Interactions of hydraulic fractures with discontinuities in the near wellbore region

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Objective

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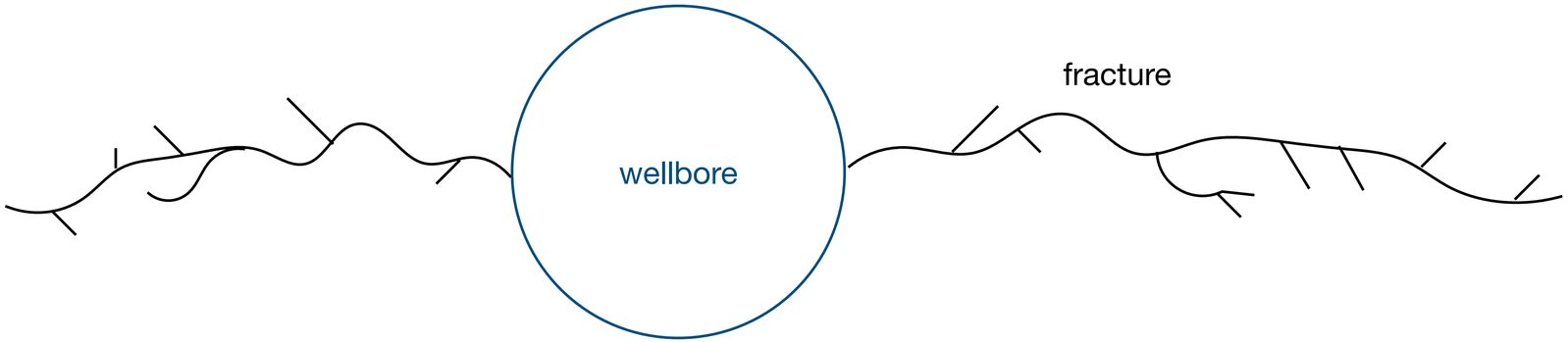
