Evolution of Clay Microstructure Under 1D Consolidation

Rishabh Tiwari[1] Prof. Béatrice Baudet[1] Prof. Matthew Richard Coop[1] Prof. Jean-Michel Pereira [2] Prof. Pierre Delage[2]

[1]University College London, U.K. [2]Ecole des Ponts, France

BGA Annual Conference 2025

Introduction

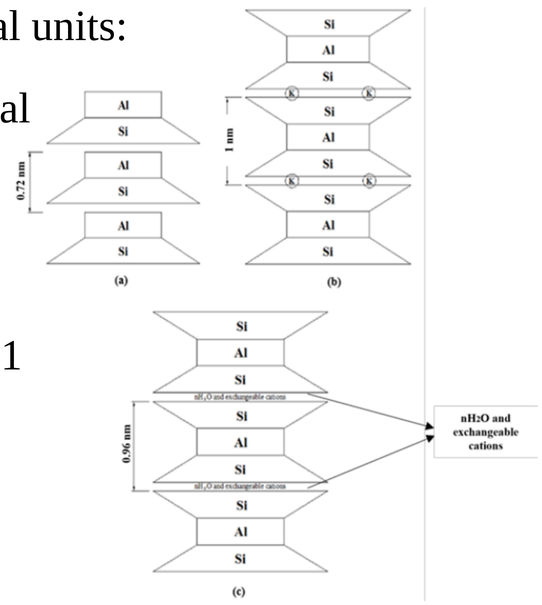
Clay mineral structural units:

