

# The tensile strength of volcanic rocks

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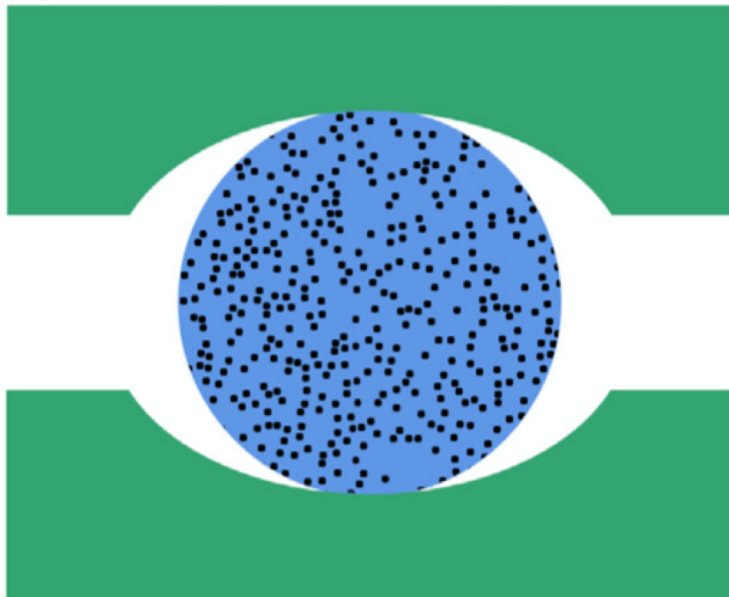
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# Introduction

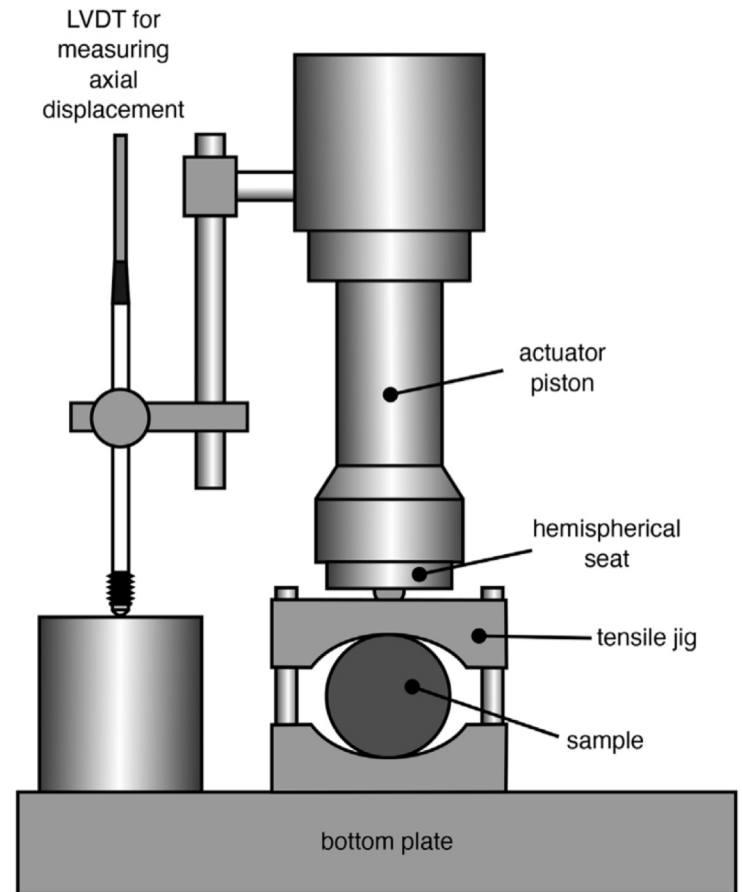
The tensile strength of volcanic rocks is an important input parameter for a variety of modelling

Although data exist for volcanic rocks, the influence of microstructural parameters (e.g., pore size and shape) and alteration on the tensile strength of volcanic rocks is largely unknown

