

# Impact of Water Content and Saturation on Shale Strength & Stiffness

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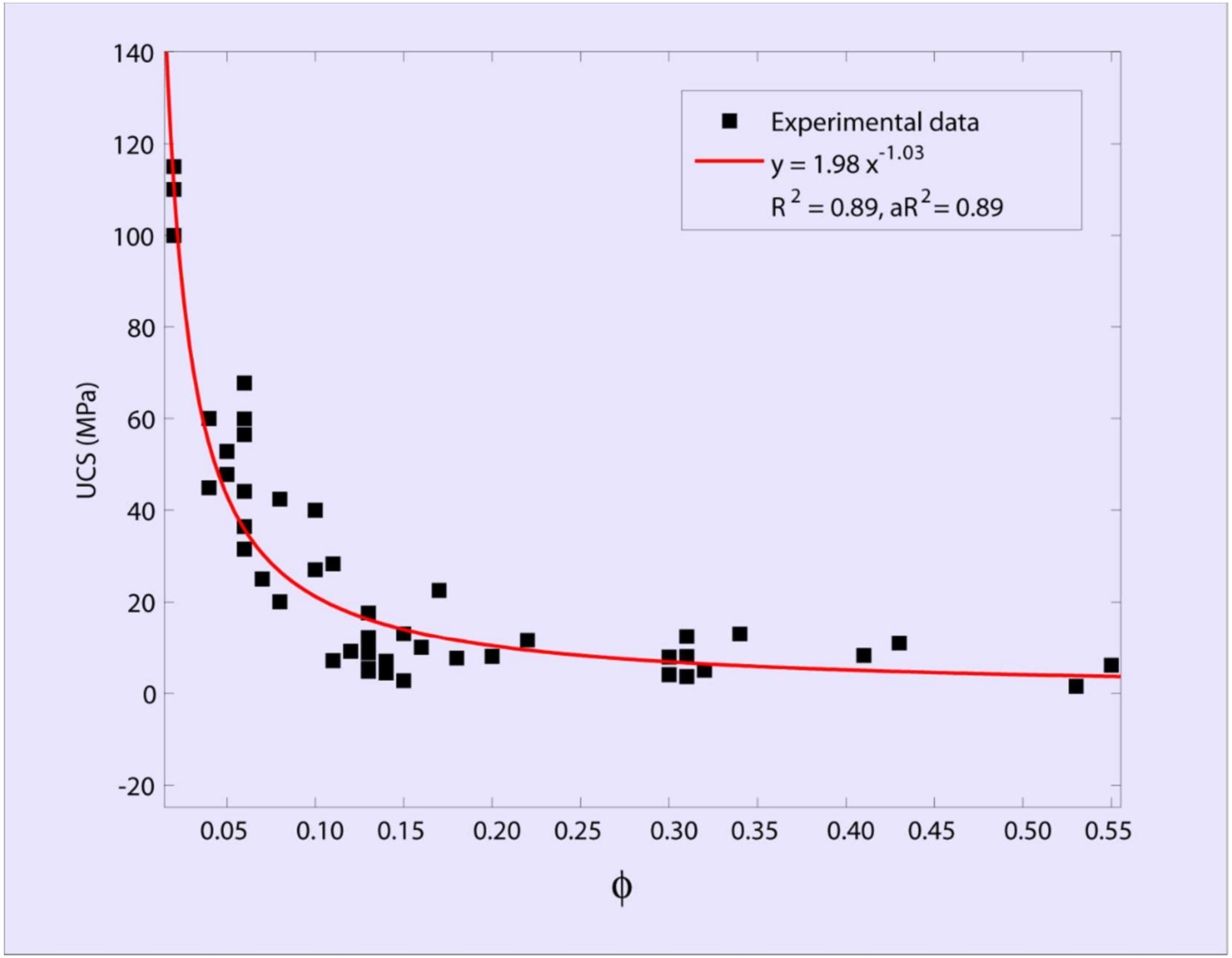
# Rationale

- Shale properties poorly understood and hard to measure
- Upsurge in interest recently
- Treat as conventional?
- Or worse.......

- Why saturation?:
  - Effect on strength
  - Affects elastic moduli/stiffness, static & dynamic
  - Changes microstructure & PSD
- Highlight Preservation
- Gas shales partially saturated