Tetrahedral: Octahedral

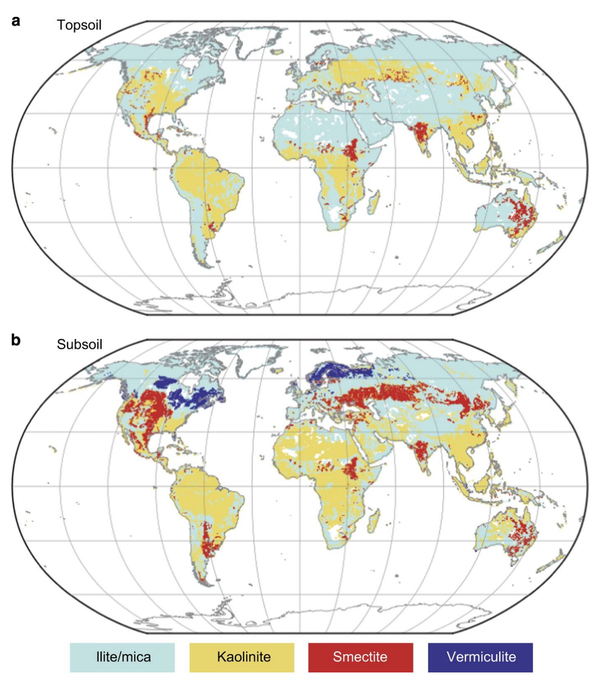
(a)Kaolinite 1:1

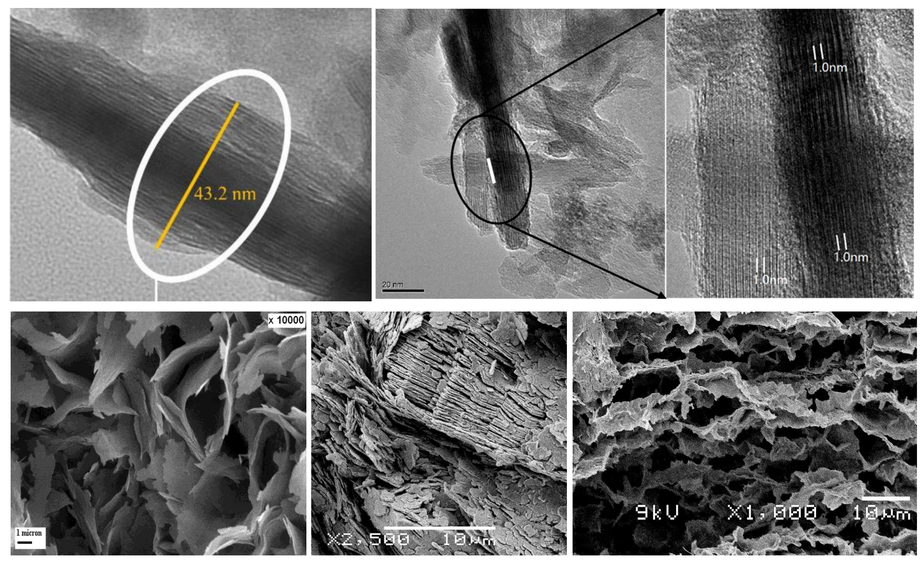
(b)Illite 2:1

(c)Montmorillonite 2:1



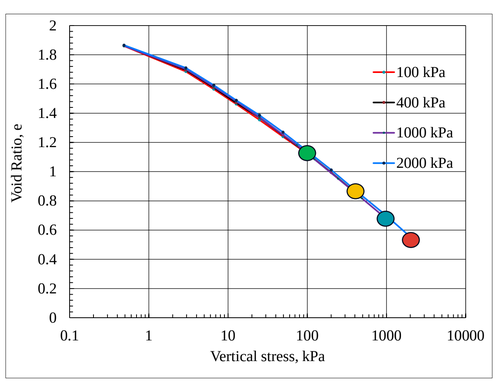
Global clay mineral distribution



