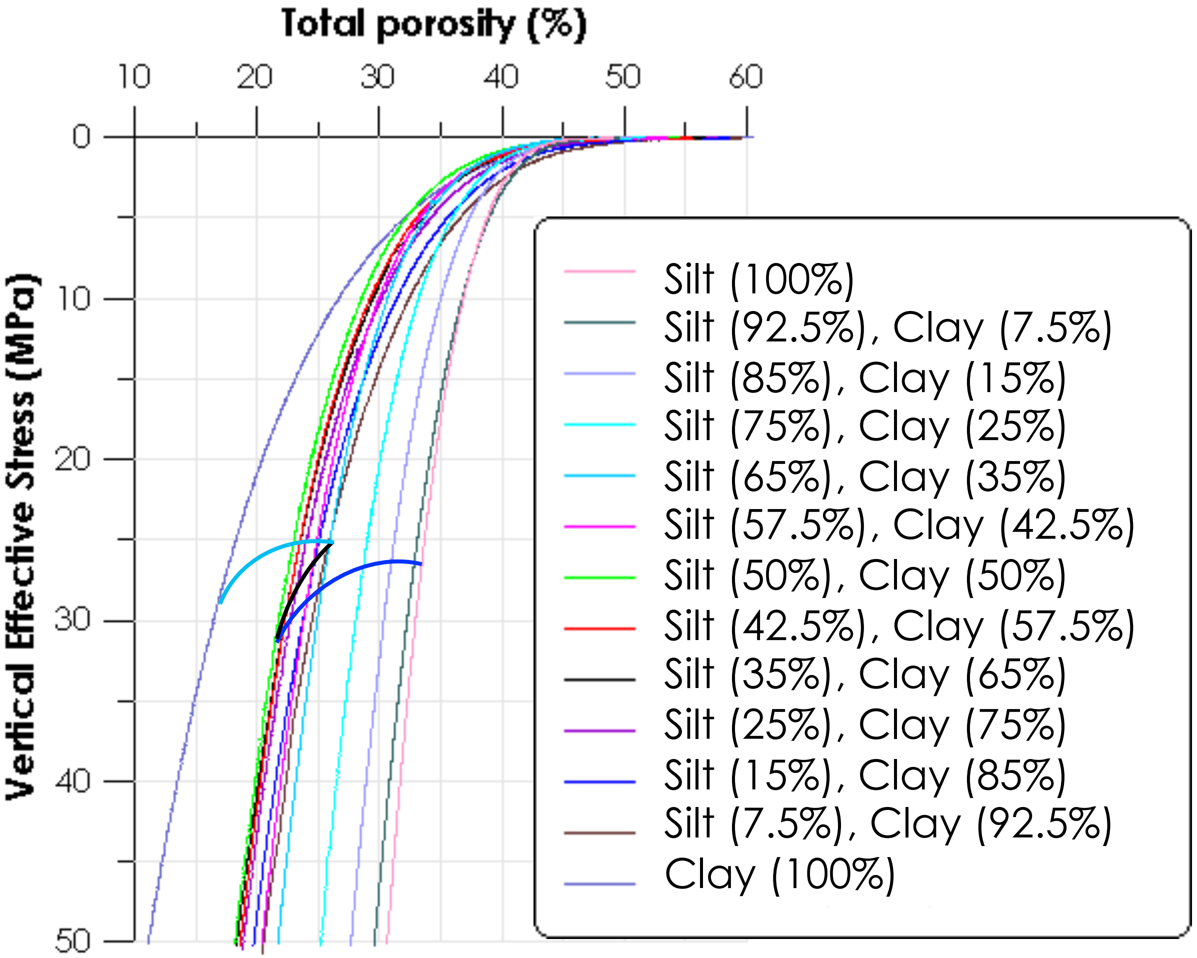
- Background
- Materials and Methods
- **Results & Discussion**
- Concluding remarks