# Impact of water content: full saturation



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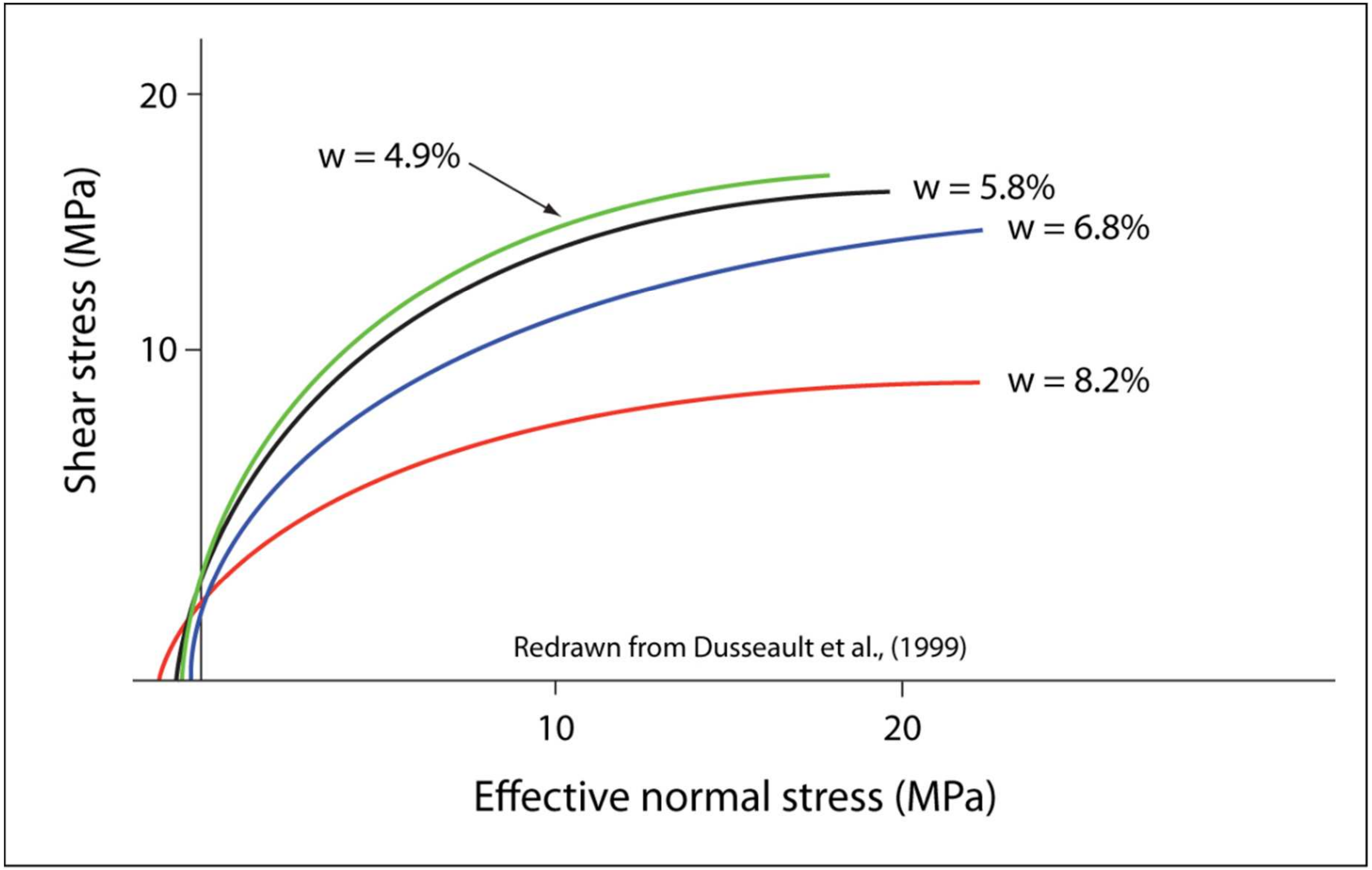
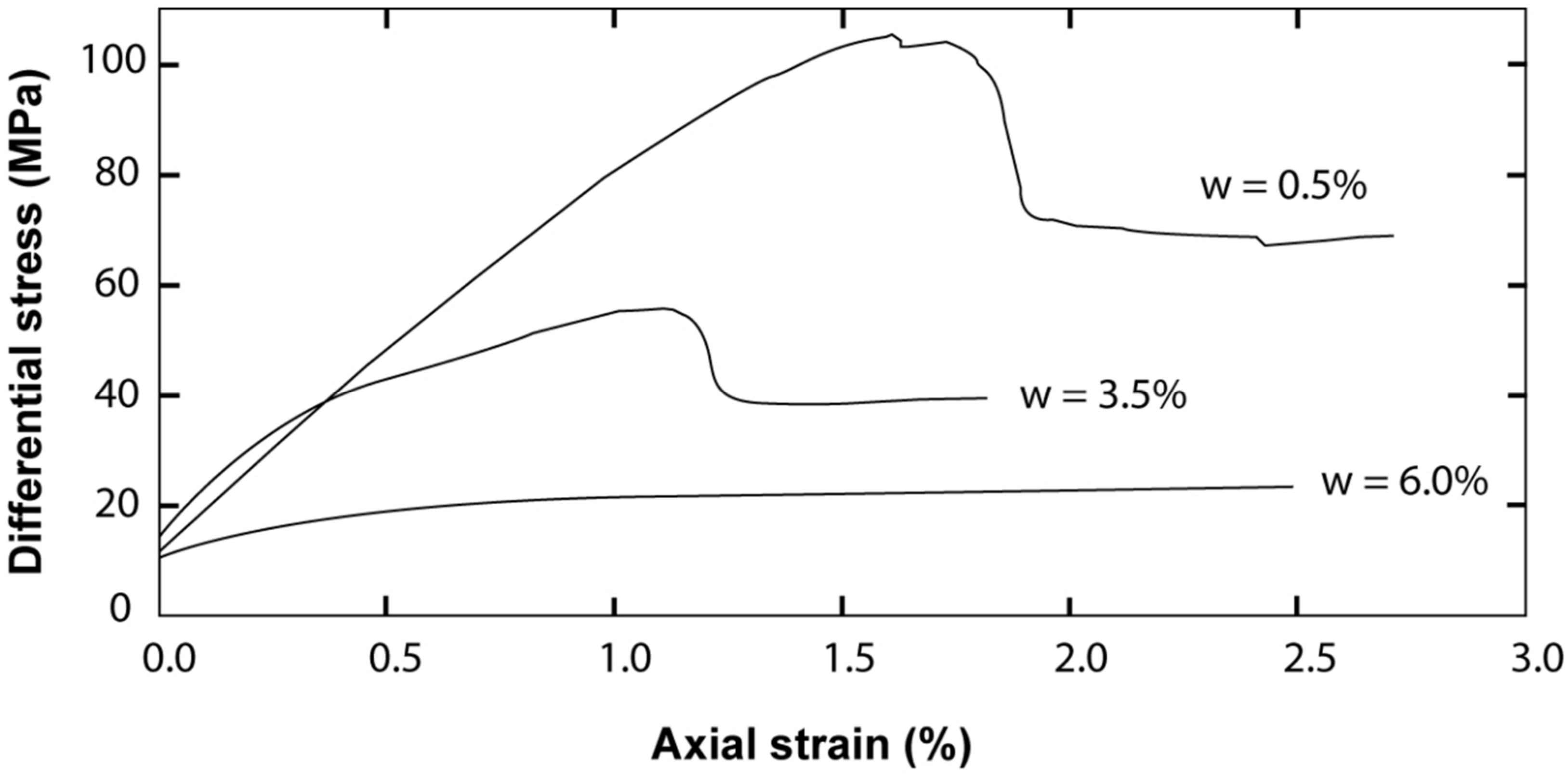