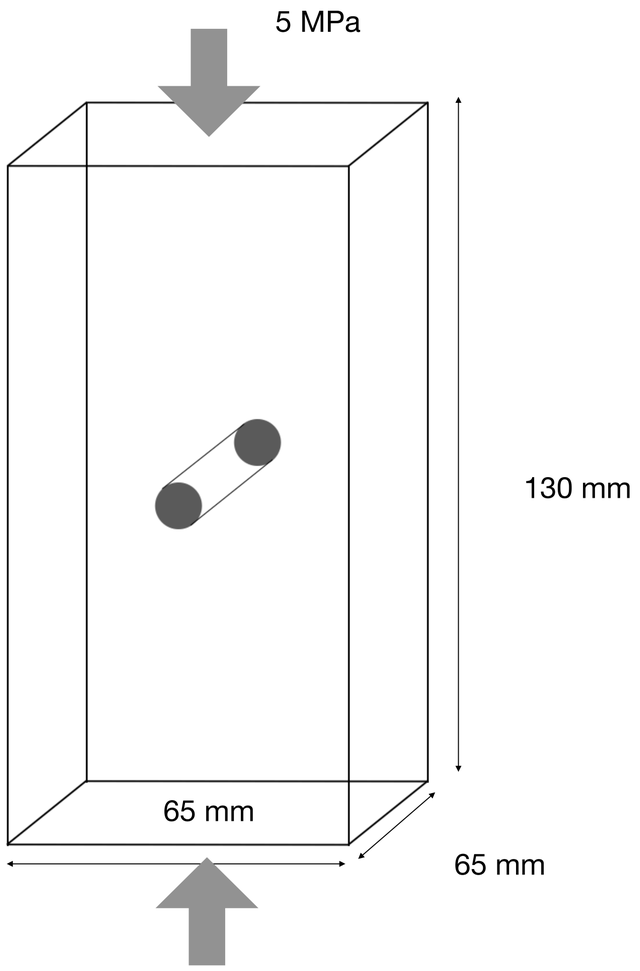


Experiment on carbonates (Eagle Ford shale)



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