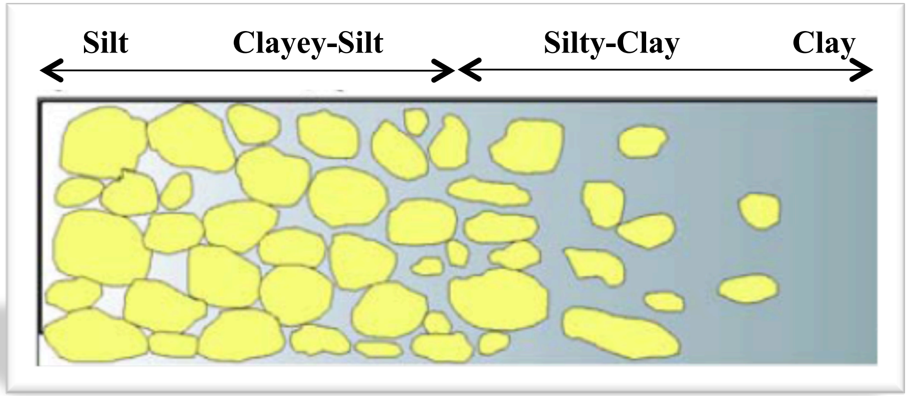
Stress-porosity



Mondol, 2009

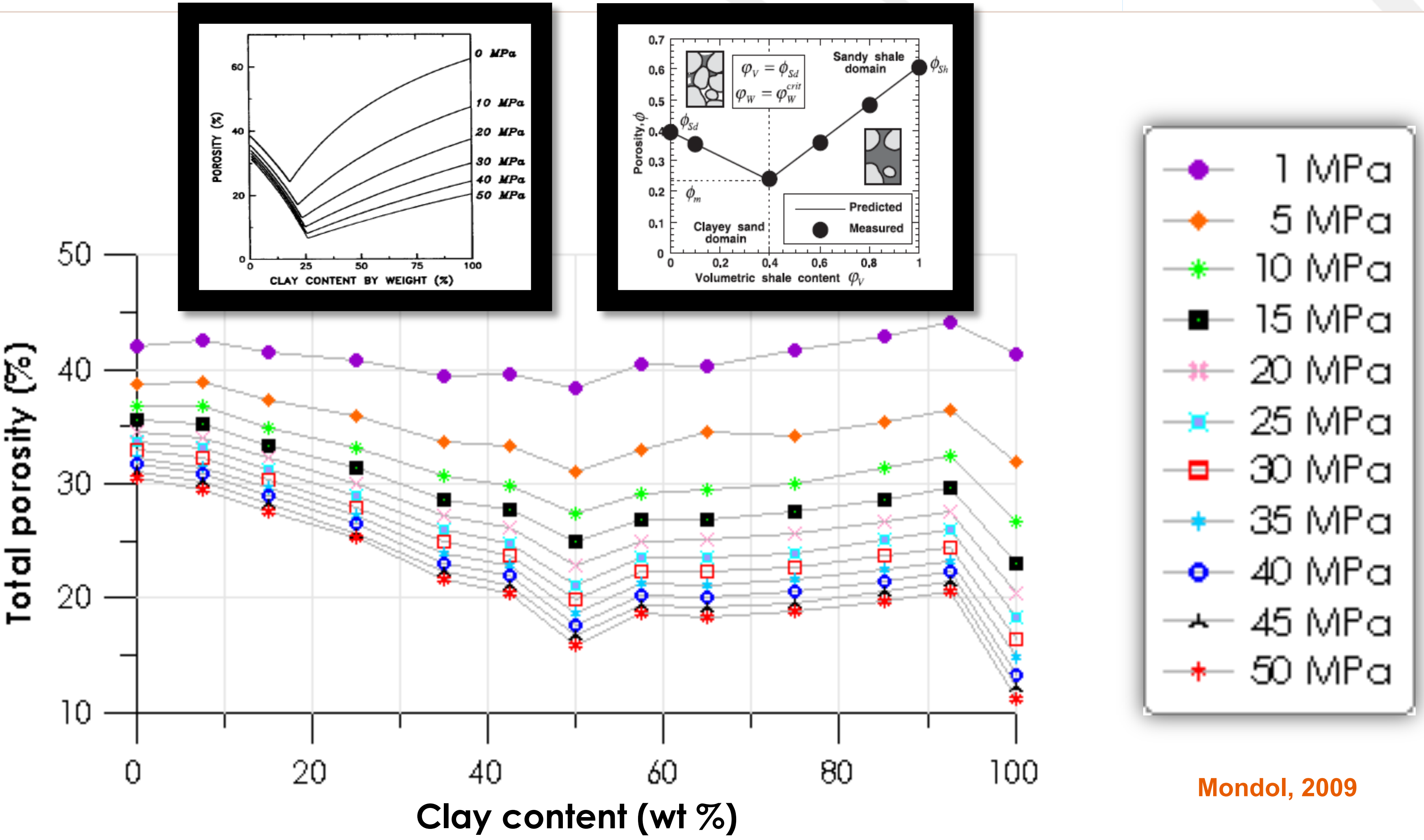
Stress-porosity





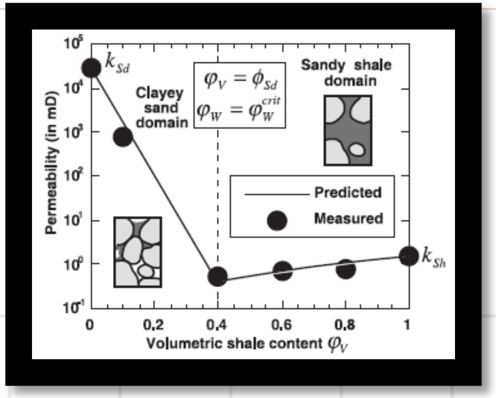
Mondol, 2009

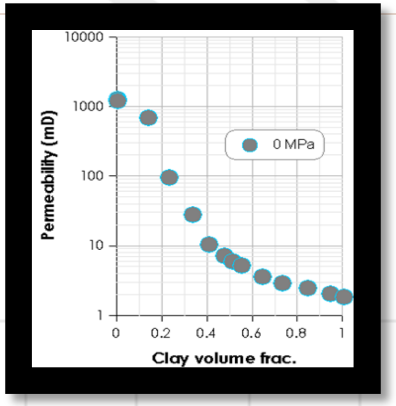
Porosity-clay content

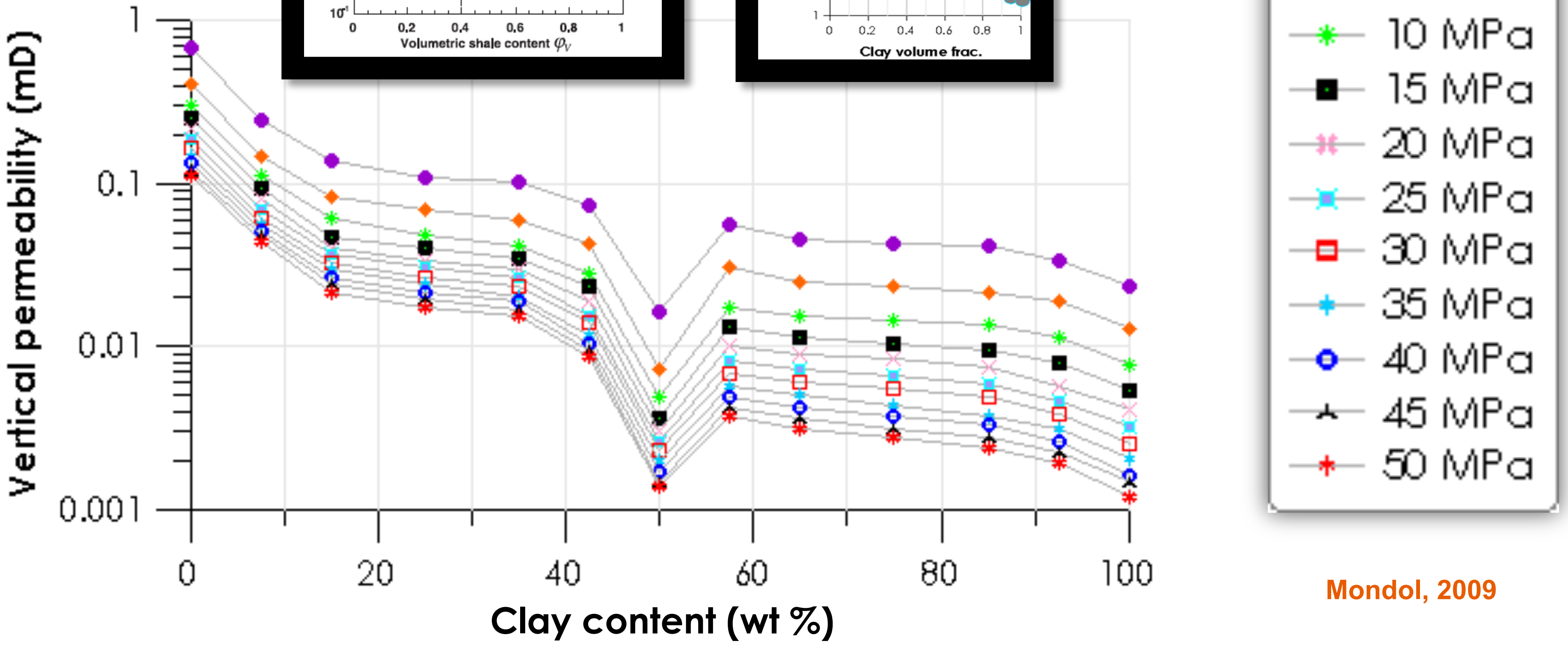


Mondol, 2009

Permeability-clay content

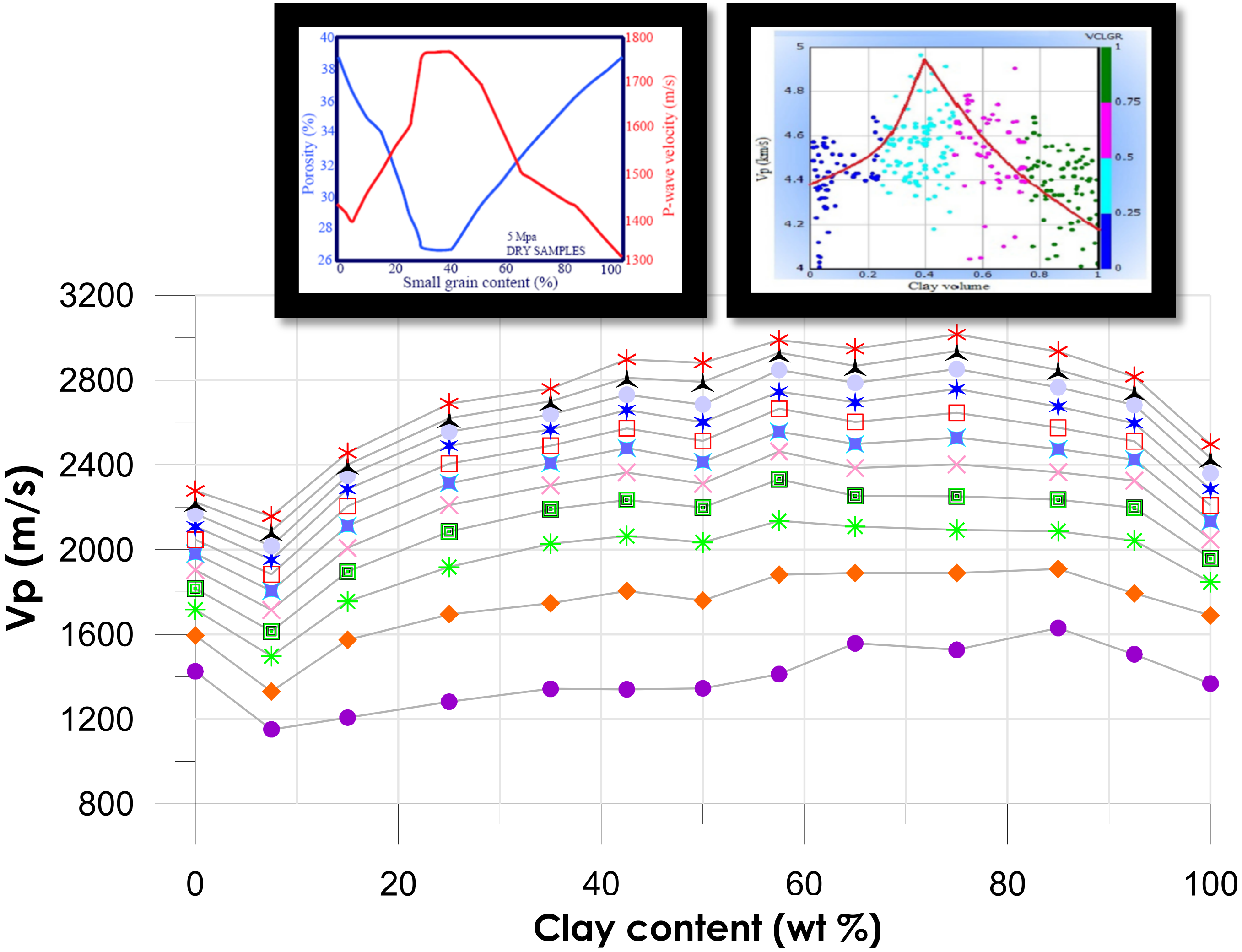


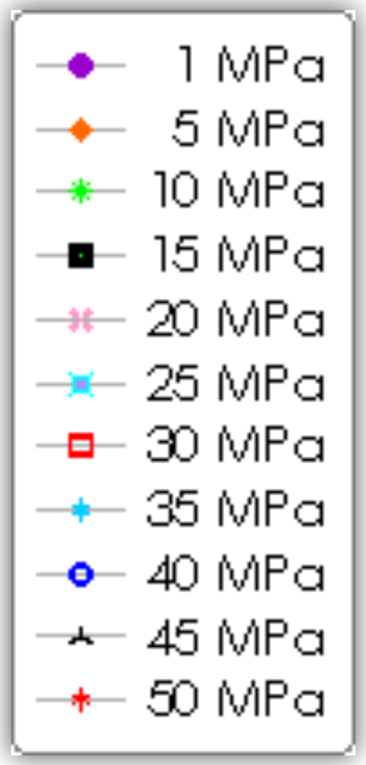




Mondol, 2009

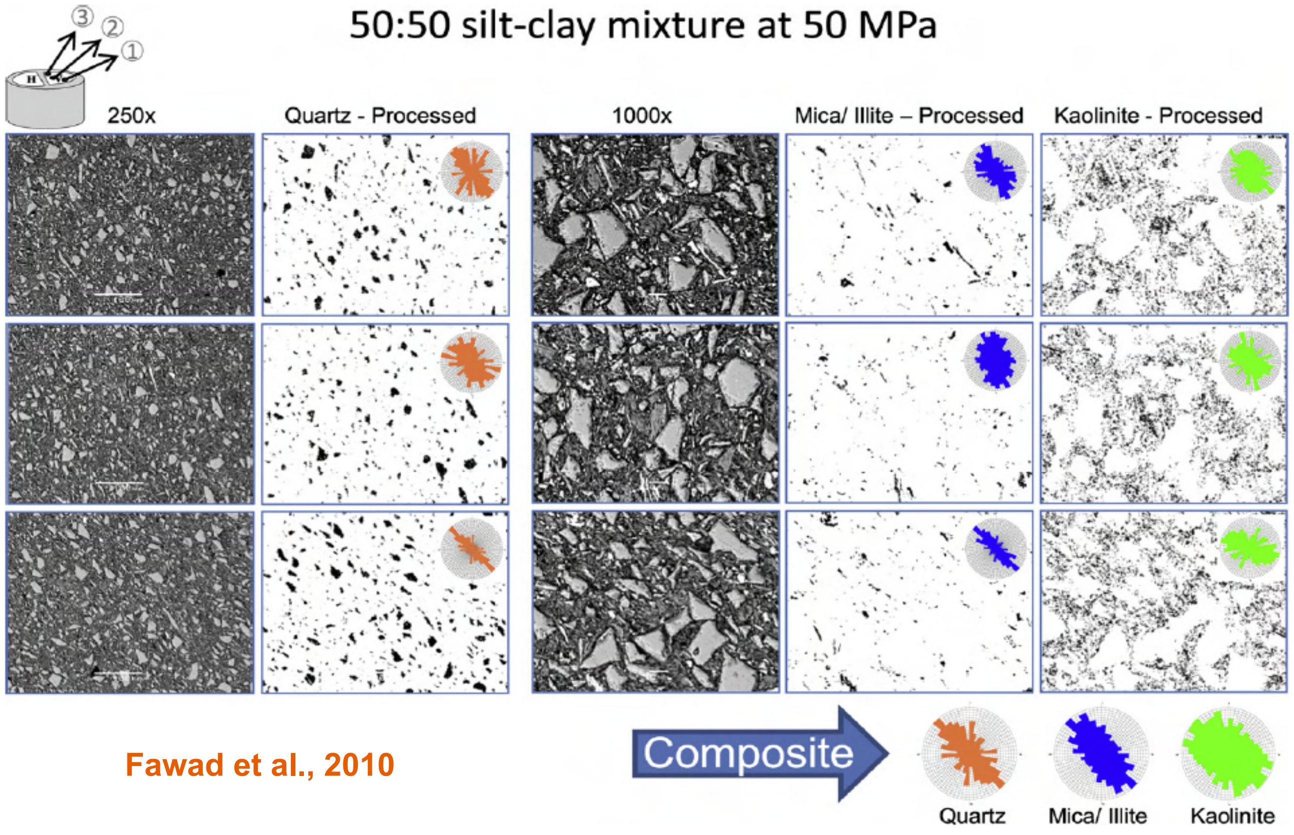