# Impact of water content: partial saturation

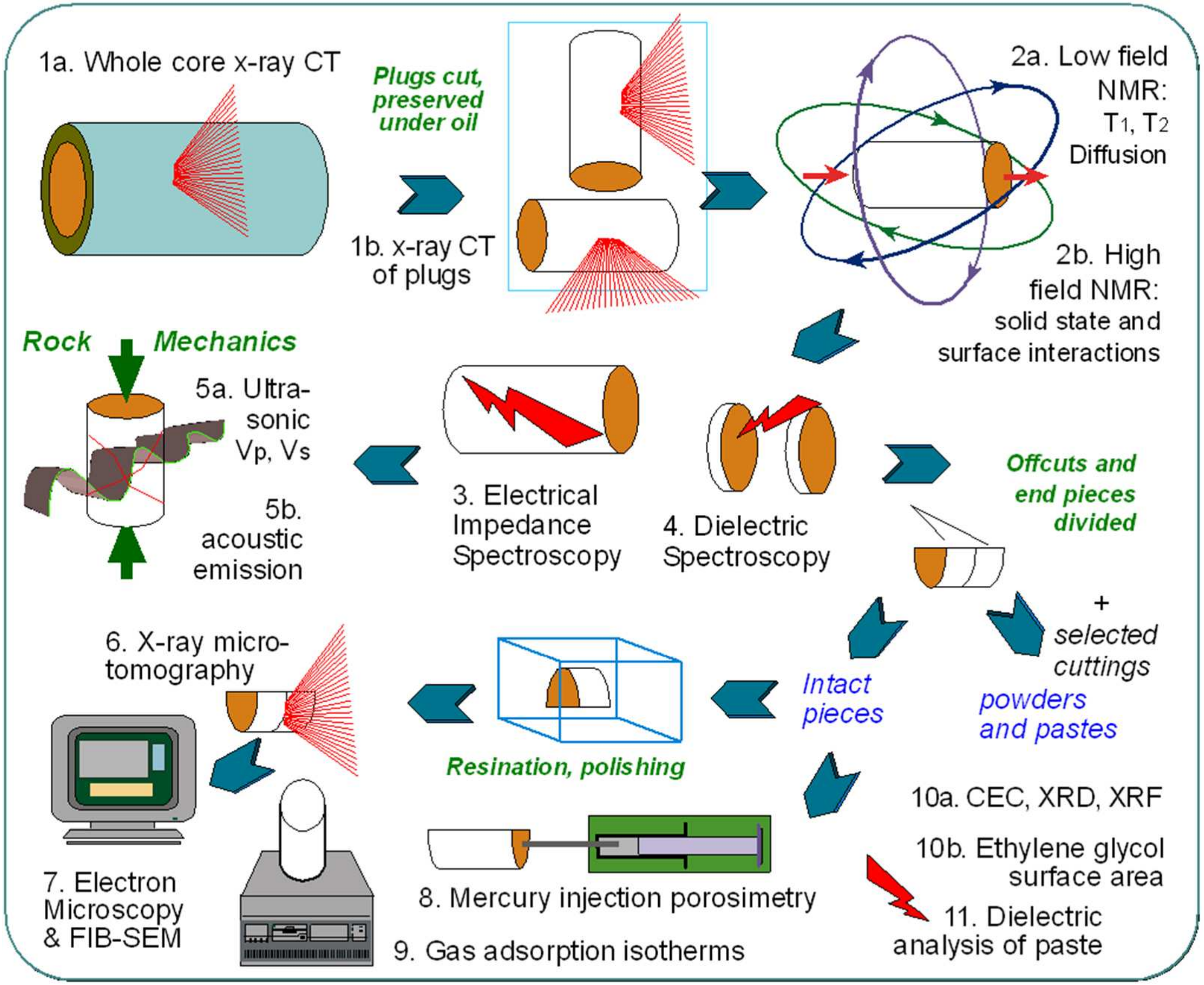



Redrawn from Nagra, 2002.

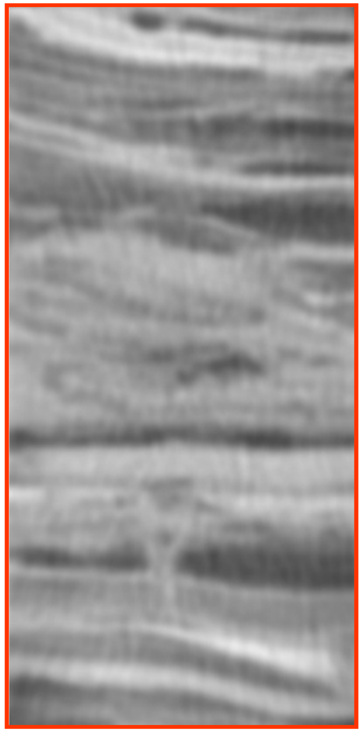
# Objectives

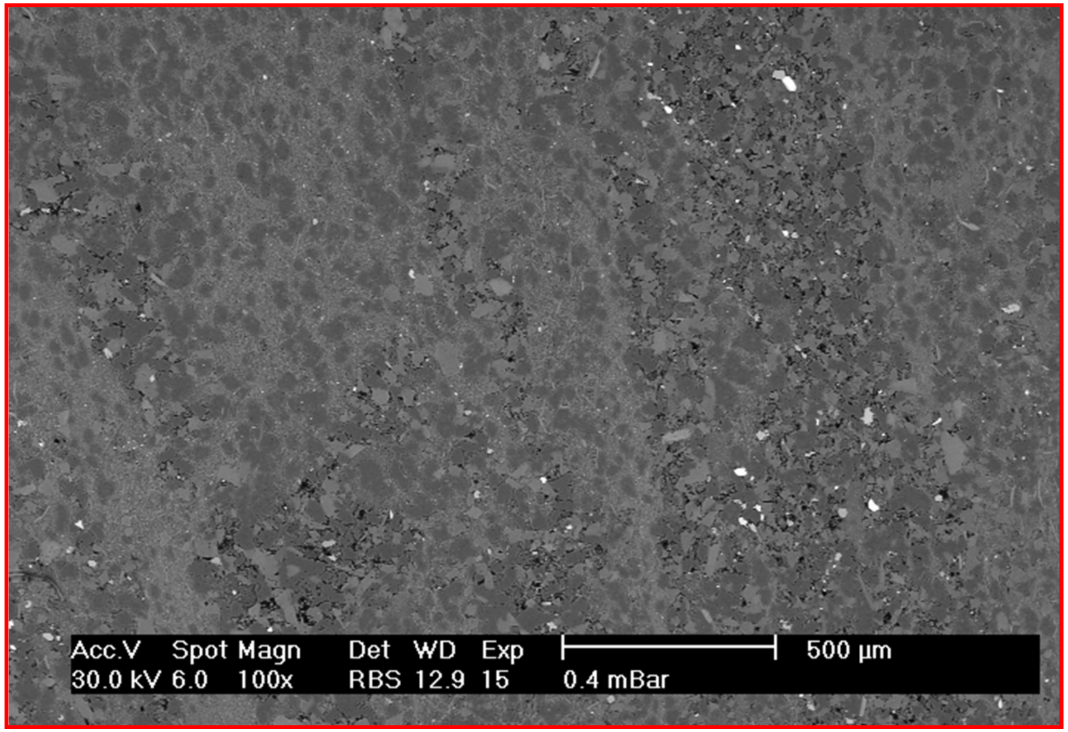
- Whole project: Investigation of Interfacial Phenomena in Shales
- This Pilot Study: Impact of drying on rock properties.
- Test static rock strength, stiffness, wet and “dry”
- Calculate P and S-wave velocity and moduli, wet and “dry”
- Evaluate petrophysical properties, wet and “dry”
- Some initial implications

