

# Microporosity-permeability relationship for complex South East Asia carbonate reservoir

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## INTRODUCTION

- Porosity and permeability are important and uncertain reservoir parameters to indicate the hydrocarbon volume and CO<sub>2</sub> storage capacity
- Establishing carbonate reservoir porosity-permeability relationships that are valid at every scale is very difficult due to complex pore network systems and diagenetic history of carbonate reservoir
- Microporosity is the porosity in small pores associated with detrital and authigenic clays or within carbonate grains with pore size < 10µm.

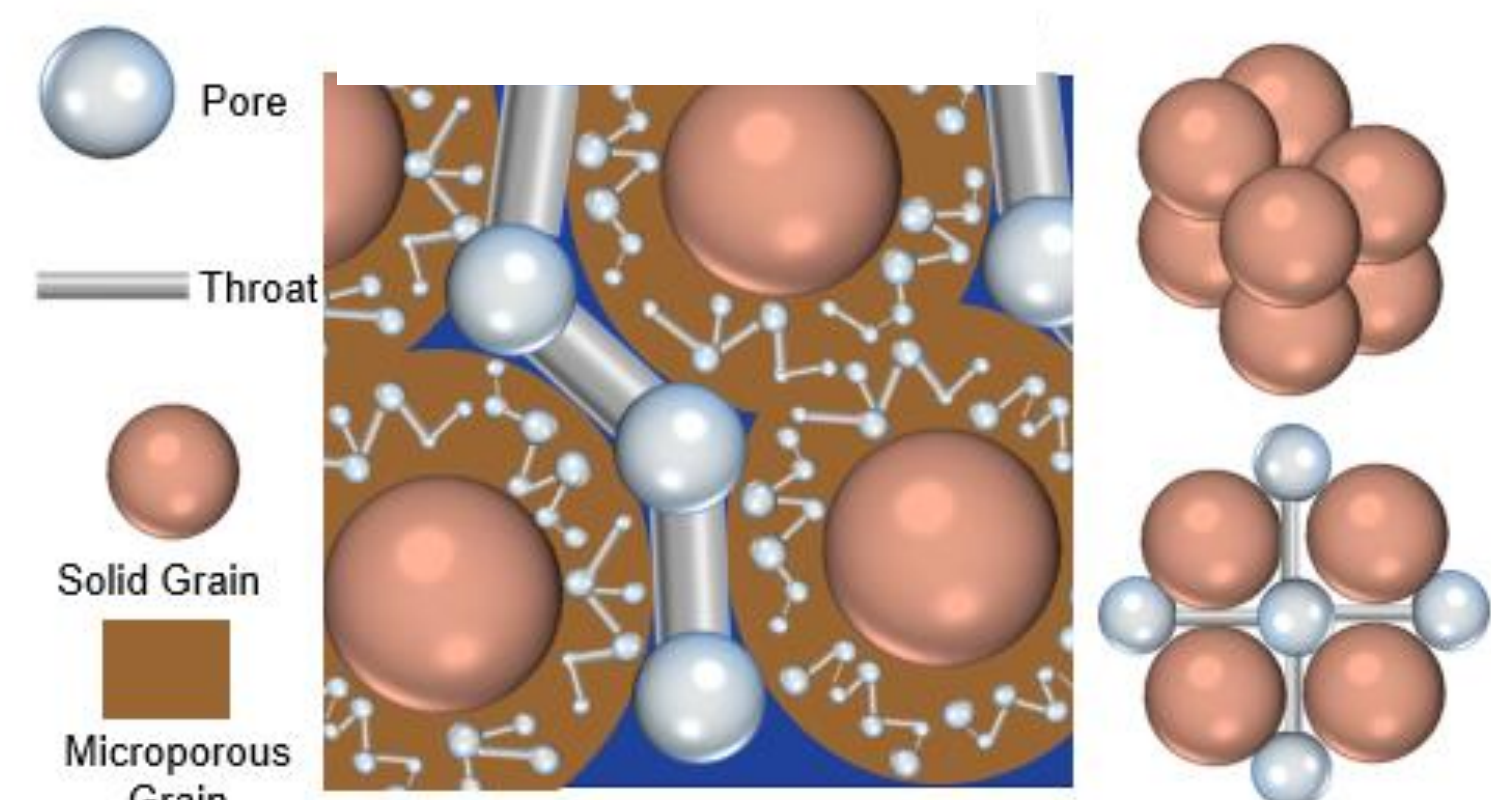


Fig. 1 Carbonate structure

## OBJECTIVES

- To share a proof-of-concept microporosity study in Central Luconia carbonate fields, Malaysia that is based on 2D and 3D imaging techniques
- To analyse the relationship between microporosity and permeability for Miocene carbonate samples