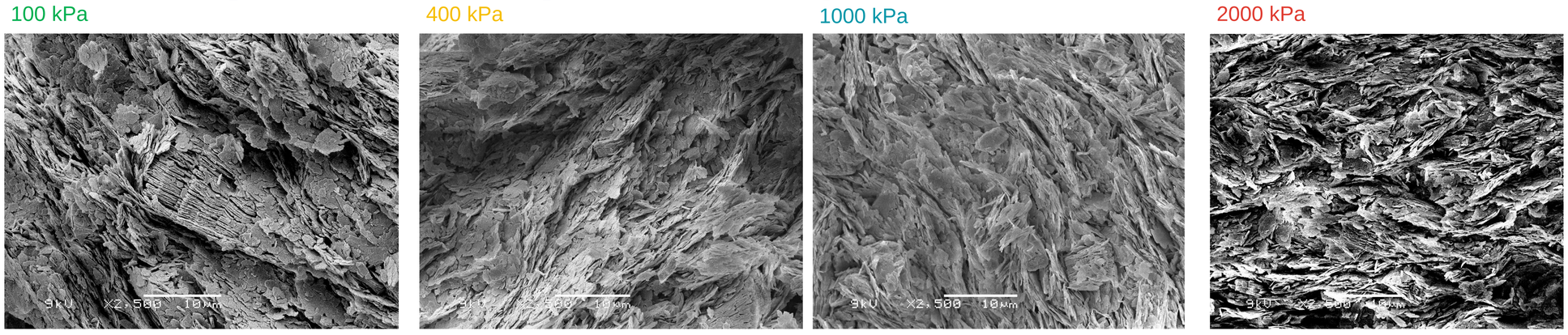


Illite Kaolinite Montmorillonite

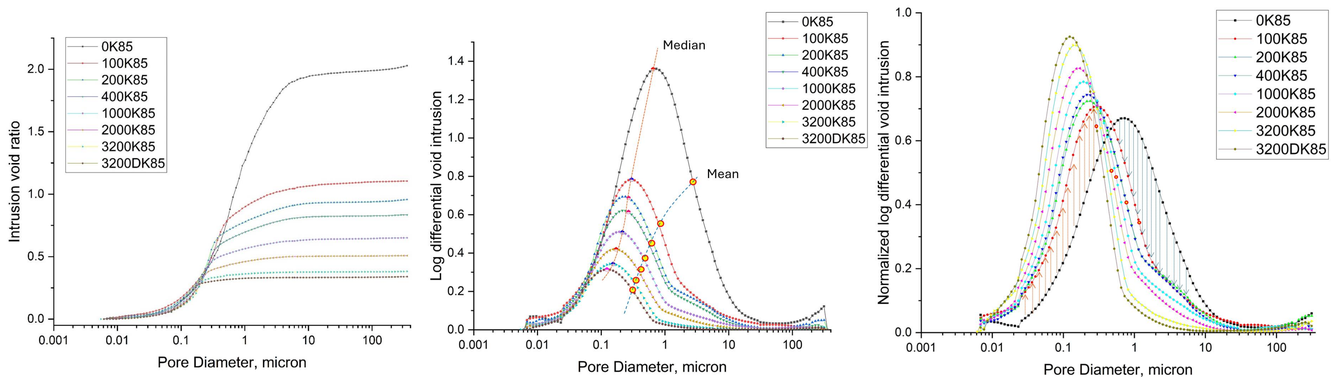
Methodology: Evolution of pore sizes, shapes and orientation of pure kaolinite during 1D consolidation