# Laboratory Workflow



# The Shales: Officer Basin

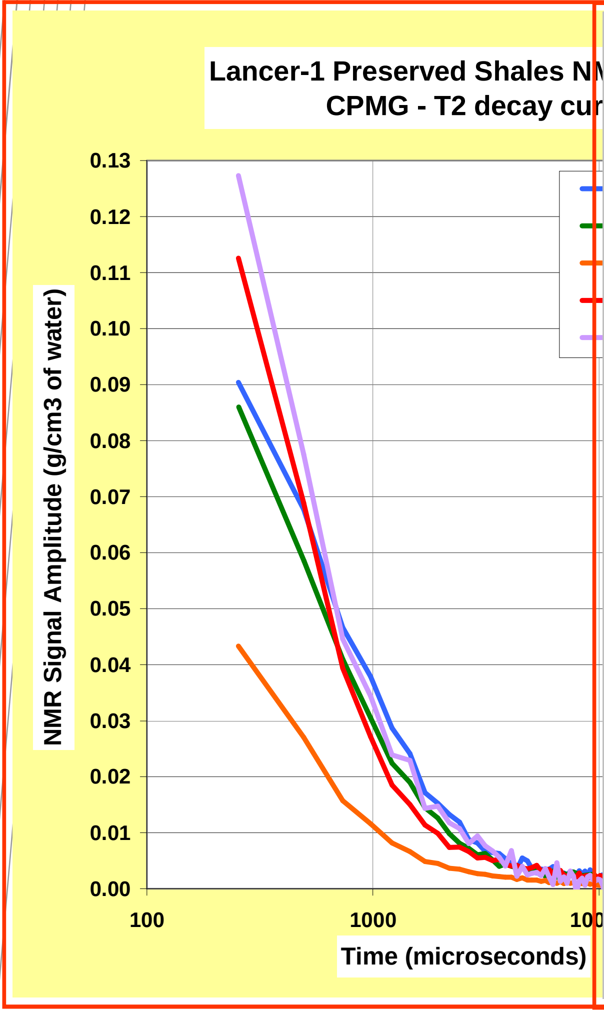


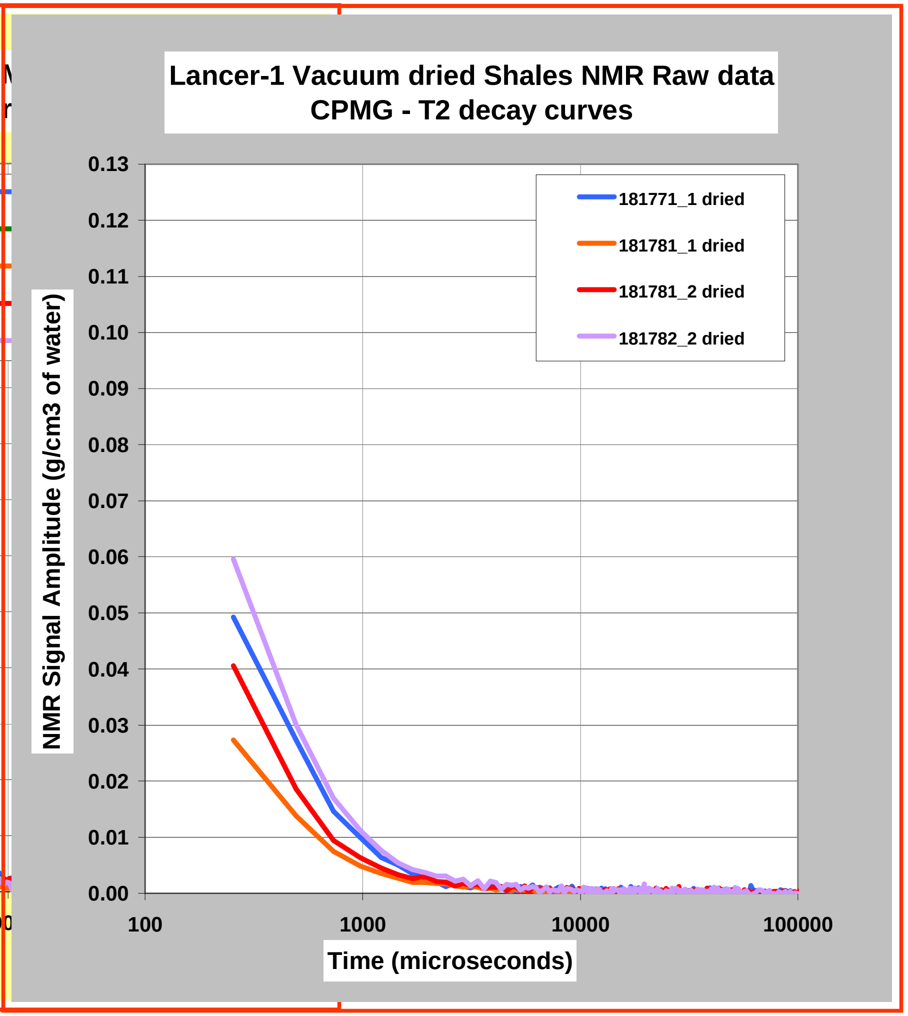



- Laminated Proterozoic shales
- Dominated by quartz, orthoclase and illite
- CC ~ 30-35%; CF ~ 30%; $\phi$ ~ 5-6%; w = 2-3%
- Essentially hard, low porosity shales