## STUDY AREA

### Central Luconia Province, Malaysia

- Promising gas resources of around ~30 TSCF have been trapped in Miocene carbonate reservoirs, Central Luconia
- Potential CO<sub>2</sub> storage sites in depleting fields

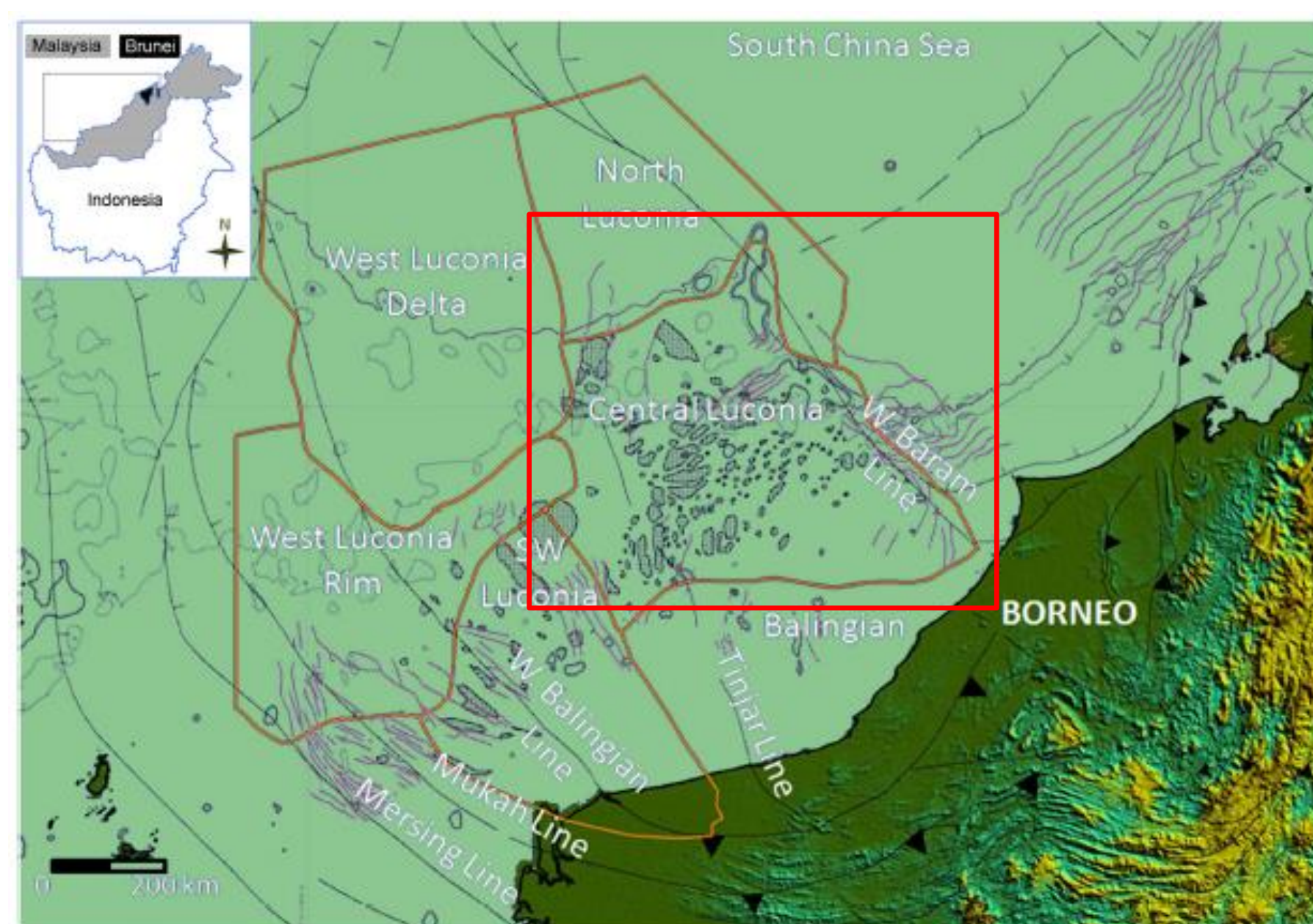


Fig. 2 Location map of Central Luconia Carbonate Platform, Malaysia [1]

## METHODOLOGY

How to tackle the porosity-permeability relationship for carbonate fields with significant amount of microporosity (Central Luconia)?