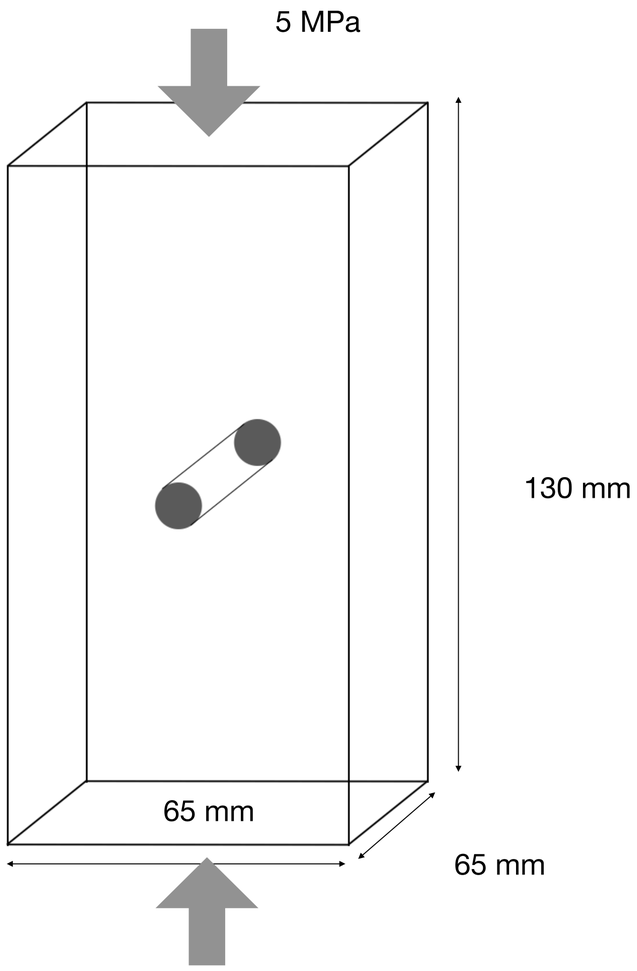
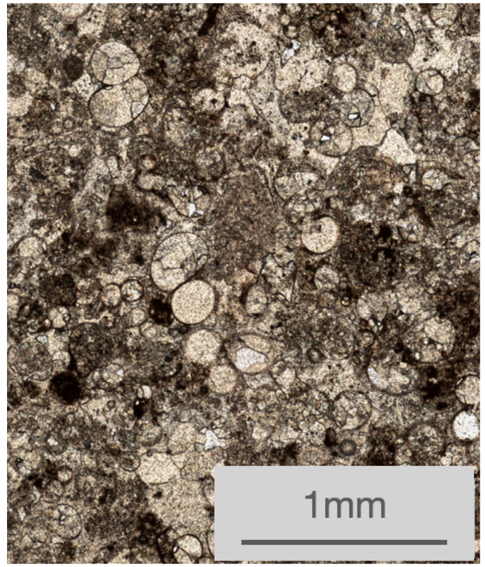
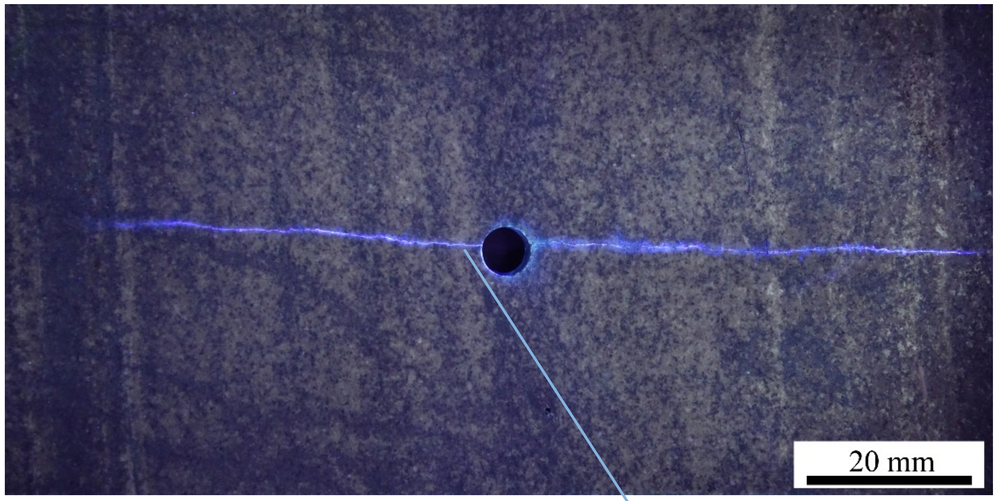
