Micro-geochemistry and Micro-geomechanics towards understanding proppant shale rock interaction: A Caney shale case study, USA

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[4]Oklahoma Geological Survey
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Abstract

A key feature of shale reservoirs is their low level of permeability. As a means of producing from these reservoirs, there is a requirement to create hydraulic fractures with highest level of conductivity, but these fractures are subsequently filled with high amounts of fracturing fluid chemicals during hydraulic fracturing and production from shale is impacted by formation damage that results from clay swelling and proppant embedment. The goal of this work is to develop insights into the proppant embedment that results from the mineral composition of the shale following instrumented indentation, Raman spectroscopy technique coupled with modelling approaches. The Caney Shale is an organic-rich, often calcareous mudrock. Many studies have examined the impact that clay has on different kinds of shale productivity but there is currently no data reported on Caney in relation to horizontal drilling. However, there also remains a lack of understanding of the mechanisms involved. While many scholars have investigated the influence that clay has on fracture conductivity, the combination of the use of indentation techniques and Raman spectroscopy coupled with modelling as a means of comprehending shale well production is an area that needs further consideration. Indentation tests were performed on a micro level on drilled rock core specimens as a means of determining the mechanical composition of bulk phases of these multiphase materials. The outcomes of the micro-indentation revealed that the bulk mechanical properties of the shale sample were higher overall. The creep effect impacts the maximum penetration depth and the modulus of elasticity of the shale sample. The variation in mechanical properties can be attributed to the changes in the mineralogical composition and microstructure. We believe that this method can provide an understanding into trends and help connect to field performance that would enable more comprehensive completions and avoid fracture plugging and loss of production.

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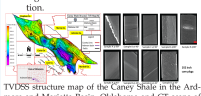
Oklahoma State University(OSU)[1], Lawrence Berkley National Laboratory(LBNL)[2], Univeristy of Pittsburgh[3], Oklahoma Geological Survey(OGS)[4], Continental Resources Inc.[5]

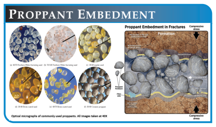
Introduction

- The Caney Shale is an organic-rich calcareous mudrock
- Clay swelling and proppant embedment affect production
- The use of indentation techniques coupled with Raman spectroscopy, EDS and modeling is an area that needs further consideration.

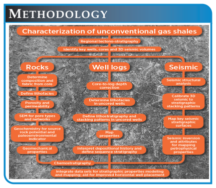


TVDSS structure map of the Caney Shale in the Ardmore and Marietta Basin, Oklahoma and CT scans of 1×2in core samples

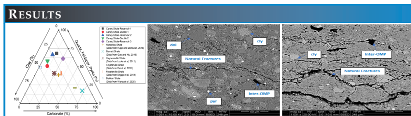
Proppant Embedment



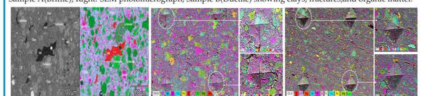
Methodology



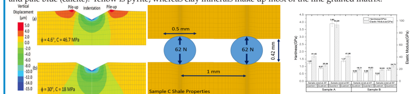
Results



Left: Mineralogy of the Caney Shale compared to other formations; Middle: SEM photo micro graph depicting Sample A(Brittle); Right: SEM photomicrograph, Sample B(Ductile) showing clays, fractures,and organic matter.



Left: (BSE) micrograph (left) and the EDS map (right) obtained from a polished surface of Caney sample. Middle: BSED surface chemistry at 20 kV of the Sample A(Brittle). Right: BSED surface chemistry at 20 kV of the Sample B(Ductile) where indentation was done. Abundant magenta (quartz) with lesser amounts of olive green (dolomite) and pale blue (calcite). Yellow is pyrite, whereas clay minerals make up most of the fine grained matrix.



Left:Modeled indentation pit for two alternatives. Middle: Sample E properties after unloading; Modeled proppant embedment due to elastic and plastic shale deformation. Right:Mechanical properties obtained from indentation of the shale samples at different orientations.

References

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Discussions

- Microstructural characterization is critical for better understanding of the rock susceptibility to mechanical or chemical failure.
- Variations in the microstructure and mechanical properties illustrated in the figures reflect the amount of total clays present, which correlates with the mineralogical analysis.
- Shale samples can exhibit small-scale fractures, bands of kink and shear zones, with the location of the fractures and the geometry of the shear zones depending on the orientation the sample relative to the bedding.

Conclusions

- Energy Dispersive Spectroscopy and Raman Spectroscopy can improve mineral mapping and establishing rock surface chemistry that is vital for predicting proppant embedment.
- Surface profilometry can be effective in estimating indentation depth and help predict proppant embedment.
- Mineralogy, microstructural characteristics and bedding orientation play a vital role in governing proppant embedment.