Qualitative

Quantitative

Winland R35 analysis

MICP data

Grain diameter analysis

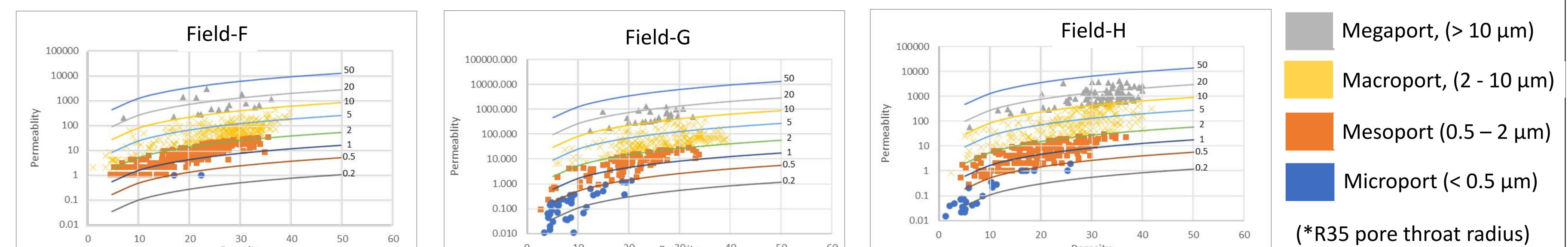
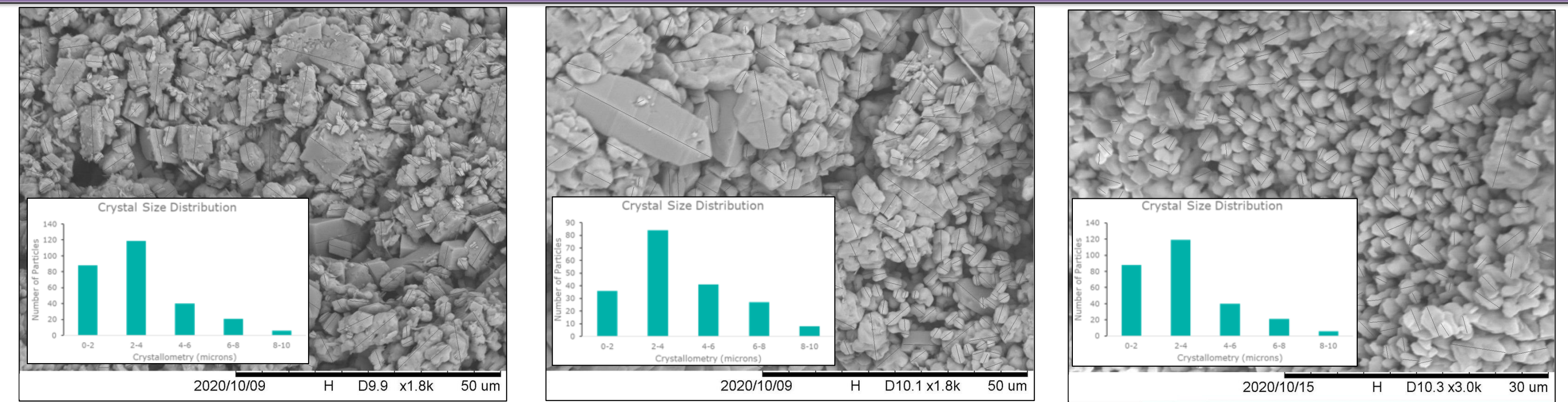
RCA + 2D Thin section data

3D imaging data + digital rock analysis + pore scale modelling

(\*RCA Routine Core Analysis)