Vp-clay content



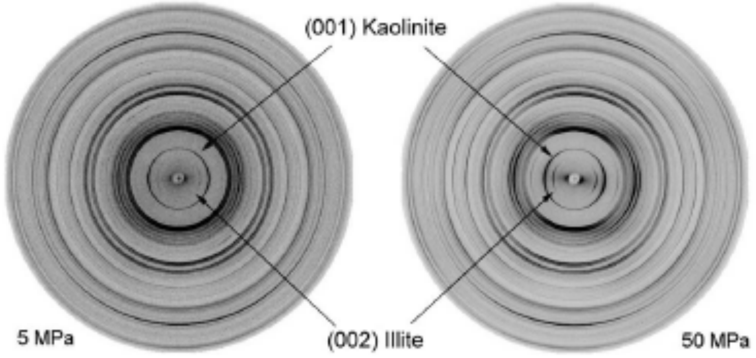


Mondol, 2009

Microfabric analysis

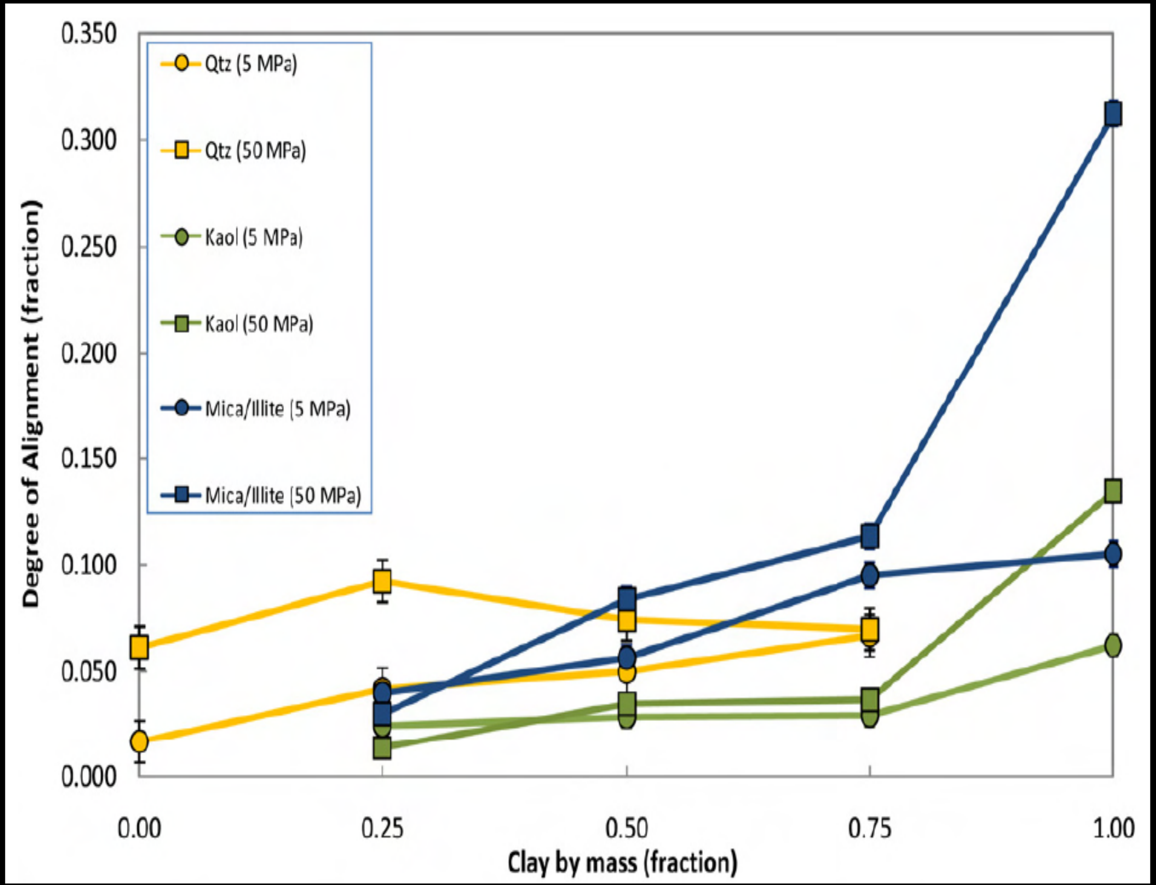


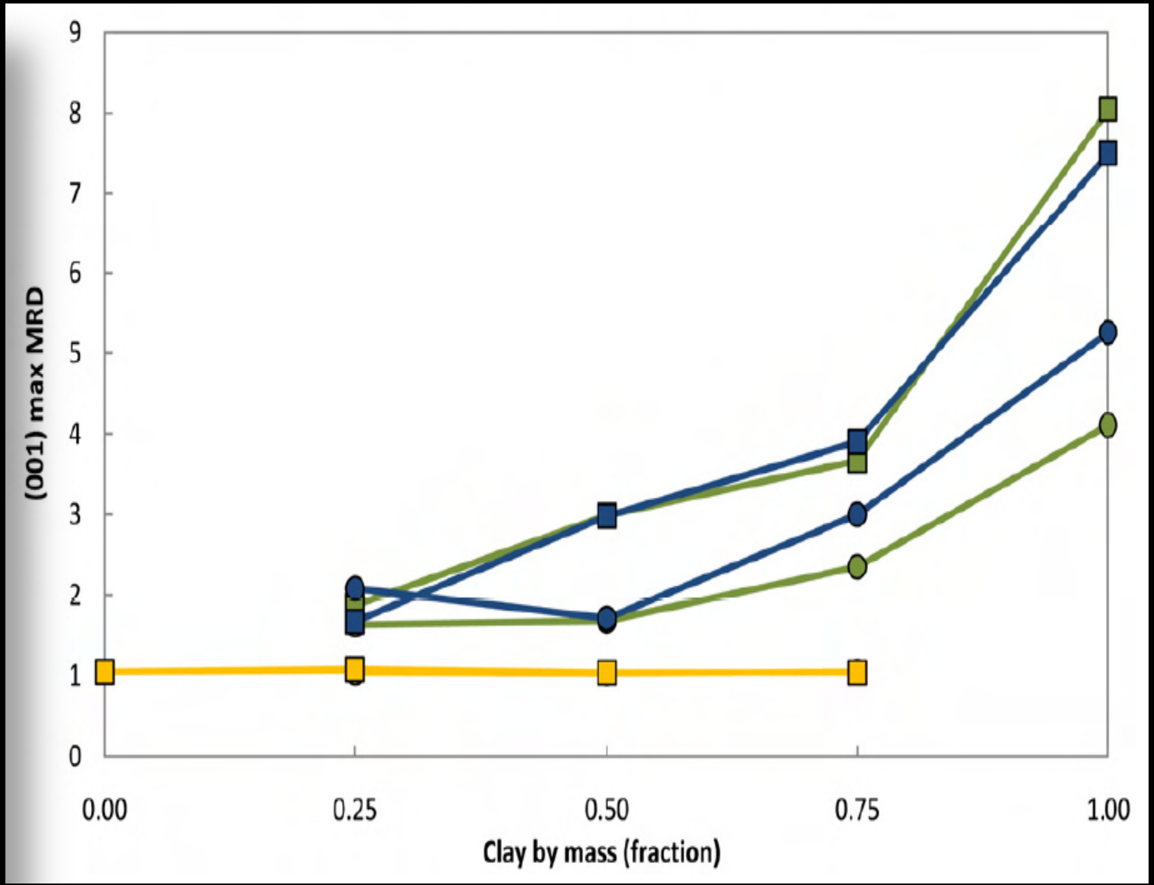
Fawad et al., 2010



Voltolini et al., 2009

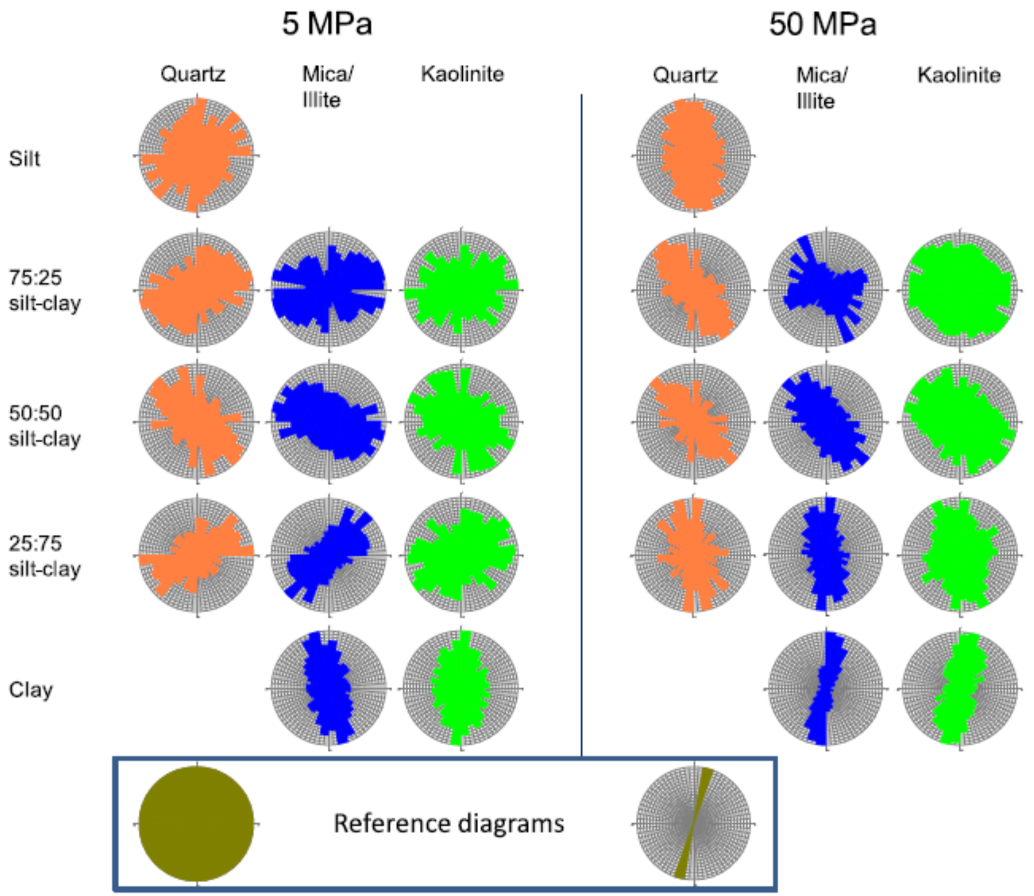
Orientation of minerals

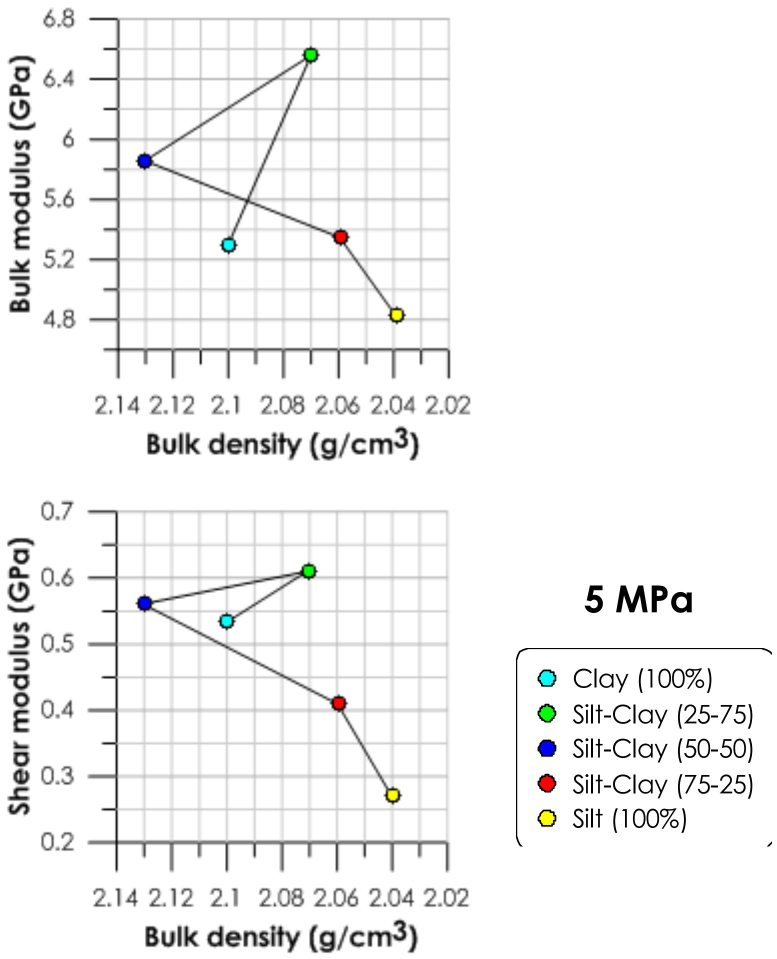




Fawad et al., 2010

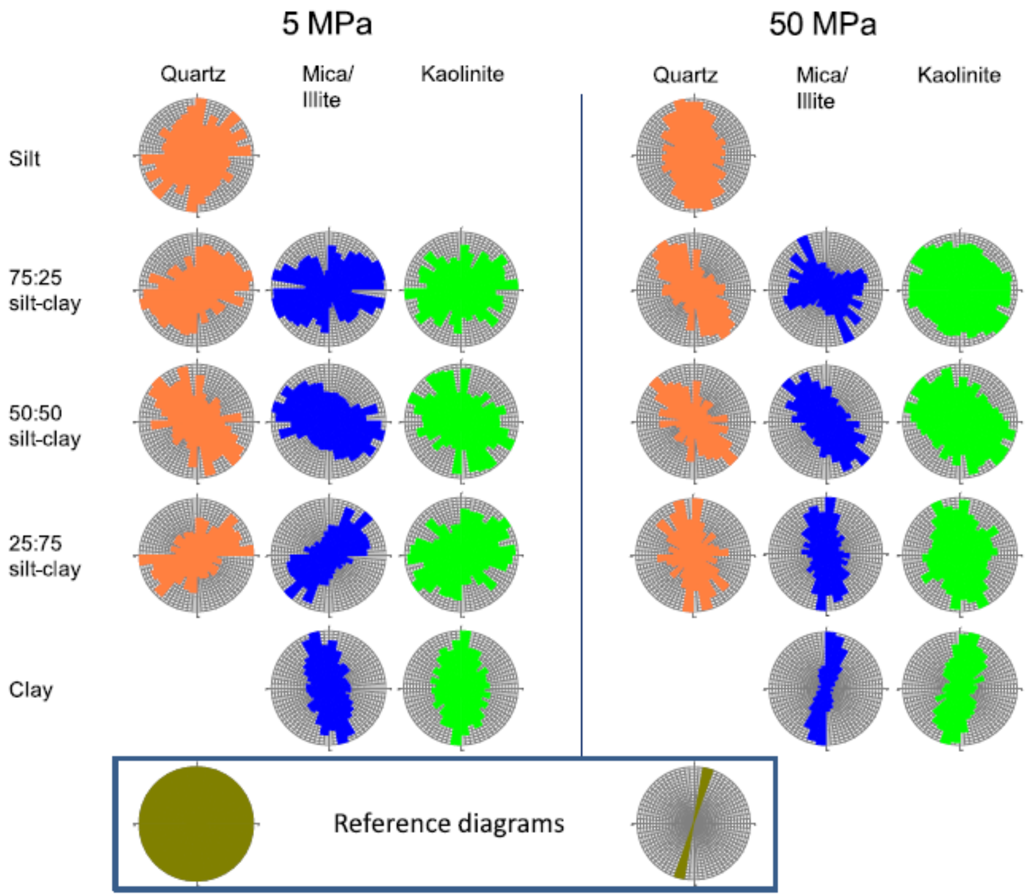
Micofabric & RP

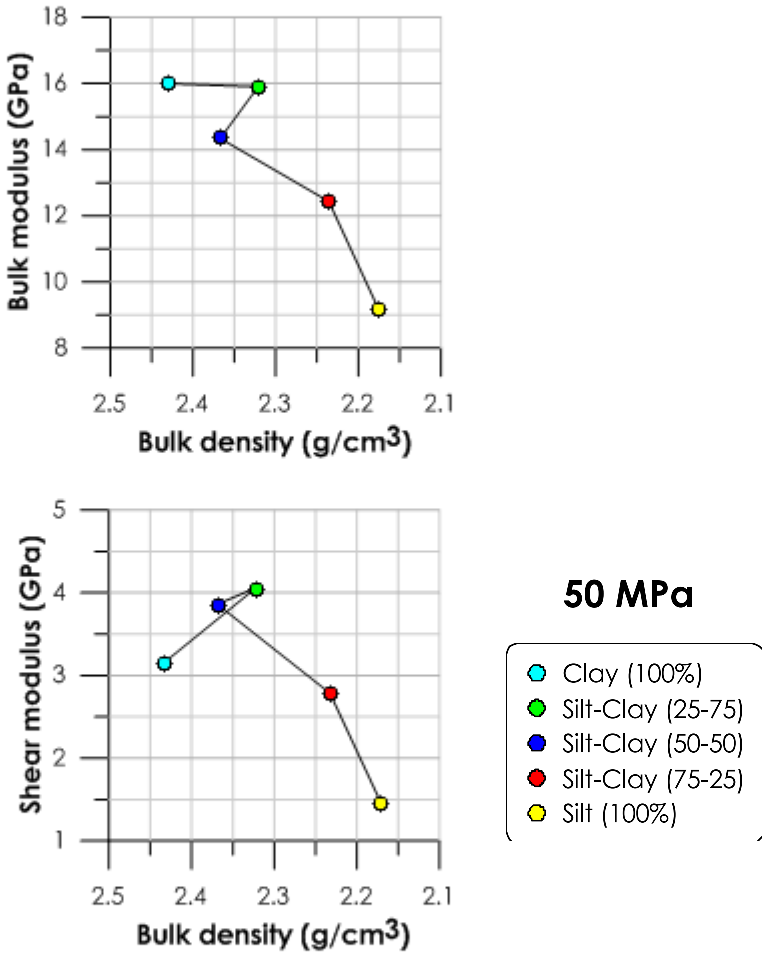




Fawad et al., 2010