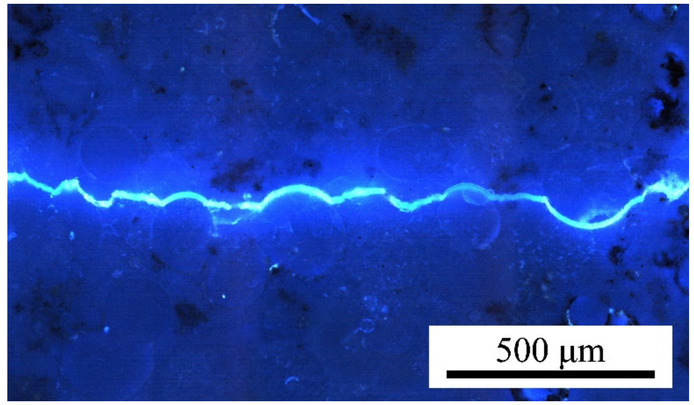




Post-morterm analysis





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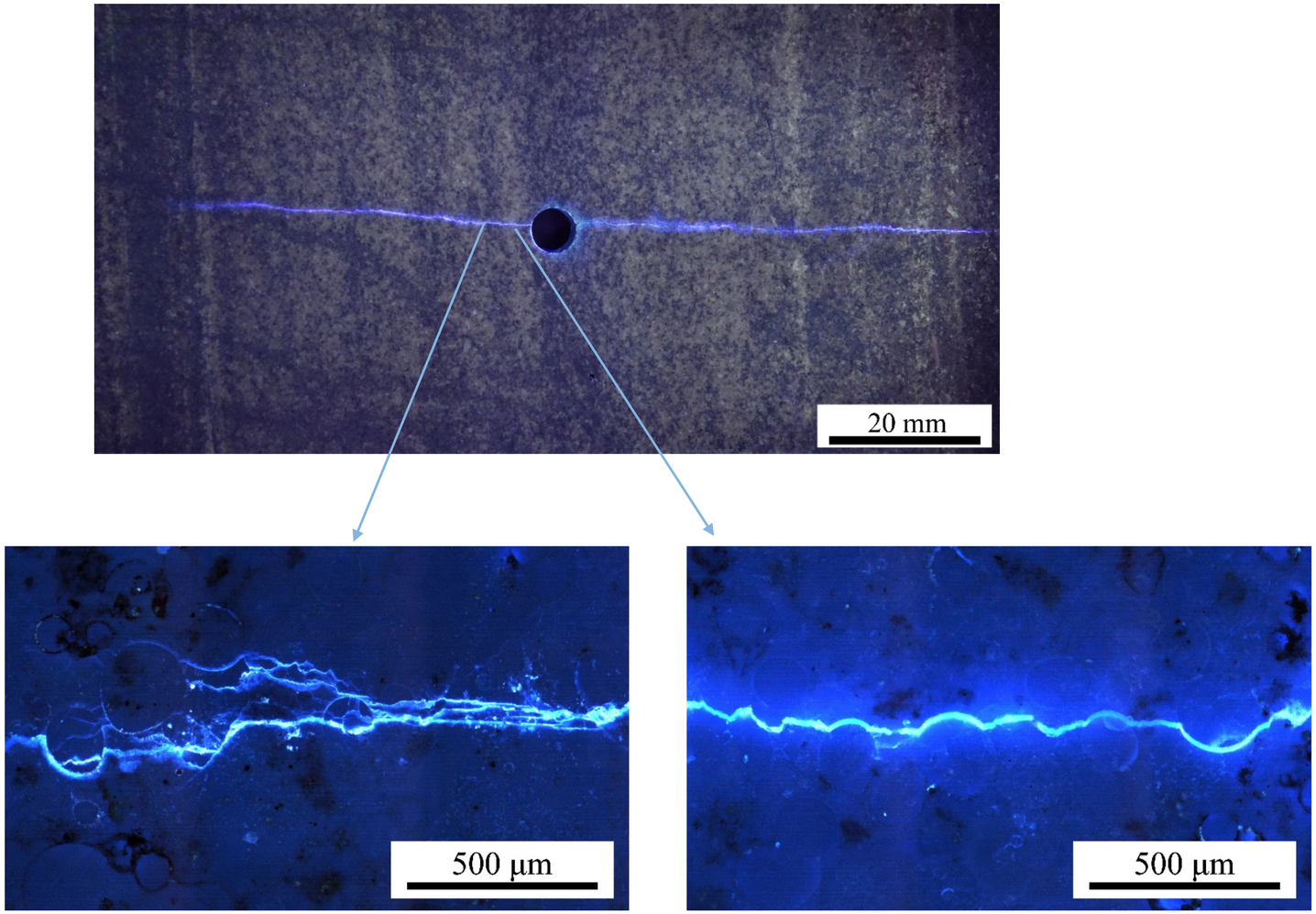
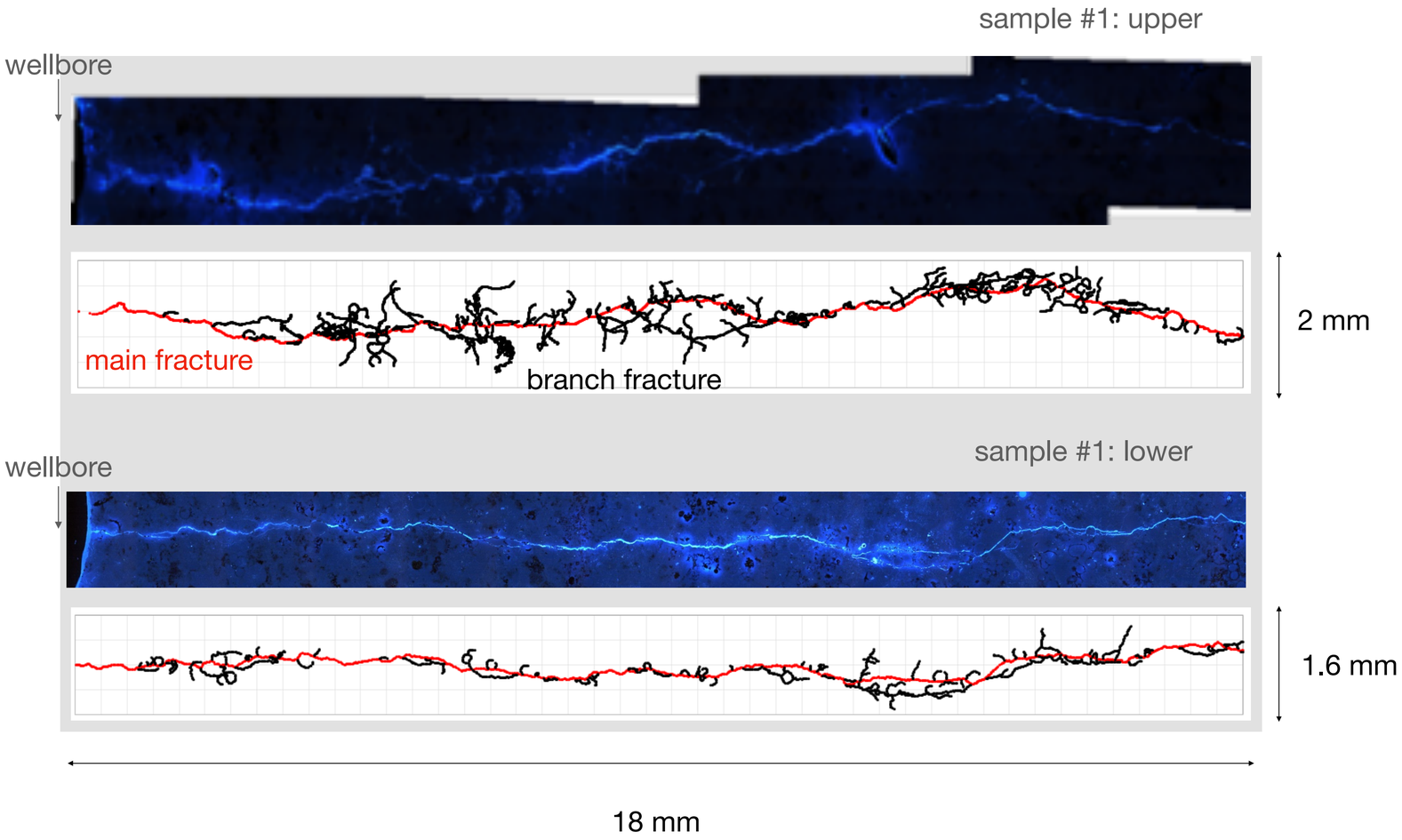


Fracture path analysis