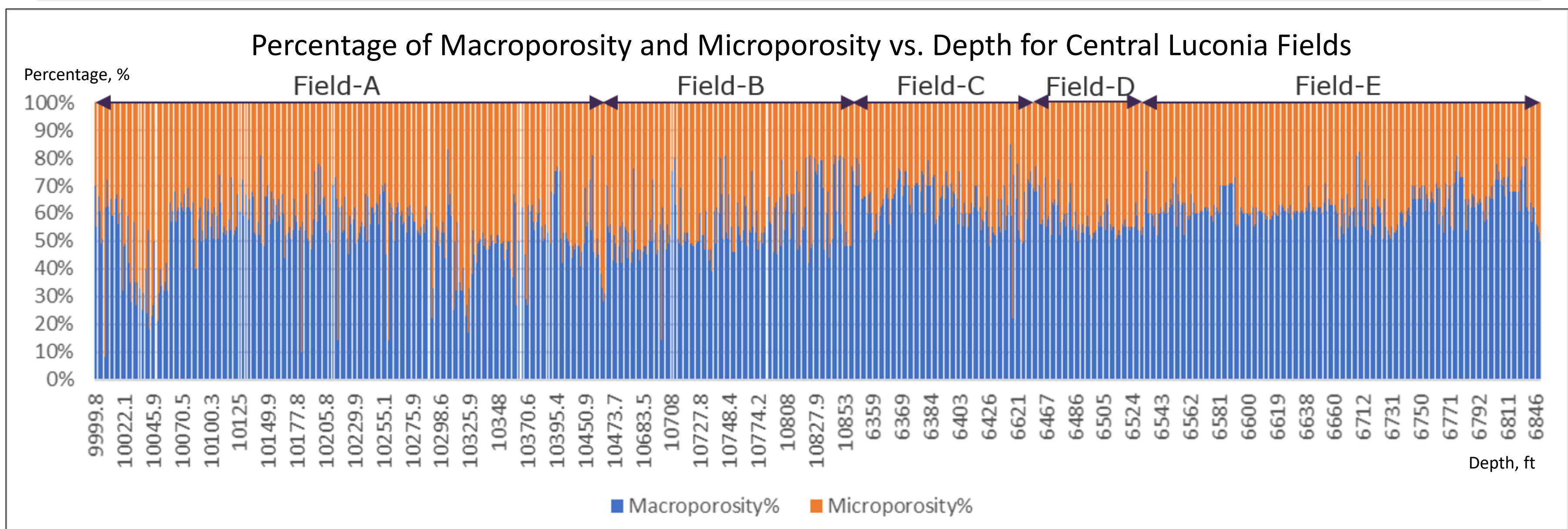
## RESULTS & DISCUSSIONS

Qualitative analysis: Grain diameter analysis (SEM images), Winland R35 analysis (RCA data) and MICP data



- Heterogenous behaviour and presence of microporosity are observed based on porosity-permeability plots and SEM images with crystal size distribution below 10 µm.
- Macroport (2 - 10 µm) and mesopore (0.5 - 2 µm) are common flow units for Central Luconia carbonate fields.
- MICP plots observes 1 macropore, 6 meso-macropore, 16 mesopore and 7 micropore samples

Quantitative analyses: 2D imaging technique



- 2D-imaging microporosity calculation = Total porosity (RCA data) - Macroporosity (Thin section data)
- A range of microporosity (15-83%) presents in Field A, B, C, D and E with average value of 41%.