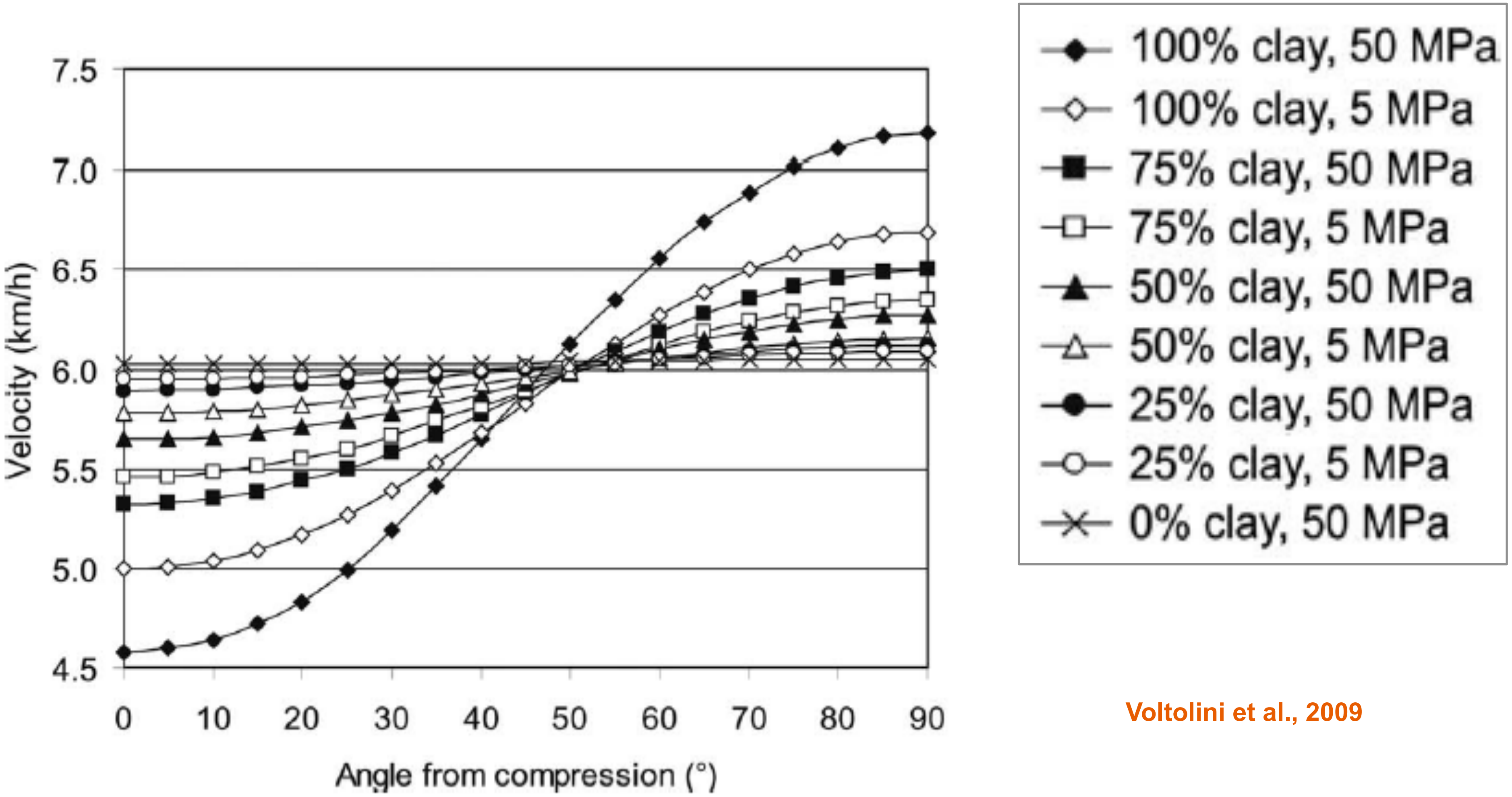
Micofabric & RP





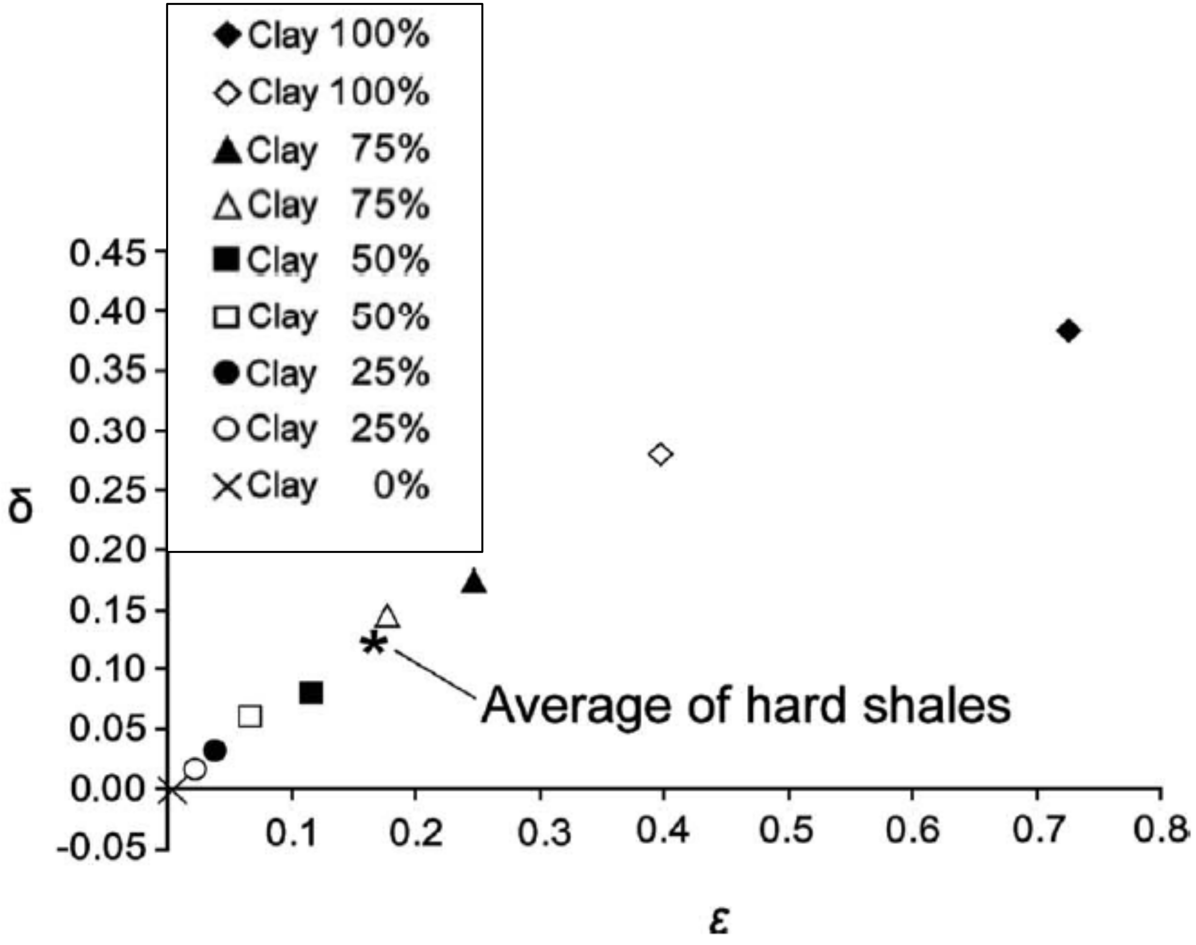
Fawad et al., 2010

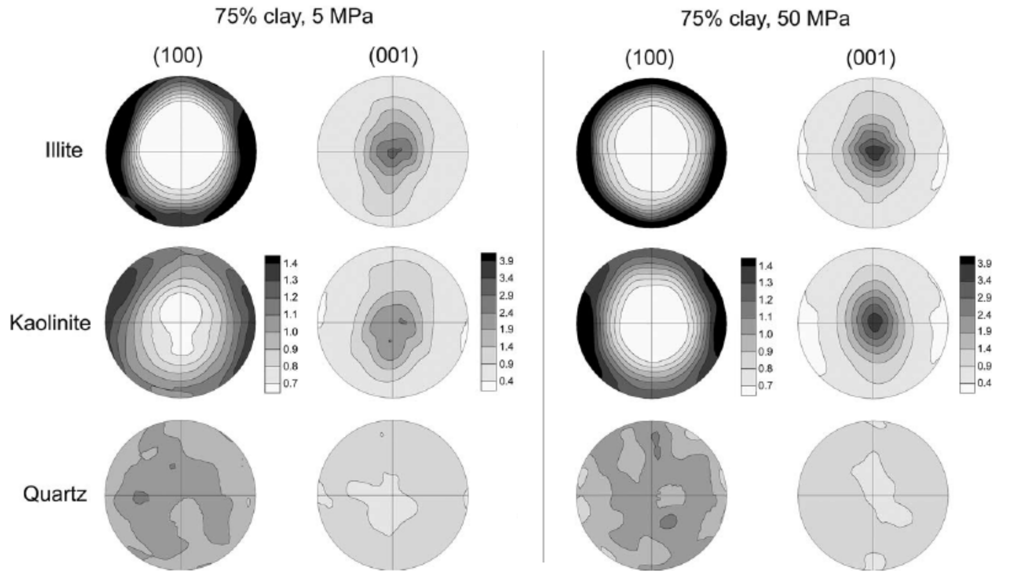
Anisotropy of P-wave velocity



Voltolini et al., 2009

Thomsen parameters





Voltolini et al., 2009

Outline

- Background
- Materials and Methods
- Results & Discussion
- Concluding remarks

Concluding remarks

- Experimental compaction shows that porosity, permeability and velocity in silt-clay mixtures vary greatly as functions of framework