Pore structural features and seepage characteristics of coral reef limestone

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Introduction

Coral reef limestone is a biogenic limestone that is widely distributed in tropical and subtropical coastal areas. The pore structure of coral reef limestone is extremely developed, and it is an important prerequisite for engineering activities, such as hydrocarbon resource exploitation, of coral reef tuff stratum to clarify its pore structural features and seepage characteristics.

Materials

The sample was obtained from China, from which six cubic units with different size factors n were selected to determine the REV after reconstruction. the side lengths of the cubic unit is 5 mm when n equals 1.

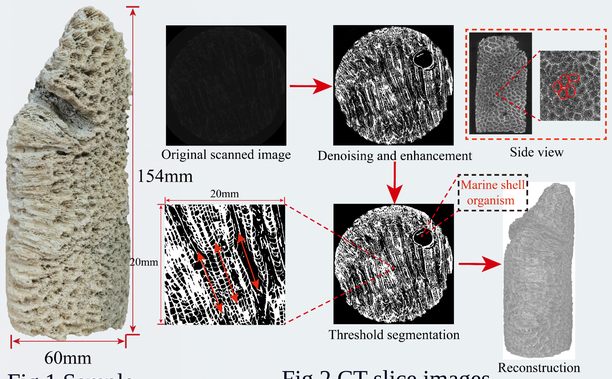

Fig.1 Sample

Fig.2 CT slice images

Results

The pore structure of the coral reef limestone is highly anisotropic (Fig.6), which further leads to the anisotropy of fluid flow within it (Fig.7); the distribution of the pore structure of this coral reef limestone is relatively inhomogeneous (Fig.8); there are key pore nodes within the coral reef limestone, most of which are located at the intersections of fluid flow routes (Fig.9), and seepage simulations have demonstrated that the disappearance of these key pore nodes will lead to a significant decrease in its permeability (Fig.10).

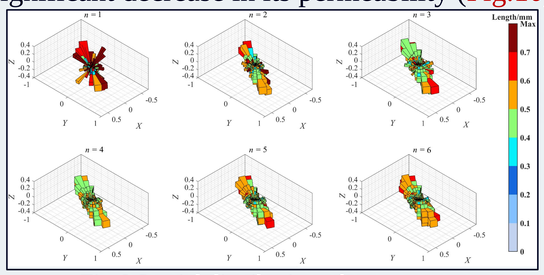

Fig.6 Spatial distribution of pore structure

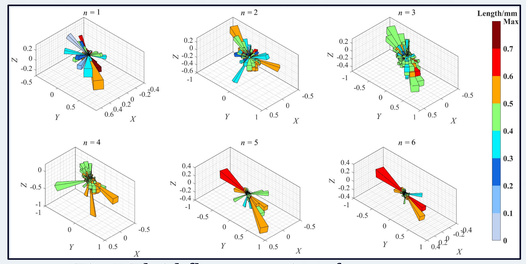

Fig.7 Fluid flow capacity of pore structure

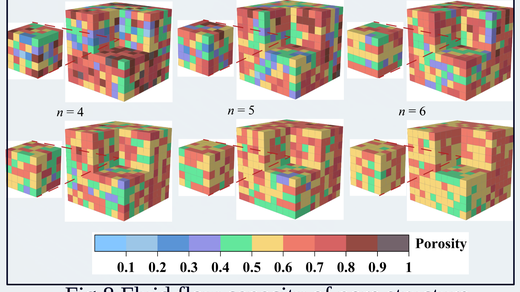

Fig.8 Fluid flow capacity of pore structure

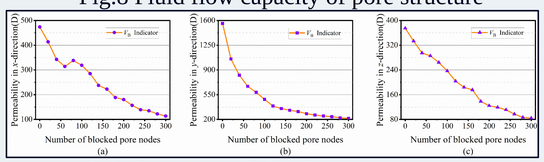

Fig.10 Permeability evolution with the blocks of key pores

Fig.9 Fluid flow paths along different directions and key pore nodes

Methods

CT scanning and two pore structure methods (Fig.3) were used to analyse pore structural features (Figs.6, 7, 8); network analysis method (Fig.4) was applied to explore seepage characteristics (Fig.9); Seepage simulation (Fig.5) was used to verify the seepage anisotropy and key pore nodes (Fig.10).