Quantitative analyses: 3D imaging technique

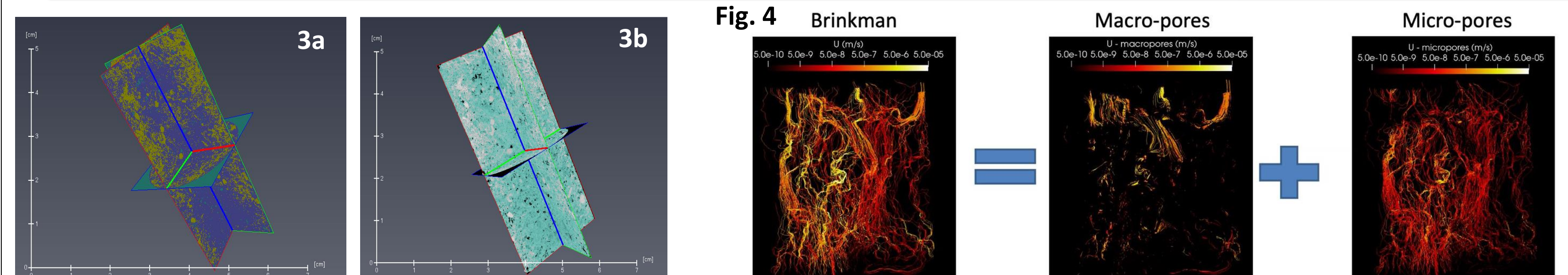
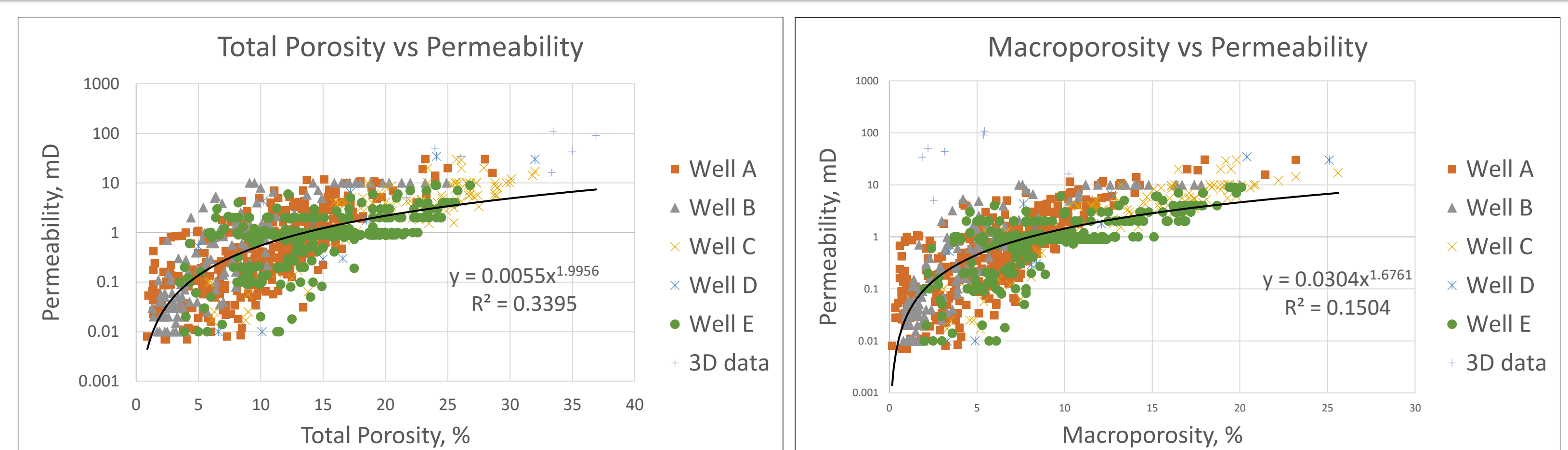


Fig. 3a: 3-phase segmentation (pore, microporous and solid phases); Fig. 3b: Masked (green) area represented microporous phase; Fig. 4: Velocity field obtained by DBS flow simulation

- The microporosity calculation for 3D micro-CT digital rock analysis at core-scale is calculated based on segmented and normalised microporous phase using formula  $[1 - (\text{Mean value}/100)] \times \text{volume fraction of microporous phase}$
- In addition, Darcy-Brinkman-Stokes (DBS) flow simulation has been conducted on one carbonate plug sample
- It is observed that micropores have contributed 83% of total permeability on the carbonate plug sample

Microporosity-permeability relationship and analyses



	Field-A	Field-B	Field-C	Field-D	Field-E	Overall
Average micro Ø%	46	43	35	36	38	42
R <sup>2</sup> Total Ø vs perm	0.5127	0.6633	0.3555	0.6736	0.2997	0.3395
R <sup>2</sup> Macro Ø vs perm	0.6304	0.6973	0.4979	0.7927	0.5547	0.1504

- Higher R<sup>2</sup> value observed for macroporosity vs permeability as compared to total porosity vs permeability.
- Micropores have more contributions in permeability especially for Field-A, C and E.

## CONCLUSION

- Central Luconia carbonate samples contain significant amount of microporosity, ranging from 15 to 93% of the total measured porosity.
- Micropores play an important role in connecting the macropores and contribute significantly to the total permeability.
- It is recommended to further extend the microporosity study using higher resolution 3D imaging techniques such as FIB-SEM and upscale the images back to core scale.

## REFERENCES

- Janjuhah, H.T., Salim, A.M.A., Alansari, A. et al. Presence of microporosity in Miocene carbonate platform, Central Luconia, offshore Sarawak, Malaysia. Arab J Geosci 11, 204 (2018). <https://doi.org/10.1007/s12517-018-3526-2>
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