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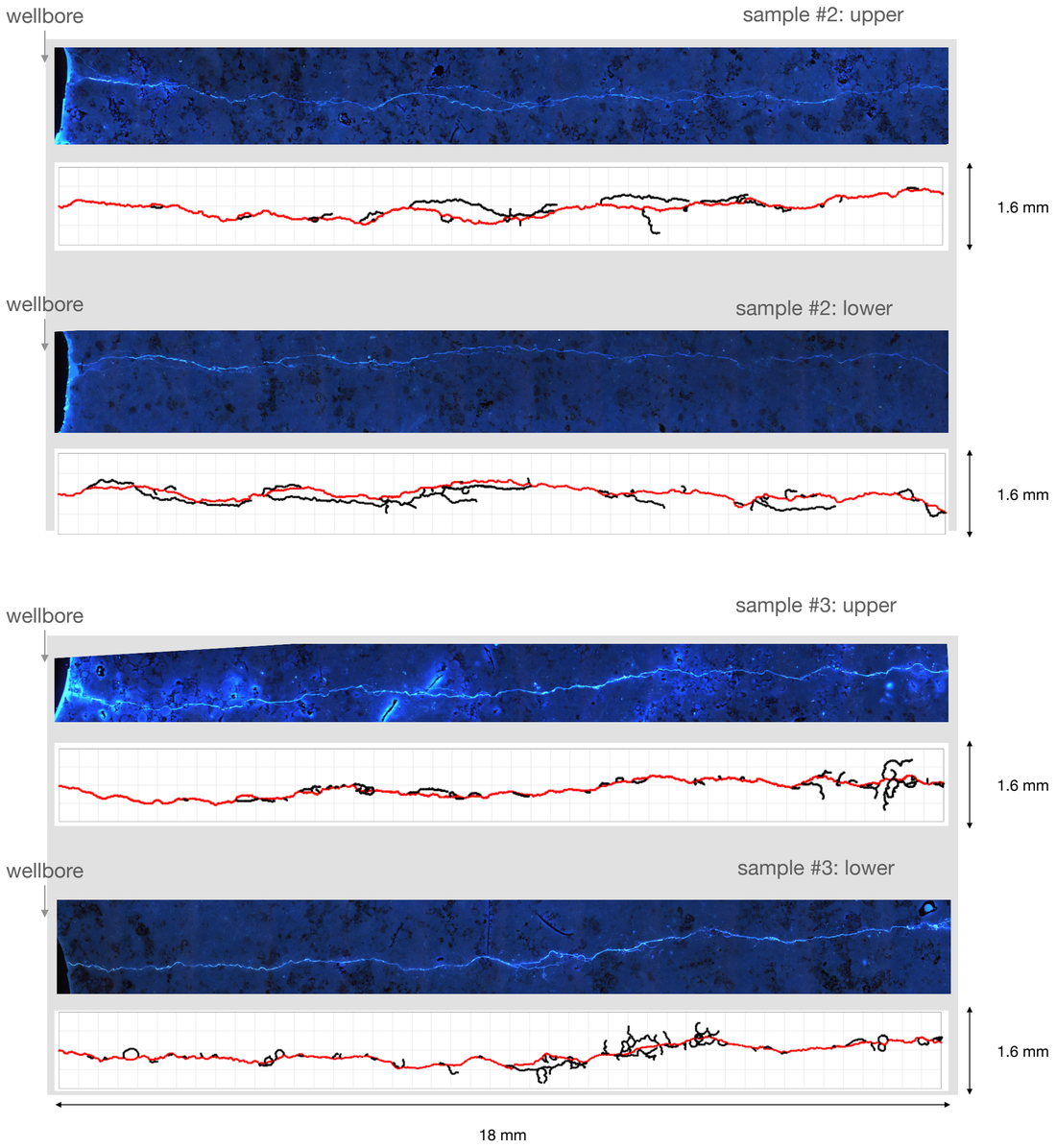

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