Acknowledgements

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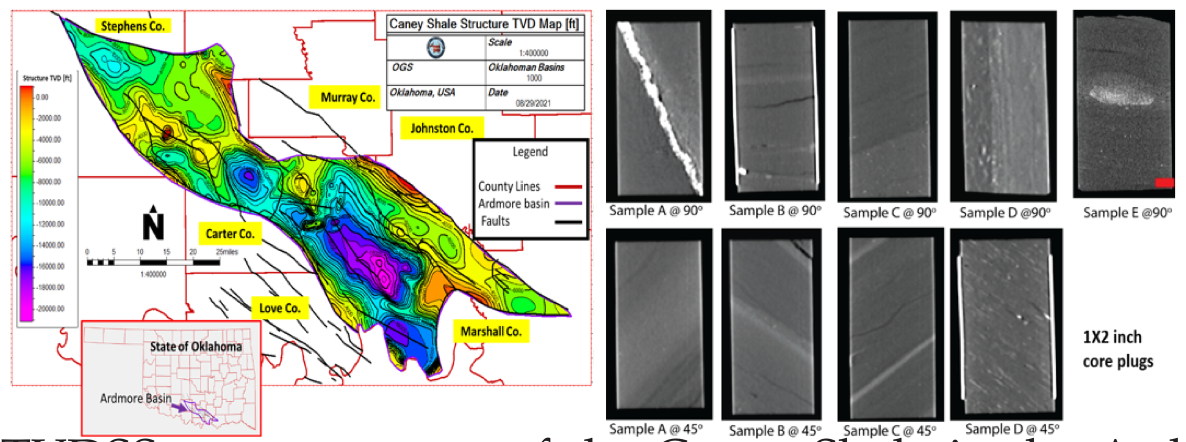

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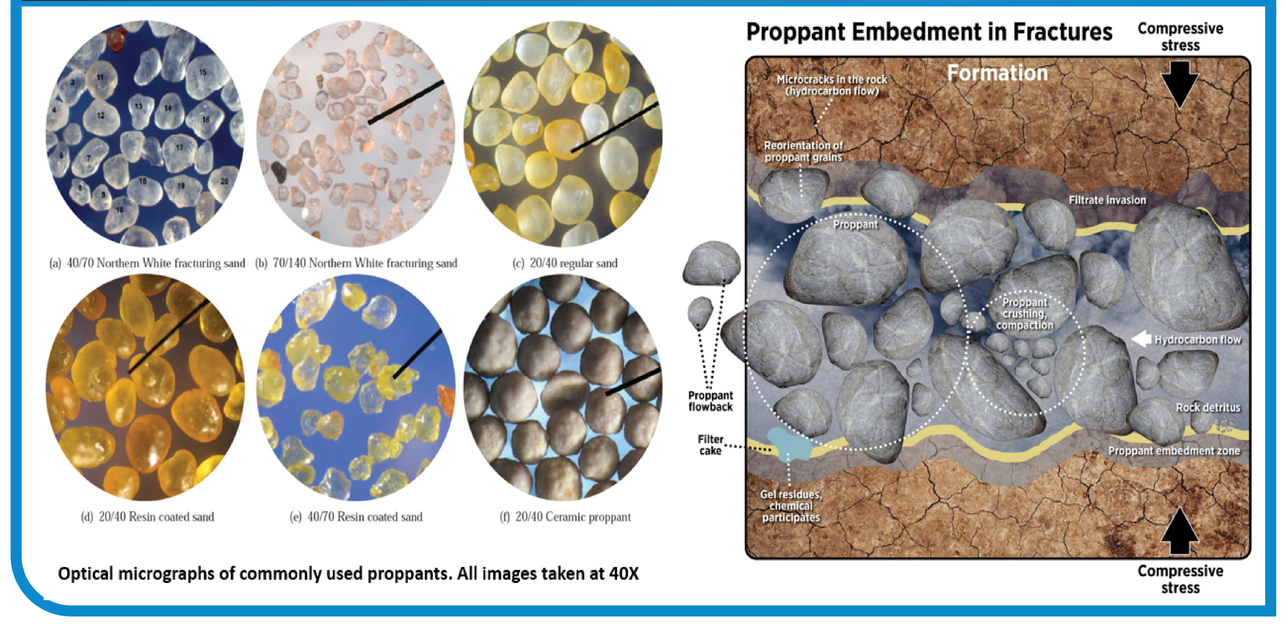