# Methods

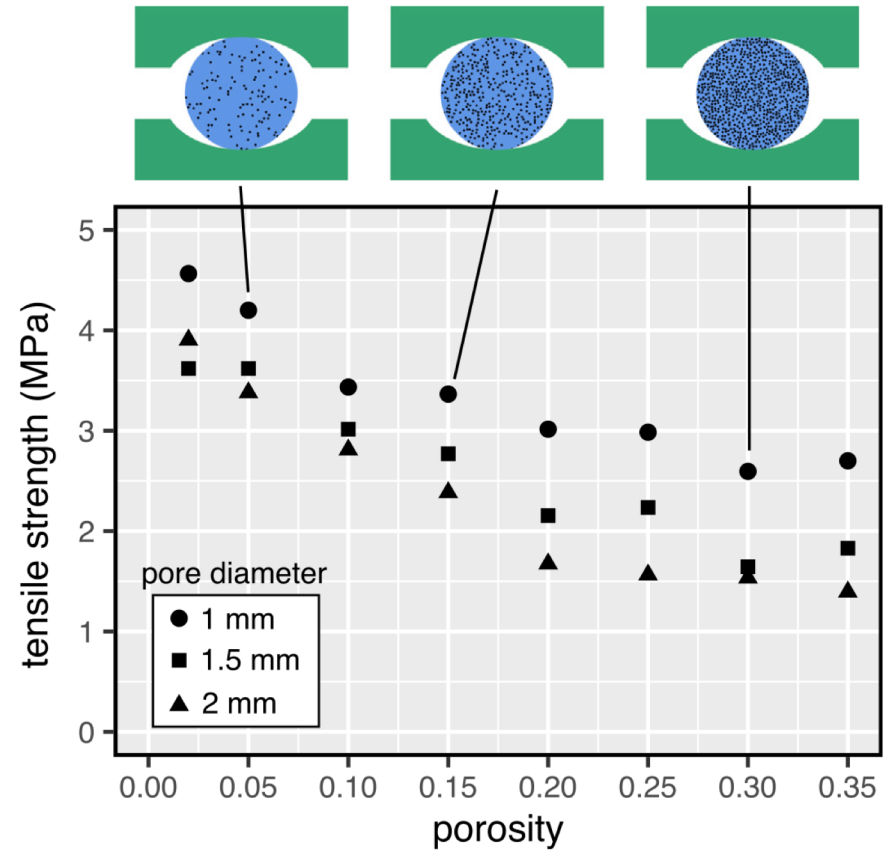
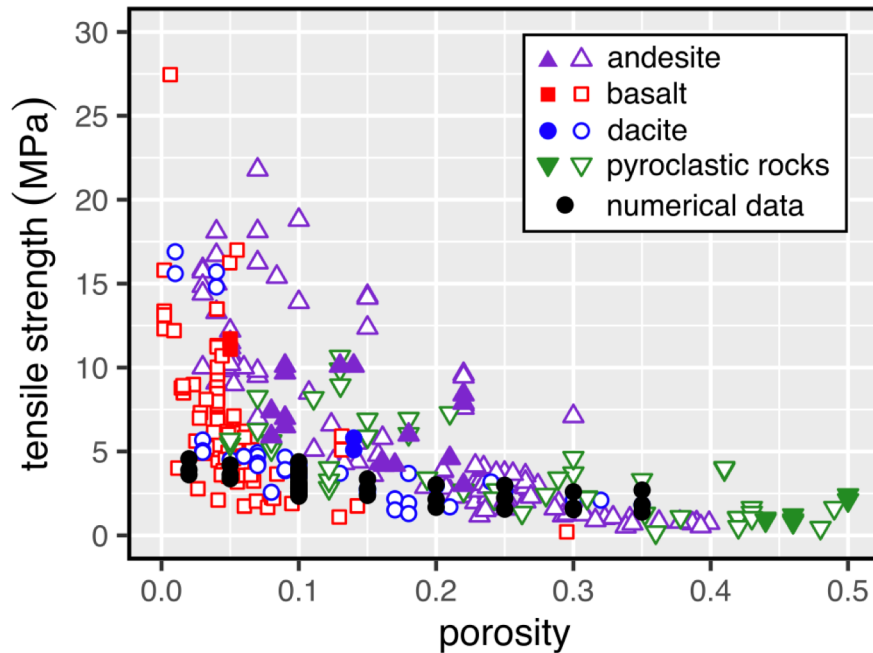