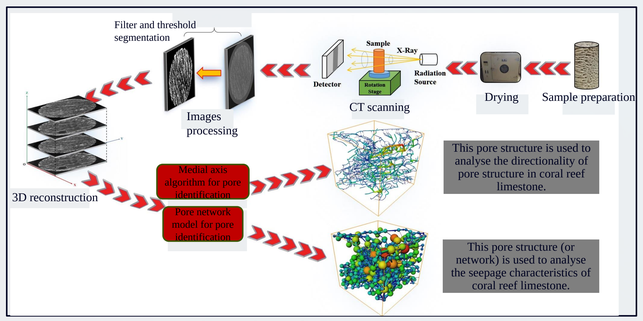

Fig.3 Flow chart for pore data acquisition

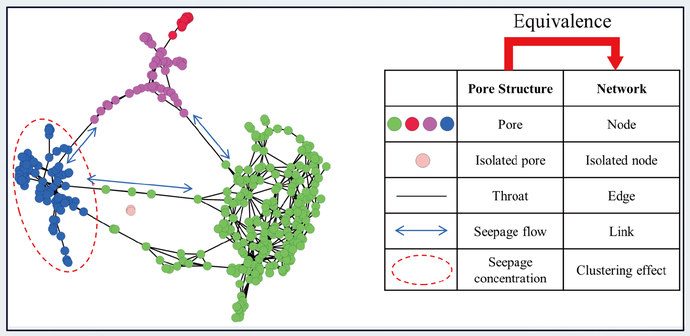

Fig.4 Schematic diagram of network analysis

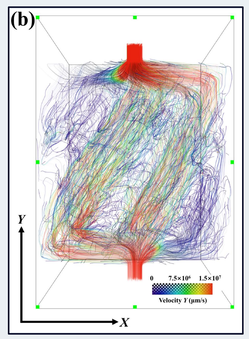

Fig.5 Seepage simulation

Conclusions

1. The pore structure of coral reef limestone is highly anisotropic, and this structural anisotropy also leads to anisotropic fluid flow within them.
2. The degree of pore development in coral reef limestone is more unevenly distributed spatially.
3. The results of the network analysis specify that in all three directions, the fluid flow paths converge on a small number of paths, and the critical pores obtained through the V_B metrics are located exactly at these positions.
4. The sealing of key pore nodes leads to a significant decrease in the permeability of the sample cube unit, confirming the criticality of these pores.

Publications

[1] **Wang, J. P.,** X. Huang, J. Xu, Z. X. Zhang, S. F. Wang, and Y. Li. 2023. "Network Analysis of Pore Structure of Coral Reef Limestone and Its Implications for Seepage Flow." Engineering Geology 318: 107103. https://doi.org/10.1016/j.enggeo.2023.107103

[2] **Wang, J. P.,** X. Huang, J. Xu, S. F. Wang, l. J. Guo and Z. X. Zhang. 2023 "Identifying the pore structure and permeability anisotropy of coral reef limestone based on CT image analysis" Marine Georesources & Geotechnology DOI: 10.1080/1064119X.2023.2243270

[3] Wan, H. B., X. Huang, **J. P. Wang,** and Z. X. Zhang. 2023. "Importance of Appropriate Segmentation in Pore Structure Analysis of Coral Reef Limestone from CT Images." Marine Georesources & Geotechnology 1–21. https://doi.org/10.1080/1064119X.2023.2185170

Acknowledgements and contact

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I highly recommend you read my three papers, if you are interested in coral reef limestone, you can contact me via email: jzw6370@psu.edu

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