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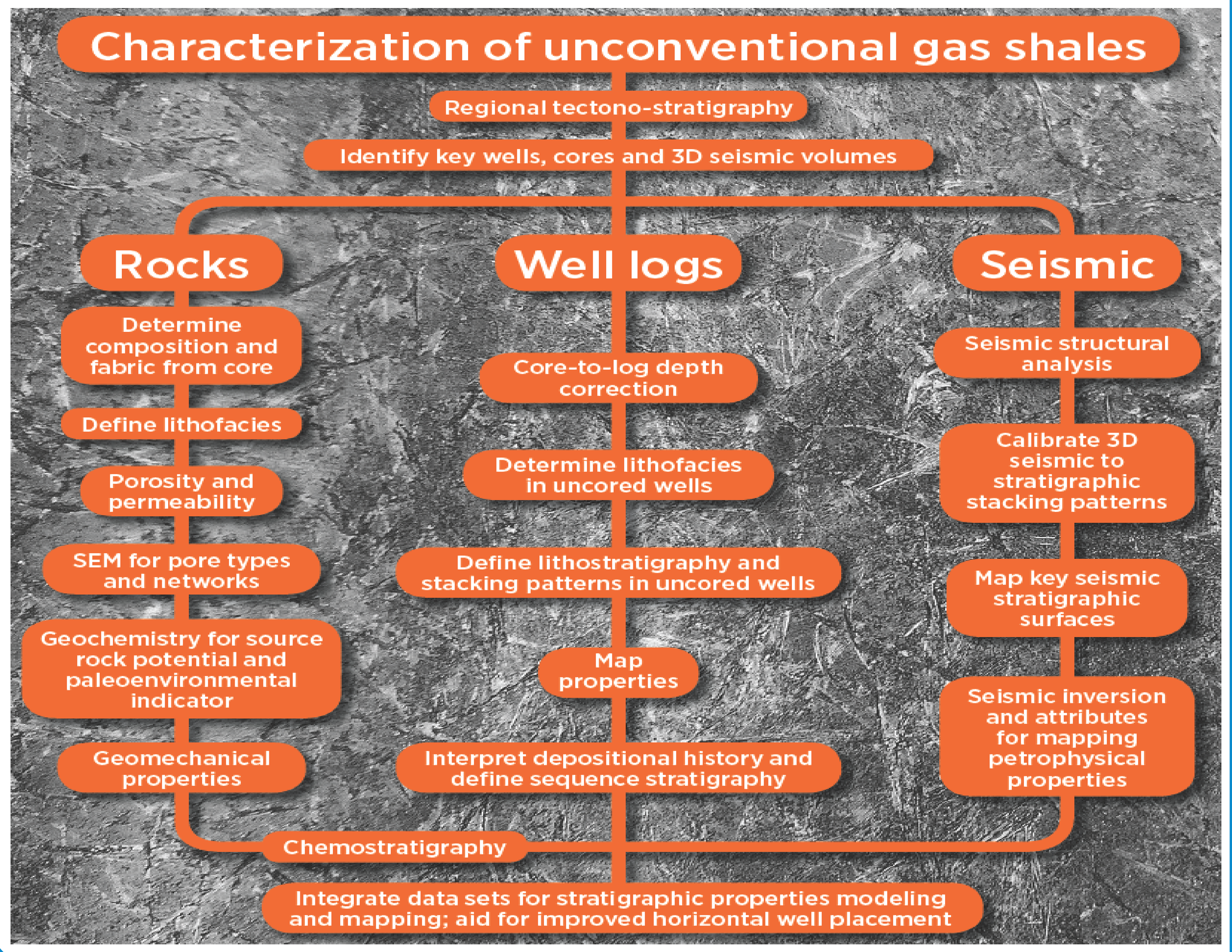

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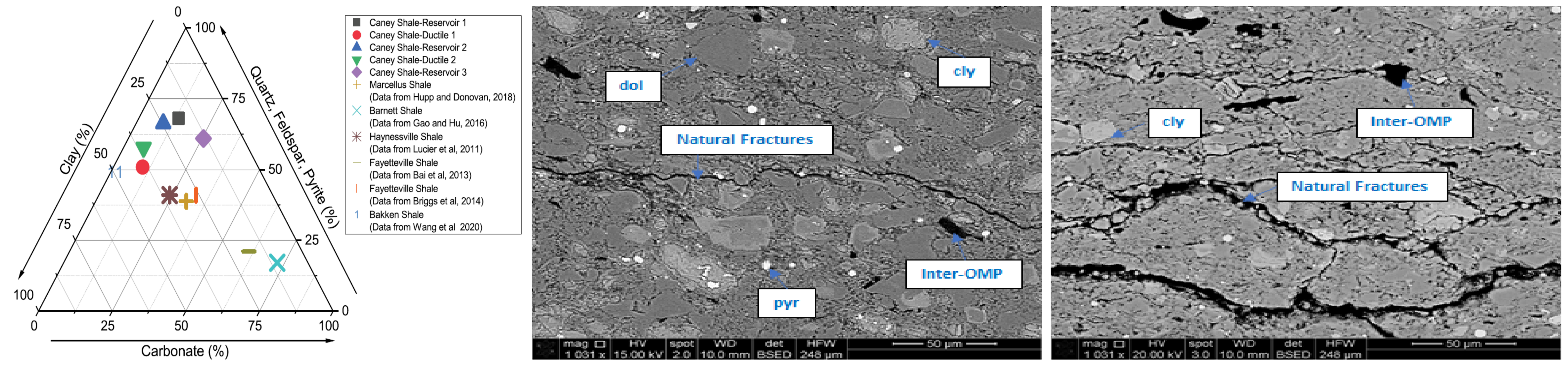