composition, mineral fractions and textural relations (size & sorting).

Concluding remarks

- Experimental compaction shows that porosity, permeability and velocity in silt-clay mixtures vary greatly as functions of framework composition, mineral fractions and textural relations (size & sorting).

- To estimate porosity, velocity and hydraulic properties in silt-clay mixtures should not only consider porosity but also must consider grain size, type, amount and distribution of the clays.

Concluding remarks

- Experimental compaction shows that porosity, permeability and velocity in silt-clay mixtures vary greatly as functions of framework composition, mineral fractions and textural relations (size & sorting).

- To estimate porosity, velocity and hydraulic properties in silt-clay mixtures should not only consider porosity but also must consider grain size, type, amount and distribution of the clays.

- Extrapolation of experimental results to natural must be done with caution since this study is based exclusively on mechanical compaction of silt-clay mixtures and does not consider any sand, OM and other clays (e.g. smectite & chlorite), chemical diagenesis, maturation of organic matter and overpressure.

Acknowledgements

UNIVERSITAS OSLOENSIS MDCCCXI

Berkeley
UNIVERSITY OF CALIFORNIA

CENTER FOR ROCK ABUSE
Squeezing Rocks since 1994

NGI

ExxonMobil

eni

The Research Council
of Norway

?

Stiffness tensors

$$\varepsilon = \frac{(C_{11} - C_{33})}{2C_{33}} \tag{2}$$

and

$$\delta = \frac{[(C_{13} + C_{55})^2 - (C_{33} - C_{55})^2]}{2C_{33}(C_{33} - C_{55})}, \tag{3}$$

Nomenclature

Lithology	Grain size (mm)
Sand	2.0-0.063
Silt	0.063-0.0039
Clay	< 0.0039

Lithology	Grain size (mm)
Very Coarse Sand	2.0-1.0
Coarse Sand	1.0-0.5
Medium Sand	0.5-0.25
Fine Sand	0.25-0.125
Very Fine Sand	0.125-0.063
Coase Silt	0.063-0.031
Medium Silt	0.031-0.0156
Fine Silt	0.0156-0.0078
Very Fine Silt	0.0078-0.0039
Clay	< 0.0039

Wentworth, 1922