Numerical experiments



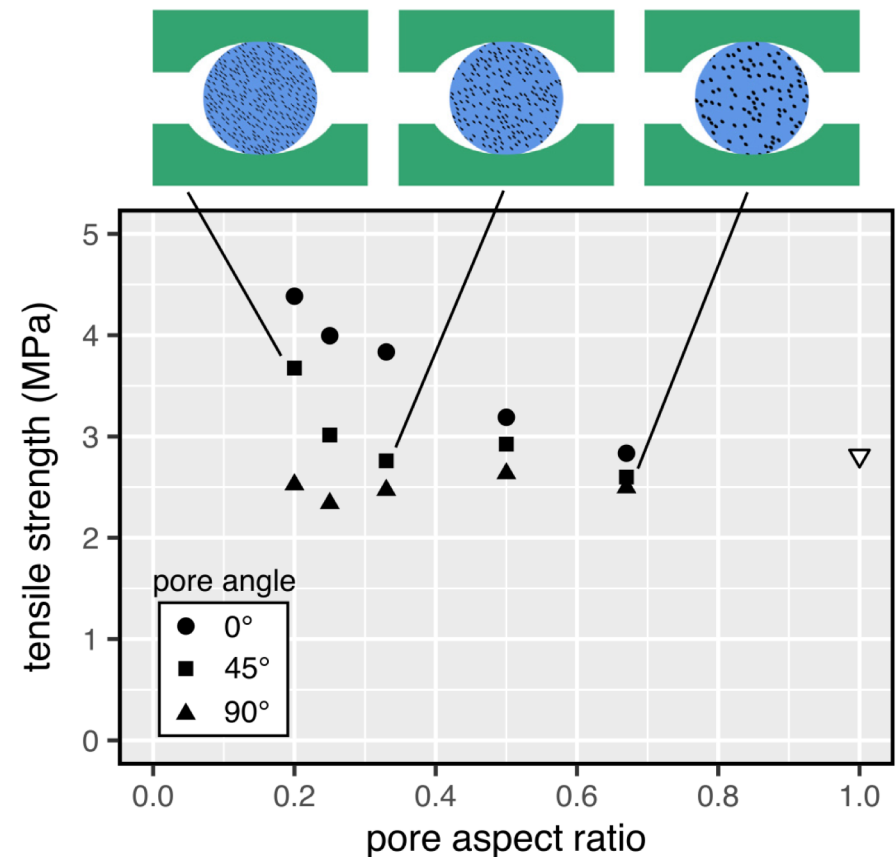
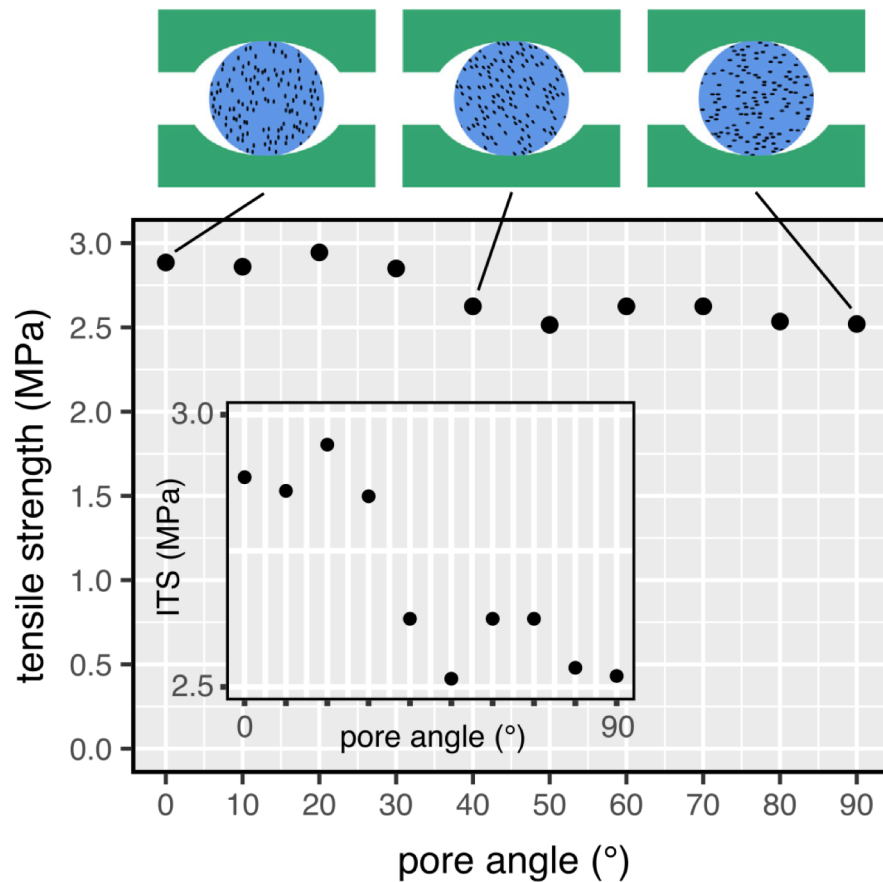
Laboratory experiments