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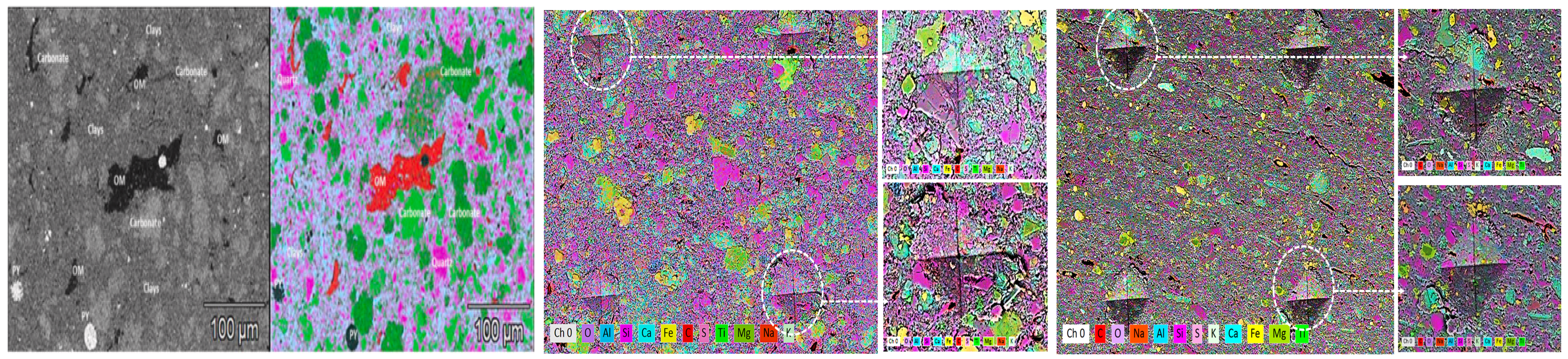

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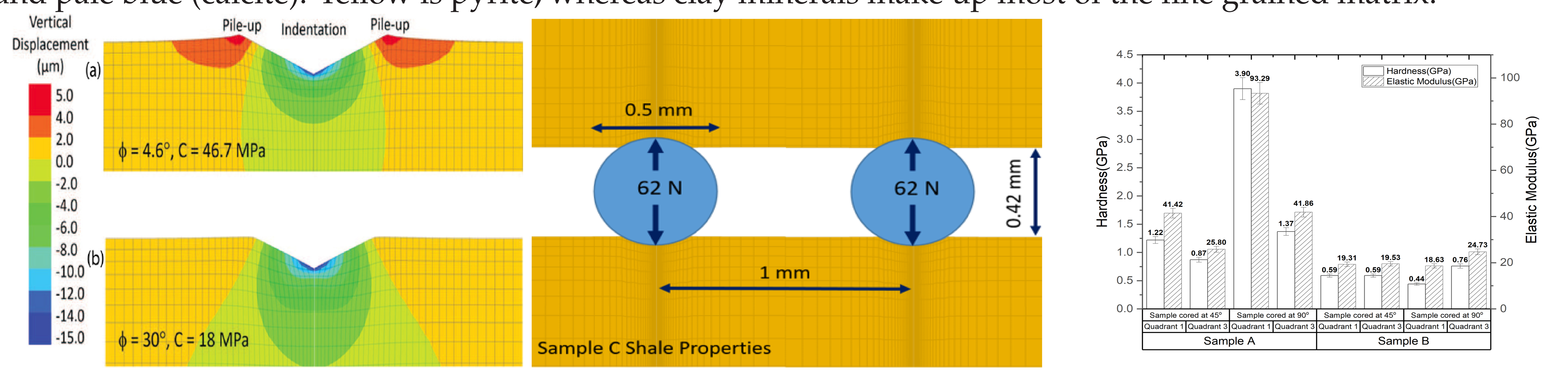

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