# The Drying

- Drying in vacuum oven at 70°C for 1 week plus

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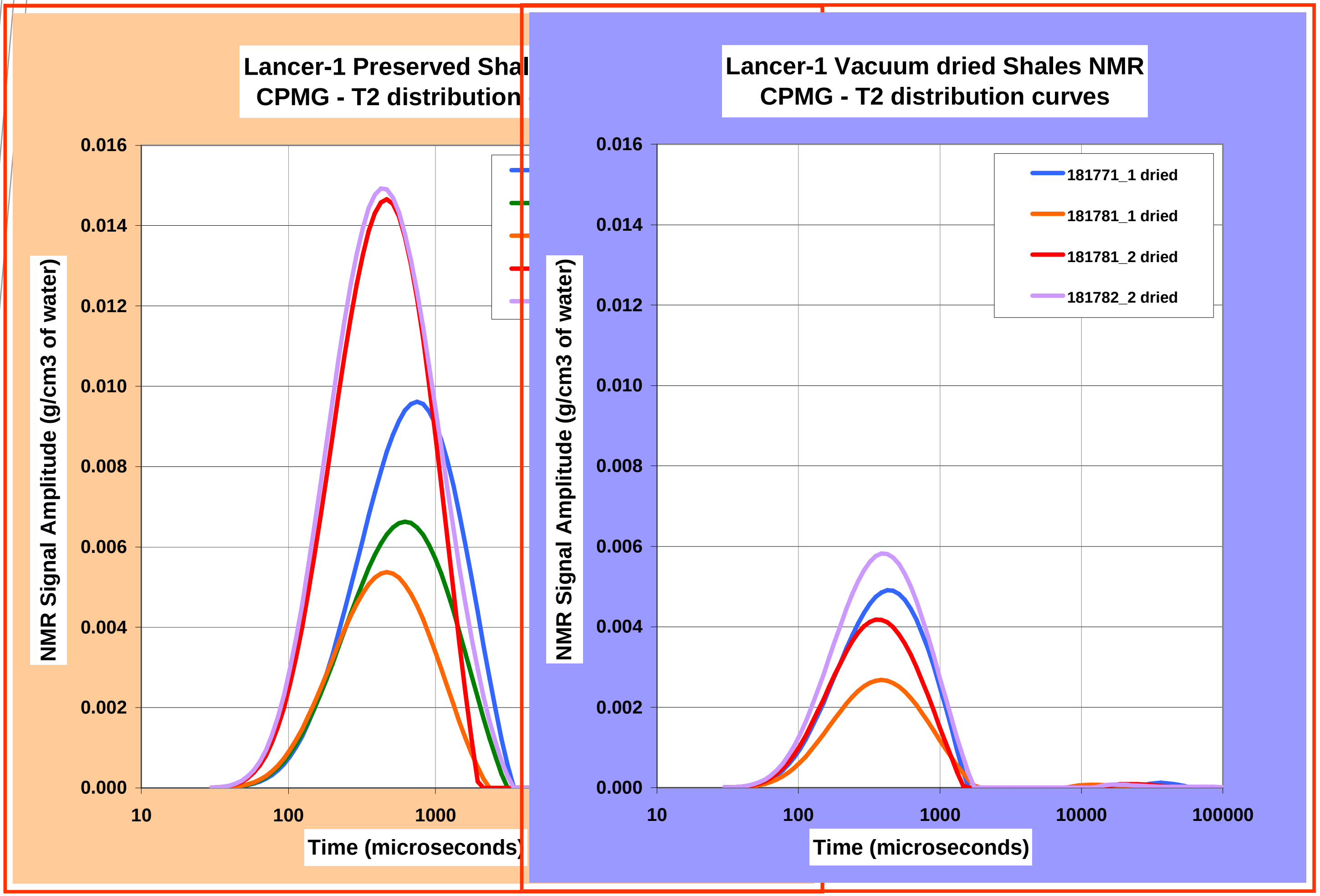
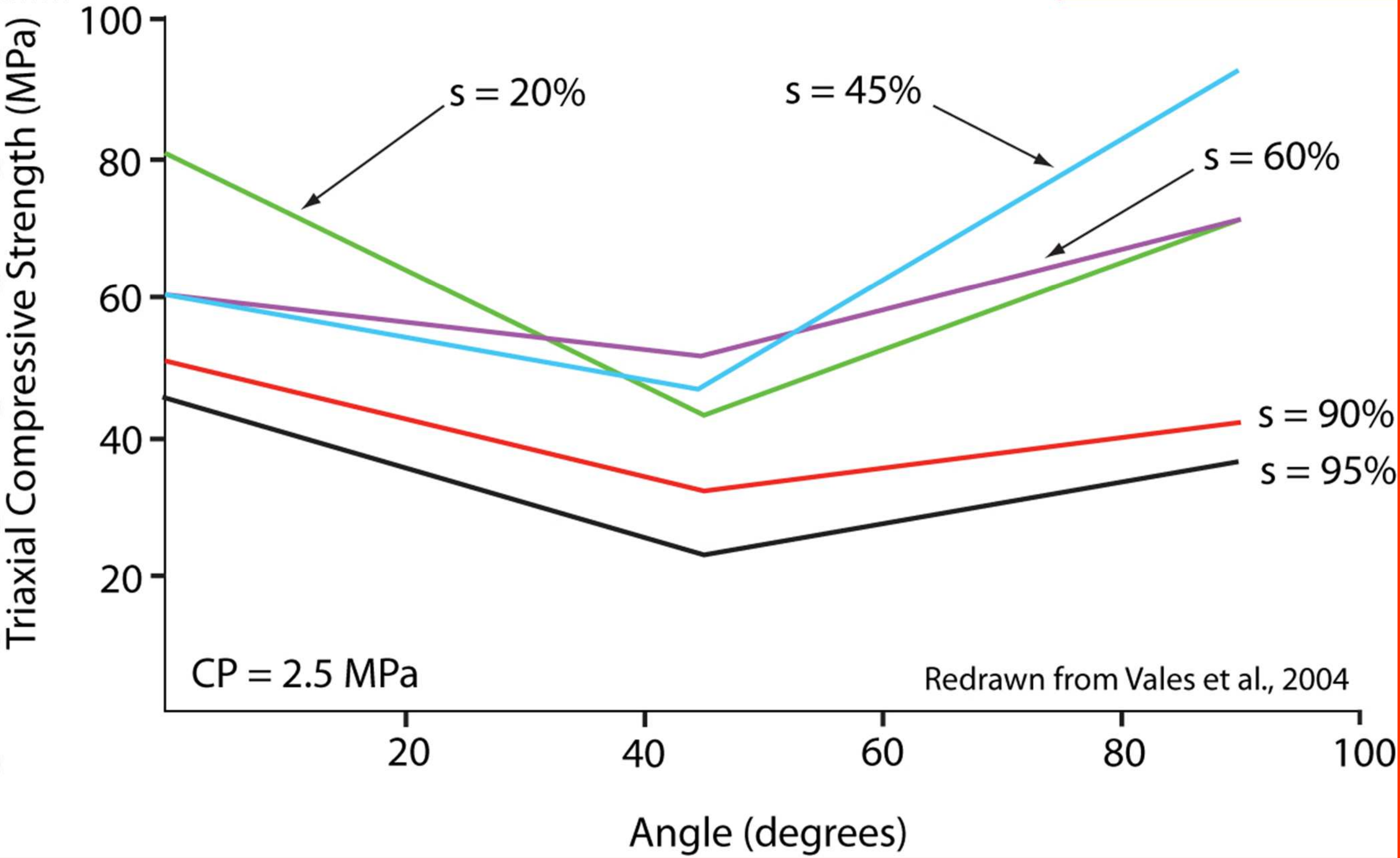
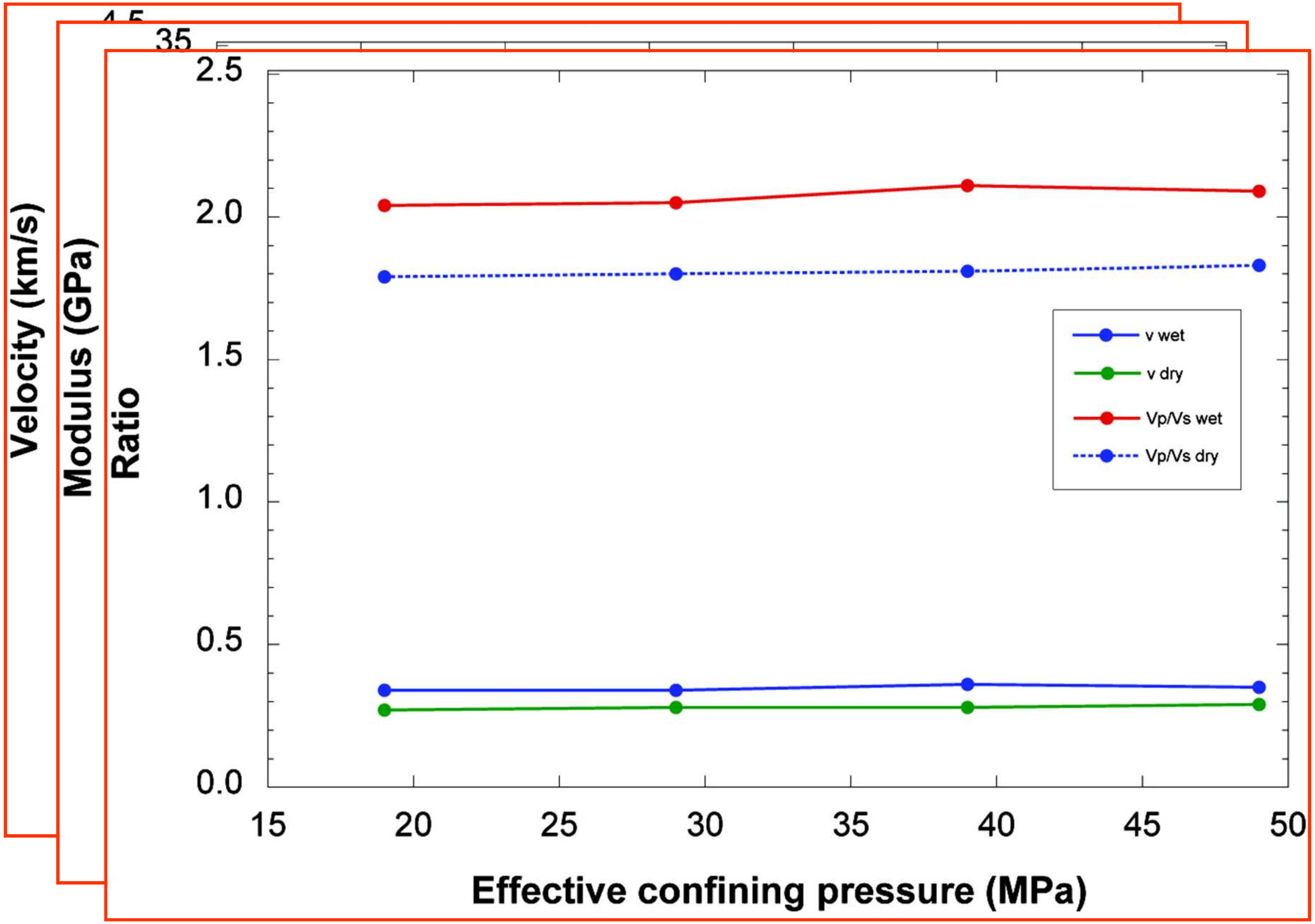