# Influence of porosity and pore size

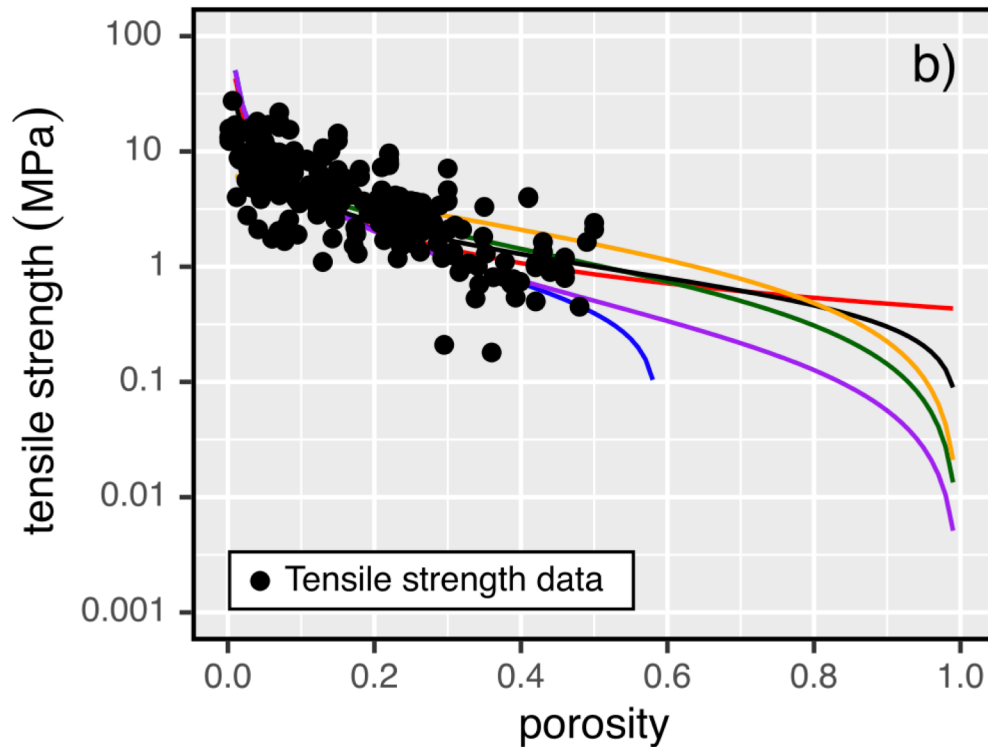




# Influence of pore angle and AR



# Estimating tensile strength



$$T \approx \frac{T_0}{\phi}$$

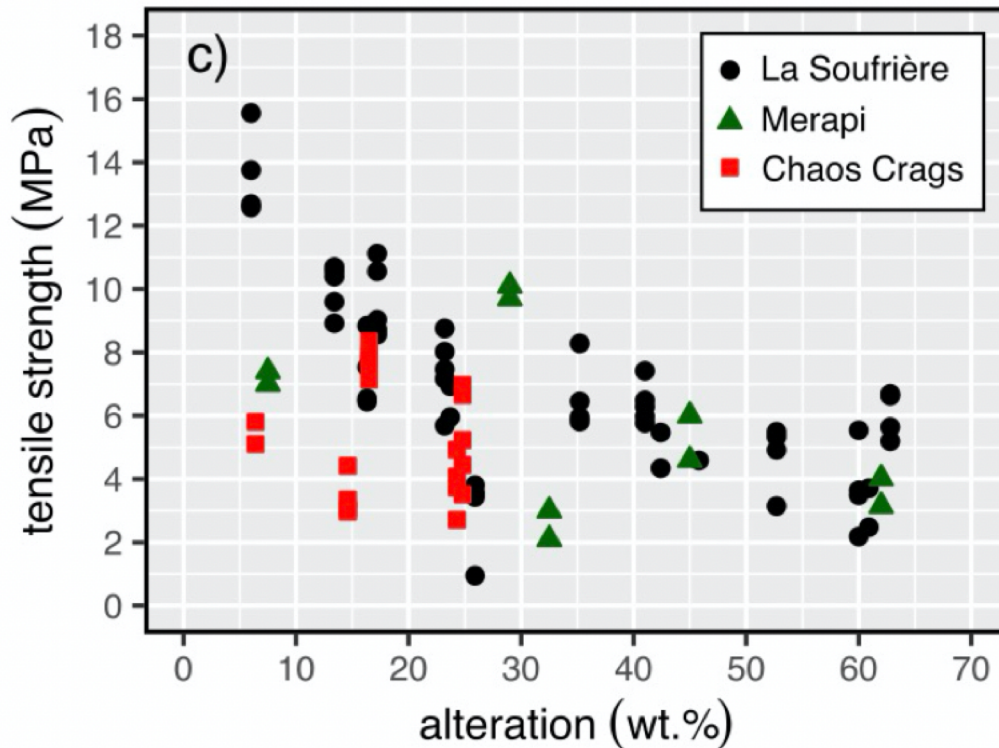
$$T \approx \frac{T_0(1-1.7\phi)^{1/2}}{\phi}$$