100 kPa 400 kPa 1000 kPa 2000 kPa

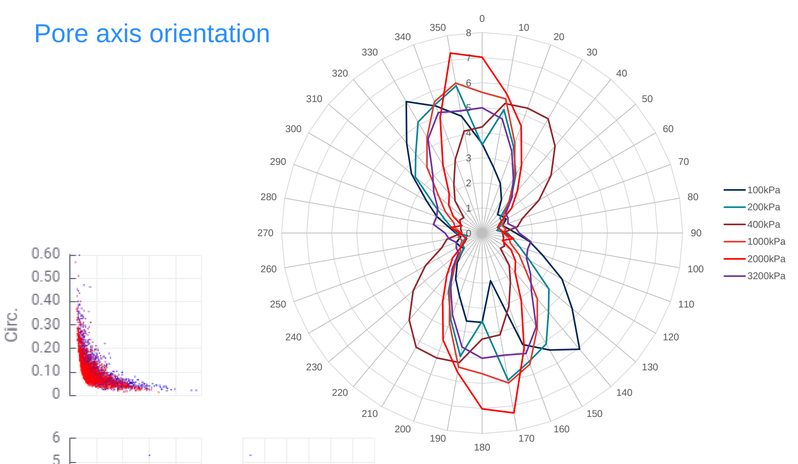


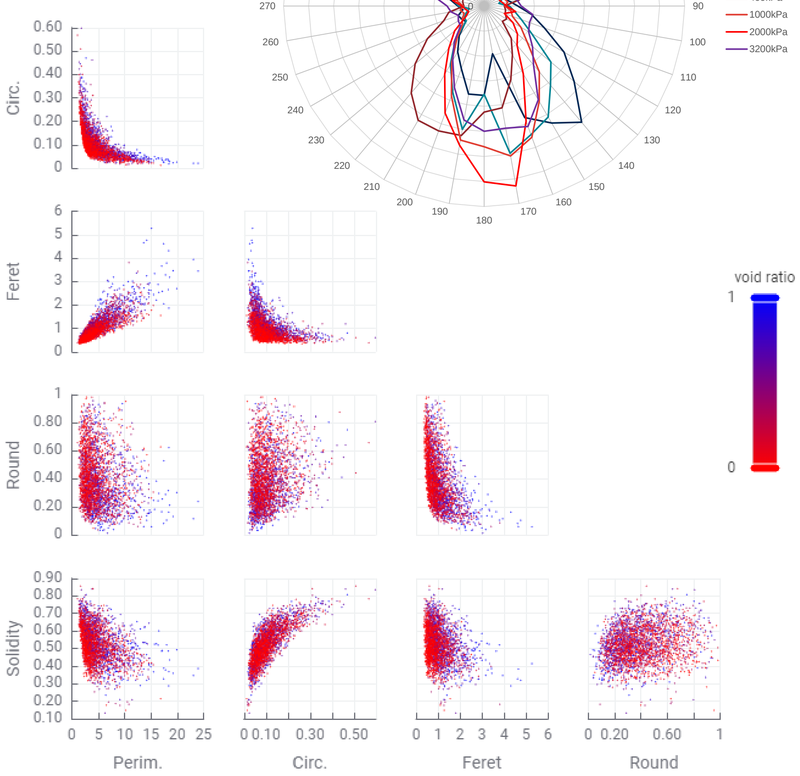
Scanning Electron Microscopy



Mercury Intrusion Porosimetry

Pore axis orientation

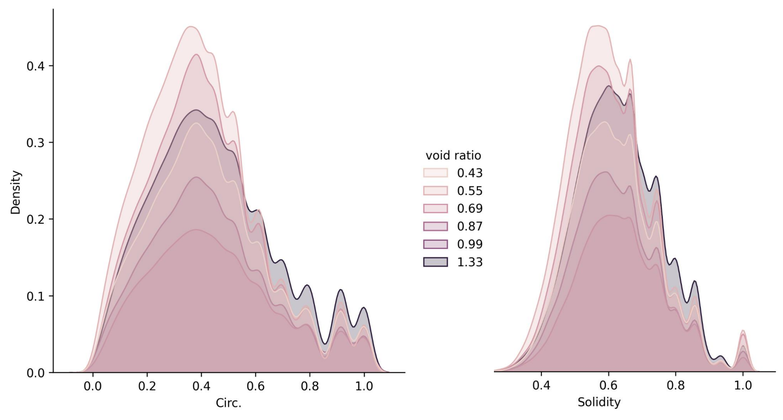




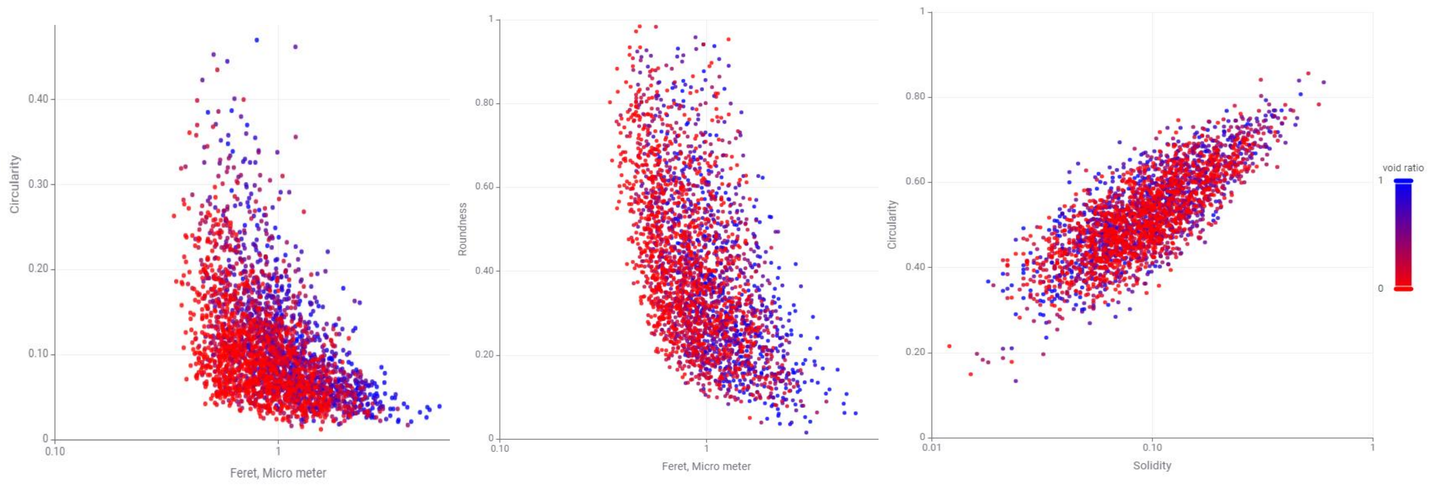
Pore shape descriptors

Label	Area	Perim.	Feret	AR	Round	Solidity	Circ.
1	28.21	27.941	8.307	1.062	0.941	0.684	0.454
2	19.621	29.338	7.665	1.006	0.994	0.506	0.286
3	14.191	25.743	7.968	1.062	0.942	0.468	0.269
4	28.296	24.784	8.677	1.953	0.512	0.791	0.579
5	47.429	26.544	8.815	1.031	0.97	0.965	0.846
6	48.233	27.503	8.737	1.054	0.949	0.959	0.801
7	32.002	22.689	8.312	1.14	0.877	0.935	0.781
8	23.413	23.147	9.6	1.757	0.569	0.959	0.549
9	48.894	37.471	9.713	1.28	0.781	0.838	0.438
10	66.59	30.198	9.451	1.016	0.984	0.974	0.918

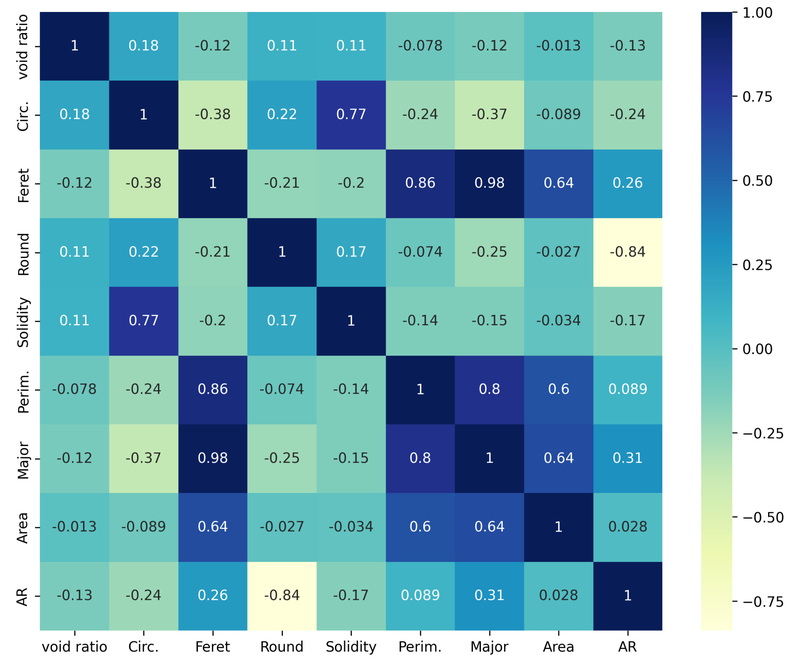
Evolution of pore shape descriptors



Evolution of relations in pore shape descriptors



Correlations in pore shape features



Conclusion

The effect of mechanical loading can be interpreted at the microscale.
Micro-structural parameters can be correlated with applied load to establish constitutive relation.
The pore shape characteristics can be used to train machine learning models.

References:
ITO, A. & WAGAI, R. 2017. Global distribution of clay-size minerals on land surface for biogeochemical and climatological studies. Scientific Data, 4, 170103.
MITCHELL, J. K. & SOGA, K. 2005. Fundamentals of soil behavior, John Wiley & Sons New York.
Xie, H.; He, S.; Huang, C.; Tan, W. Origin of Smectite in Salinized Soil of Junggar Basin in Xinjiang of China. Minerals 2019, 9, 100.
Gualtieri, A. F., Ferrari, S., Leoni, M., Grathoff, G., Hugo, R., Shatnawi, M., Paglia, G. & Billinge, S. (2008). Structural characterization of the clay mineral illite-1M. J. Appl. Cryst. 41

ÉCOLE NATIONALE DES PONTS ET CHAUSSÉES
INSTITUT POLYTECHNIQUE DE PARIS
LABORATOIRE NAVIER