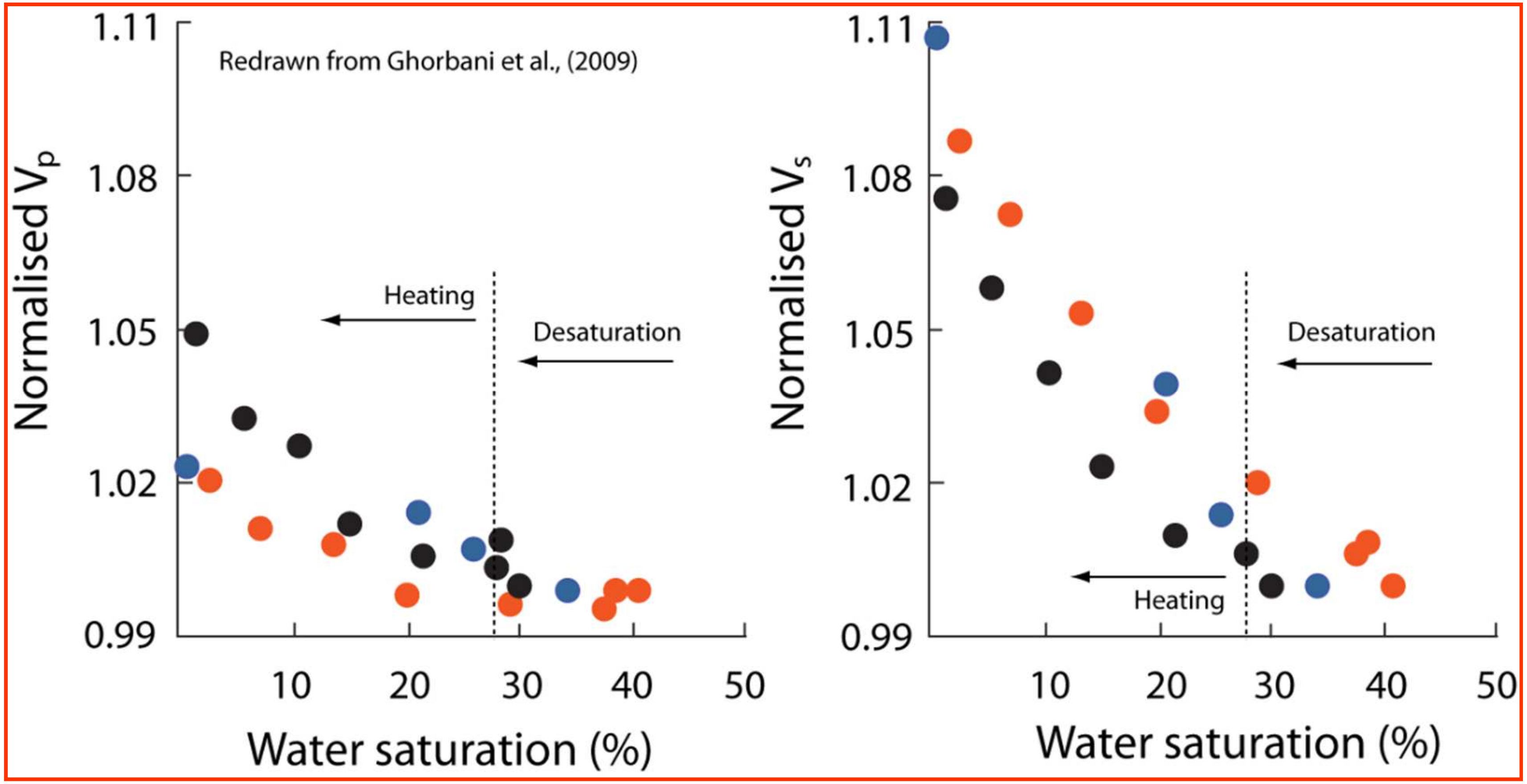

# Results: Strength testing



# Results: Dynamic properties

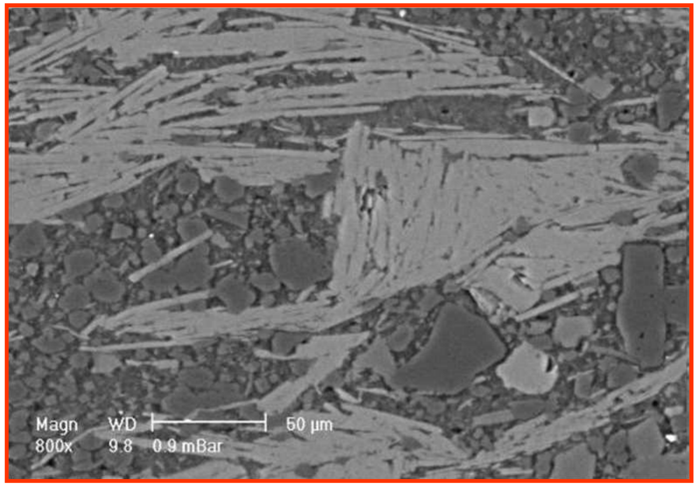


# Literature: Dynamic properties

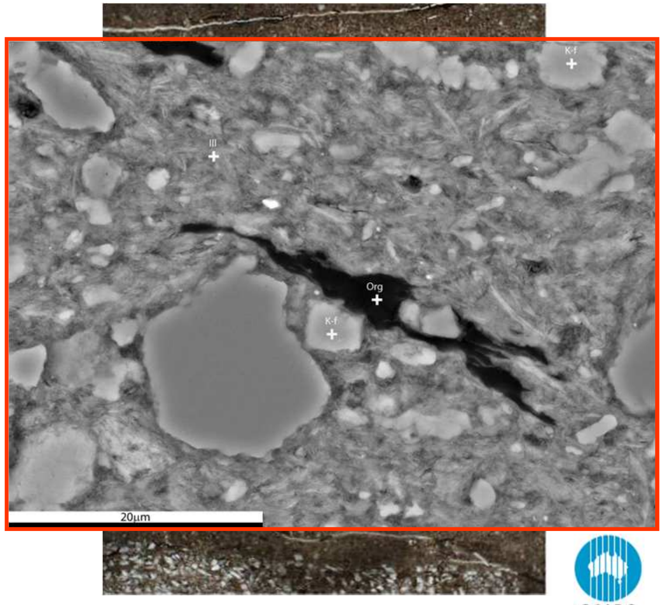


# Low Frequency Tests at ETH

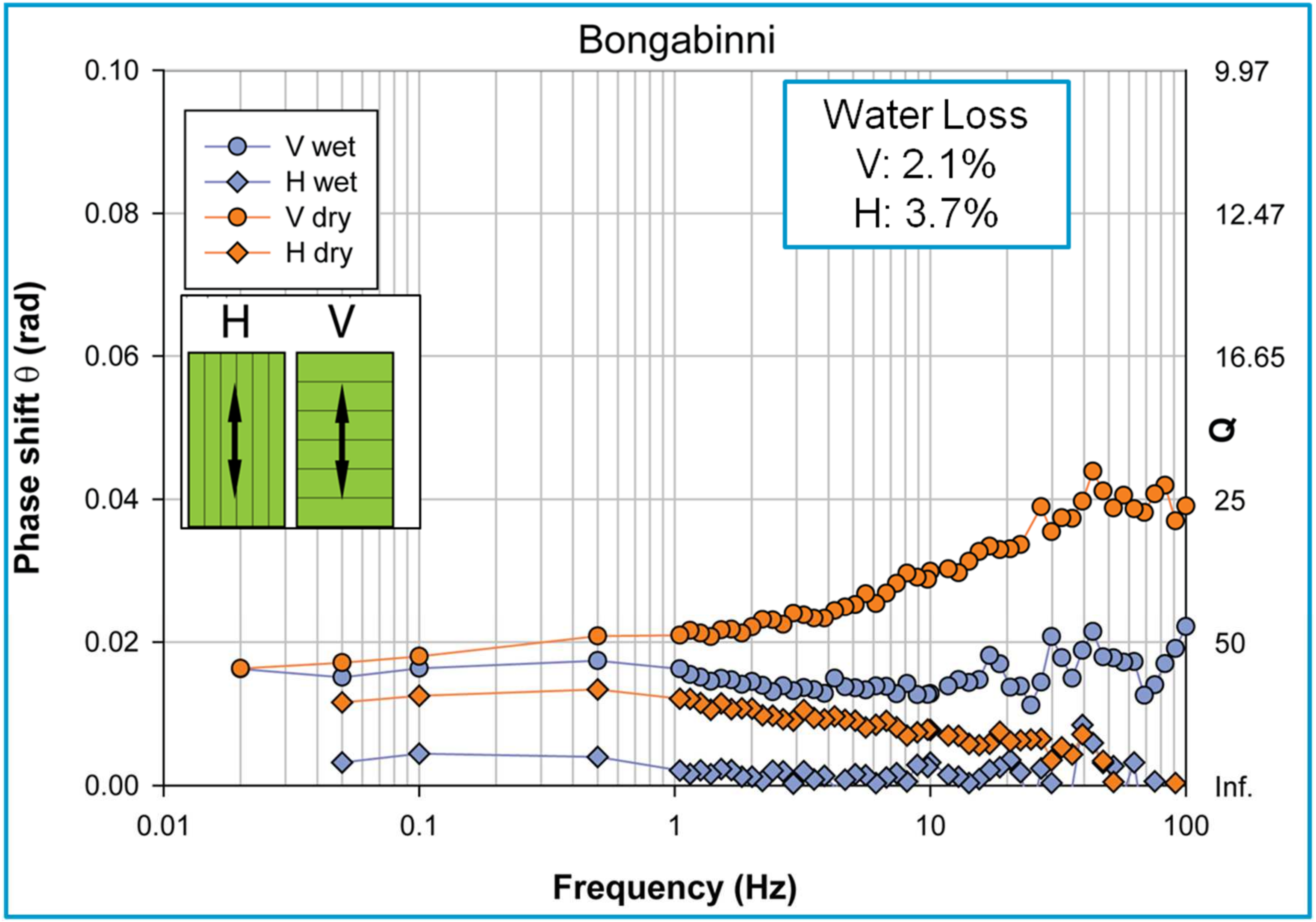
- Bongabinni
  - Clay fraction (< 2 µm) = 25%
  - Clay content (clay minerals) = 40-45%
  - Water content = 4-5% (drying and NMR)
  - Porosity = 8-11% (5-6% by MICP)
  - Pore fluid salinity = ~600g/l




- Goldwyer
  - Clay fraction (< 2 µm) = 30-50%
  - Clay content (clay minerals) = 20-75%
  - Water content = 3-4% (drying and NMR)
  - Porosity = 7-11% (4-8% by MICP)
  - Pore fluid salinity = 350-500g/l