$$T \approx \frac{2T_0(1-\phi)}{1+2\phi}$$

$$T \approx \frac{2T_0(1-\phi^n)}{a\phi^n}$$

$$T \approx \frac{2T_0(1-\phi)}{3\phi\sqrt{\phi^{-1/3}-1}}$$

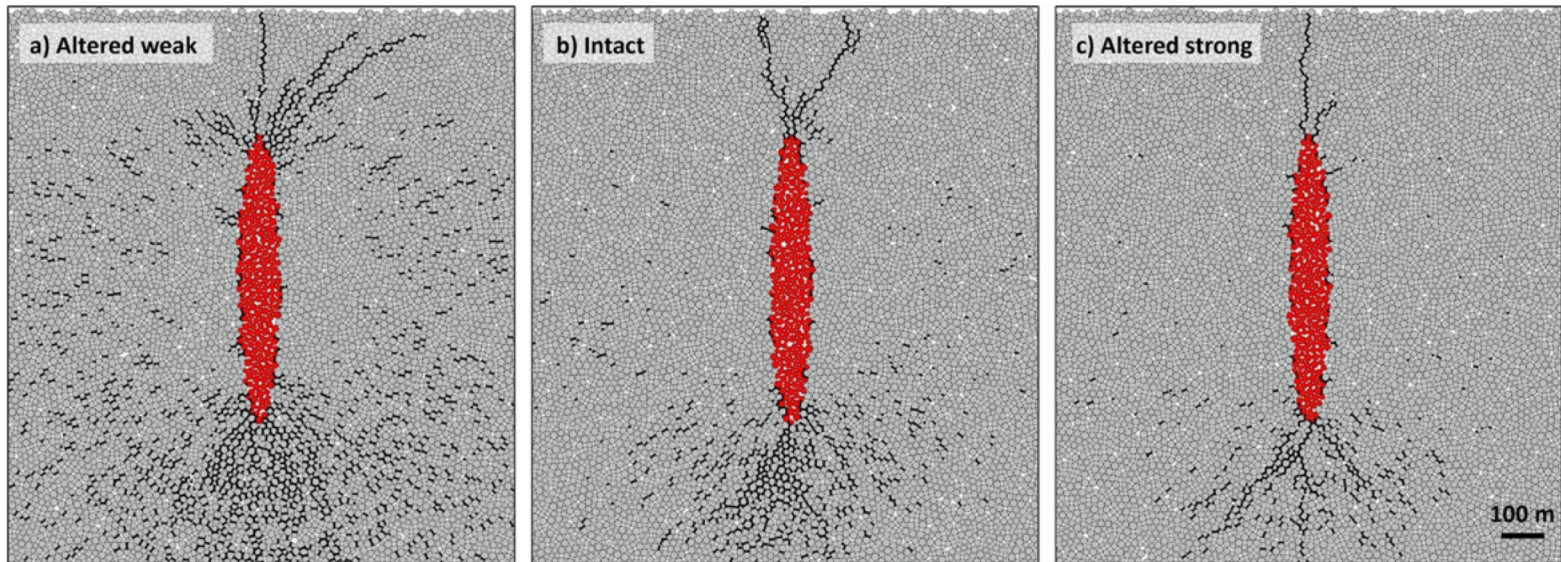
# Influence of alteration



Pore-filling alteration appears to increase tensile strength

Dissolution and mineral replacement appears to decrease tensile strength

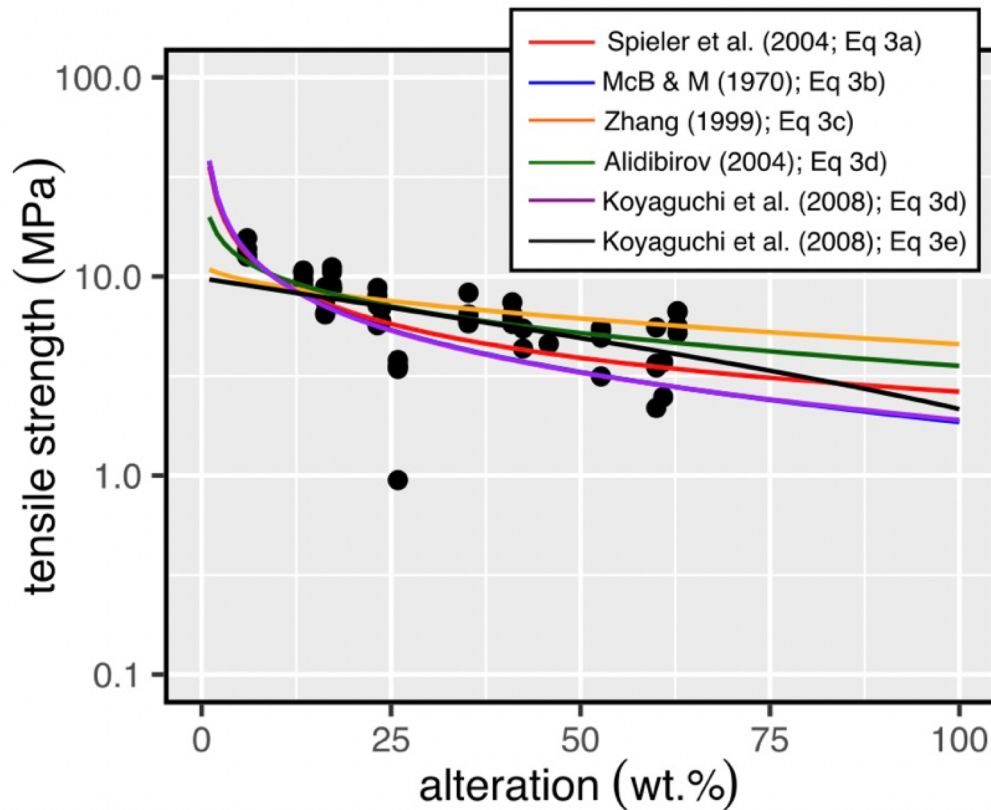
# Influence of alteration



Guided by our experimental results, we use numerical modelling to show how the host-rock fracture patterns surrounding a dyke may differ if the rock is hydrothermally altered



# Influence of alteration



$$T \approx \frac{T_0 A^{-c_2}}{c_1} \quad (3a)$$

$$T \approx \frac{T_0 A^{-c_2} (1 - 1.7 A^{c_2})^{\frac{1}{2}}}{c_1} \quad (3b)$$

$$T \approx T_0 \left( \frac{3}{2c_1 A^{c_2} + 1} - 1 \right) \quad (3c)$$

$$T \approx \frac{2T_0 ((c_1 A^{c_2})^{-n} - 1)}{a} \quad (3d)$$

$$T \approx \frac{2T_0 A^{-c_2} (1 - c_1 A^{c_2})}{3c_1 \sqrt{(c_1 A^{c_2})^{-1/3} - 1}} \quad (3e)$$

# Conclusions

The tensile strength of volcanic rocks influenced by porosity, pore size, pore shape, and pore orientation

The tensile strength of volcanic rocks is also influenced by hydrothermal alteration

These new data, and the semi-empirical constitutive models presented, can aid modelling that requires values of tensile strength

# Thanks for listening!

Heap, M.J., Wadsworth, F.B., Heng, Z., Xu, T., Griffiths, L., Aguilar Velasco, A., Vairé, E., Vistour, M., Reuschlé, T., Troll, V.R. and Deegan, F.M. (2021). The tensile strength of volcanic rocks: Experiments and models. *Journal of Volcanology and Geothermal Research*, 418, 107348.

Heap, M.J., Harnett, C.E. Wadsworth, F.B., Gilg, H.A., Carbillet, L., Rosas-Carbajal, M., Komorowski, J.-C., Baud, P., Troll, V.R., Deegan, F.M., Holohan, E.P. and Moretti, R. (in review). The tensile strength of hydrothermally altered volcanic rocks. Submitted to *Journal of Volcanology and Geothermal Research*.