# Results: Low Frequency



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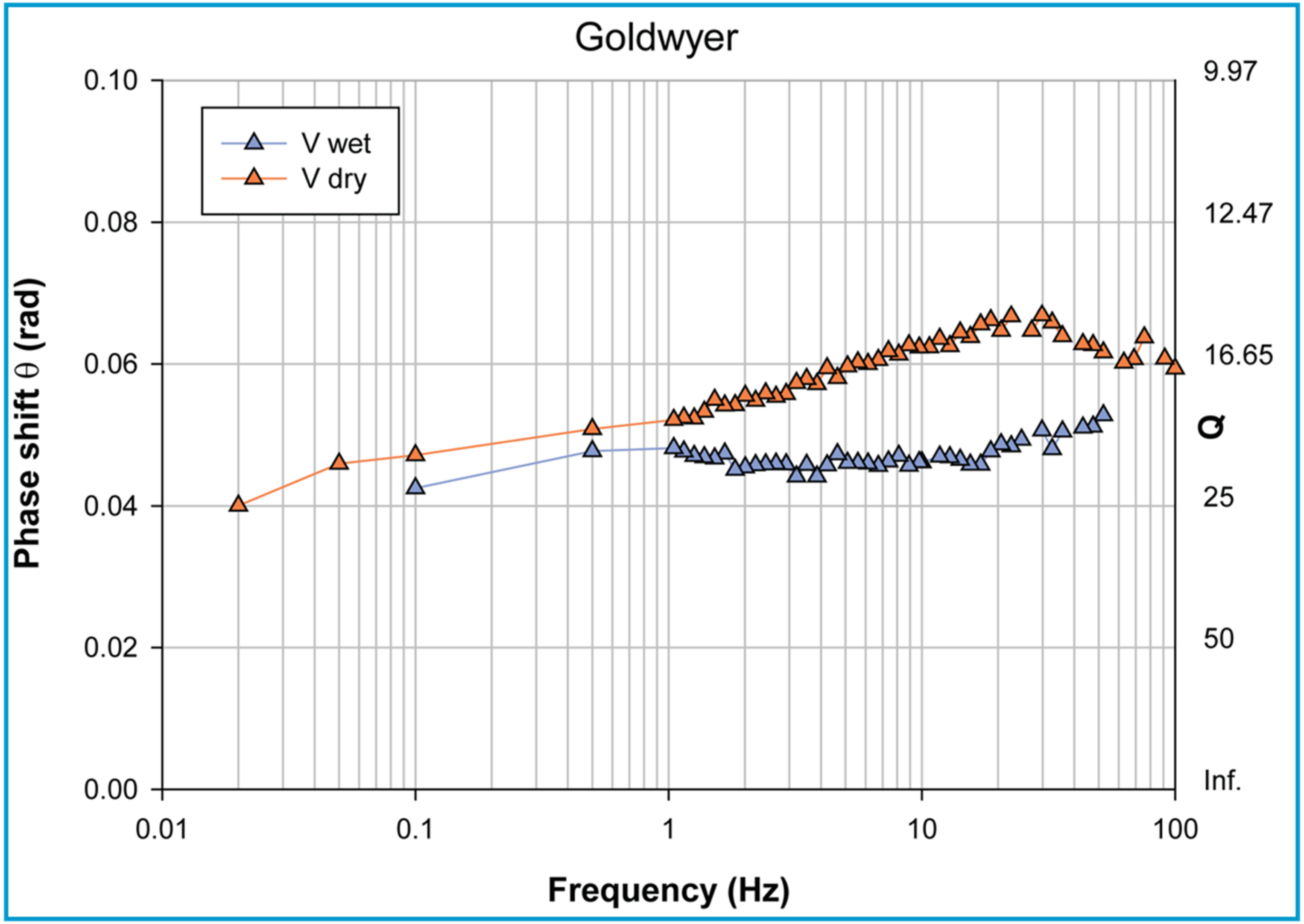
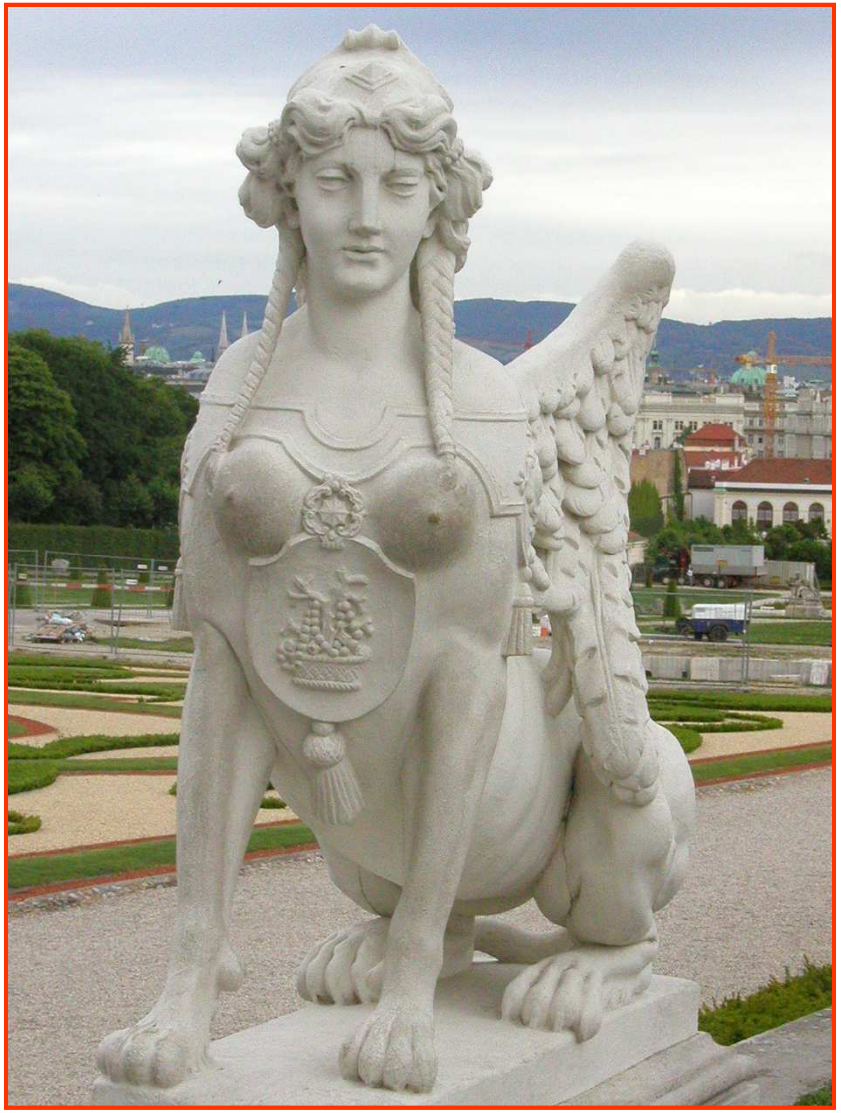


# Implications: Preservation, Gas Shale and Clays

- Preserved water content important for rock properties
- Stiffness, strength can be affected significantly, e.g.:
  - Stress dependent permeability on dry samples
  - Increasing strength/velocity with inc clay content in dry samples
  - Comparing dry shale to in situ logs/conditions
  - Estimation of stiffness assuming constant saturation
- For preservation: think human impact before geological interpretation
- For gas shale, saturation variable, impact on strength/stiffness predictions??

# Preservation of Carbonates!!!



# Acknowledgements

This work was funded through CSIRO Carbon Energy Capability Development Funding for a project investigating Interfacial Phenomena in Shales

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# Thank you

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