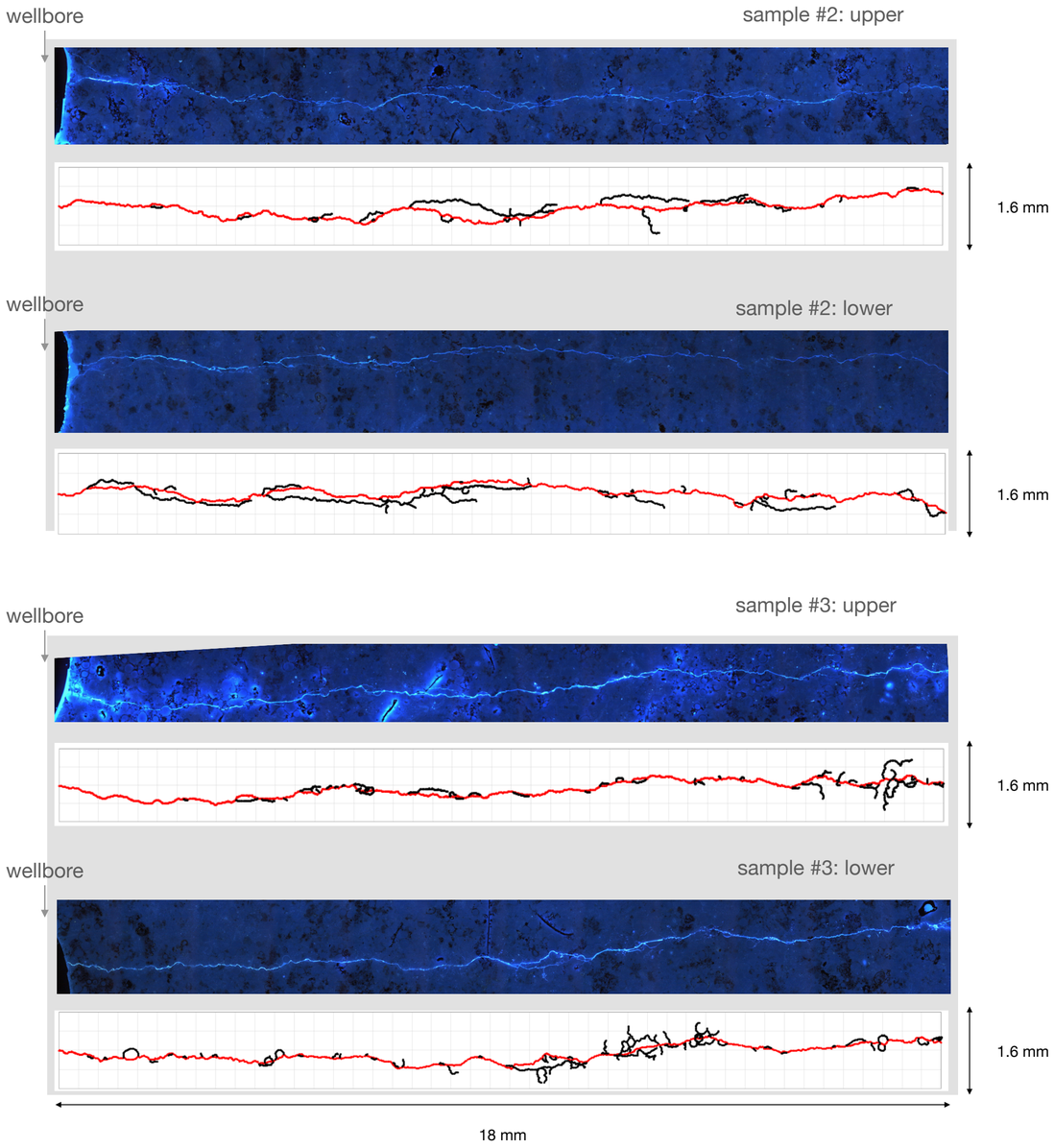
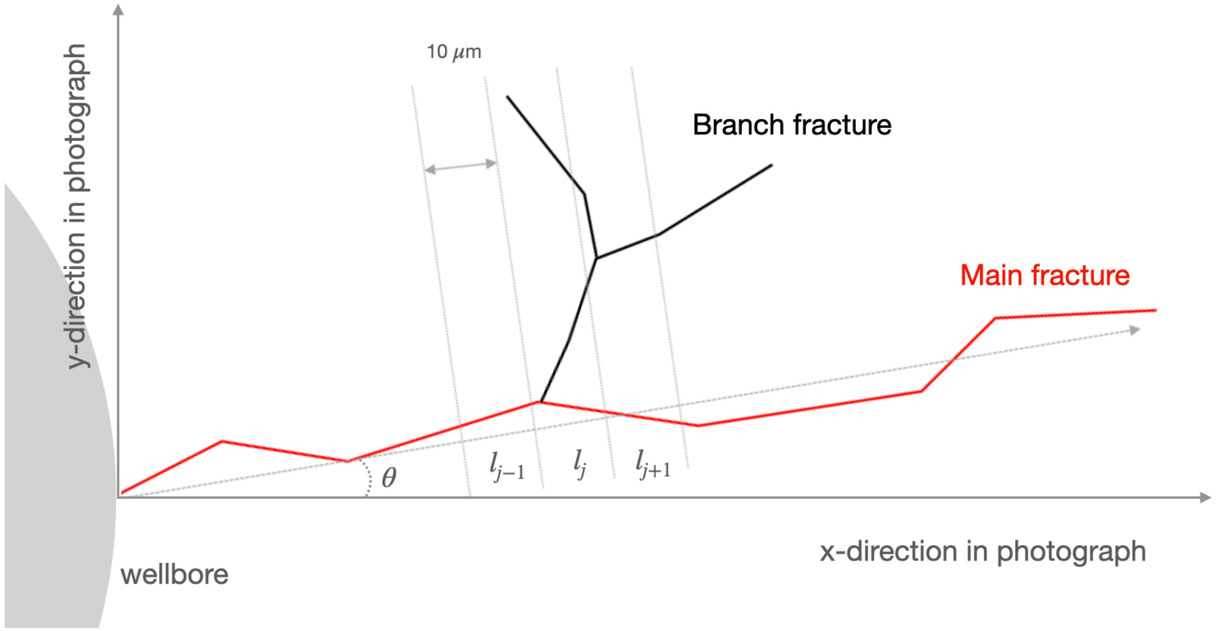
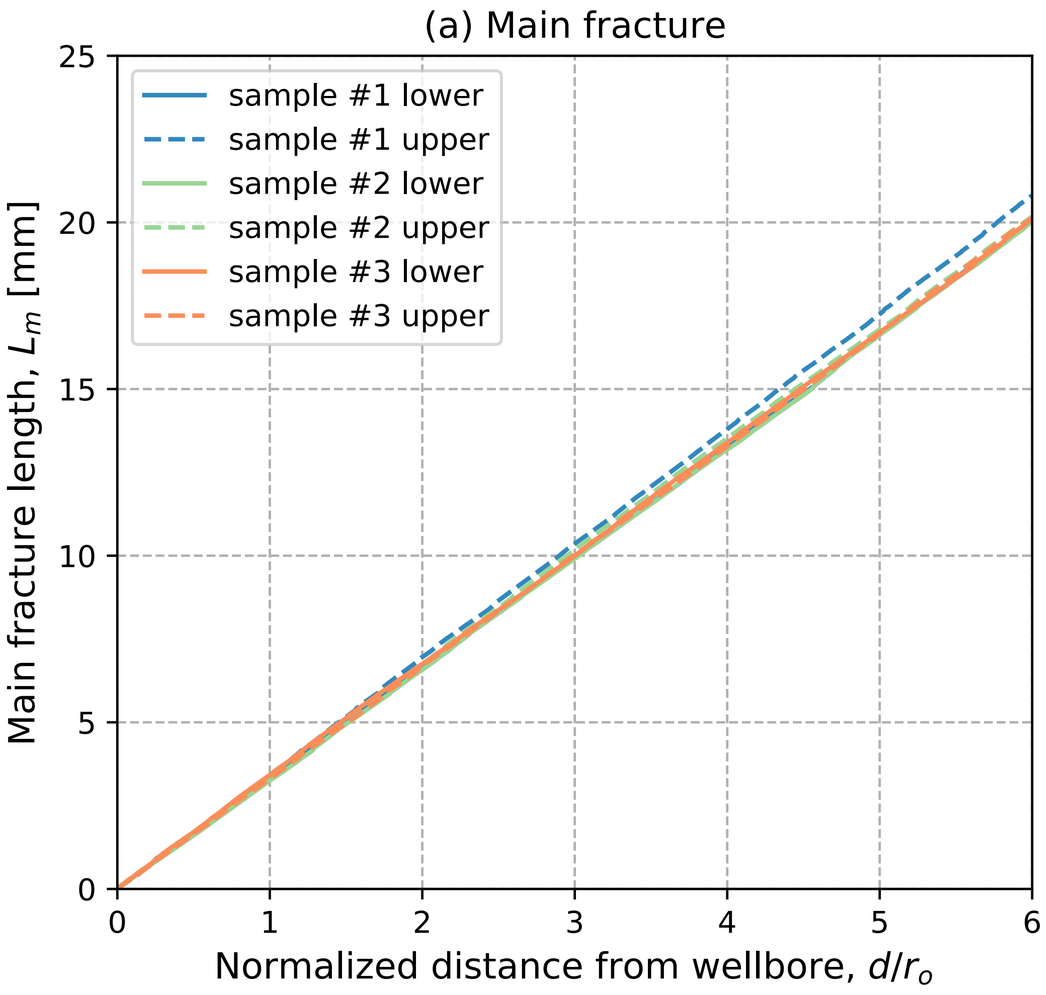
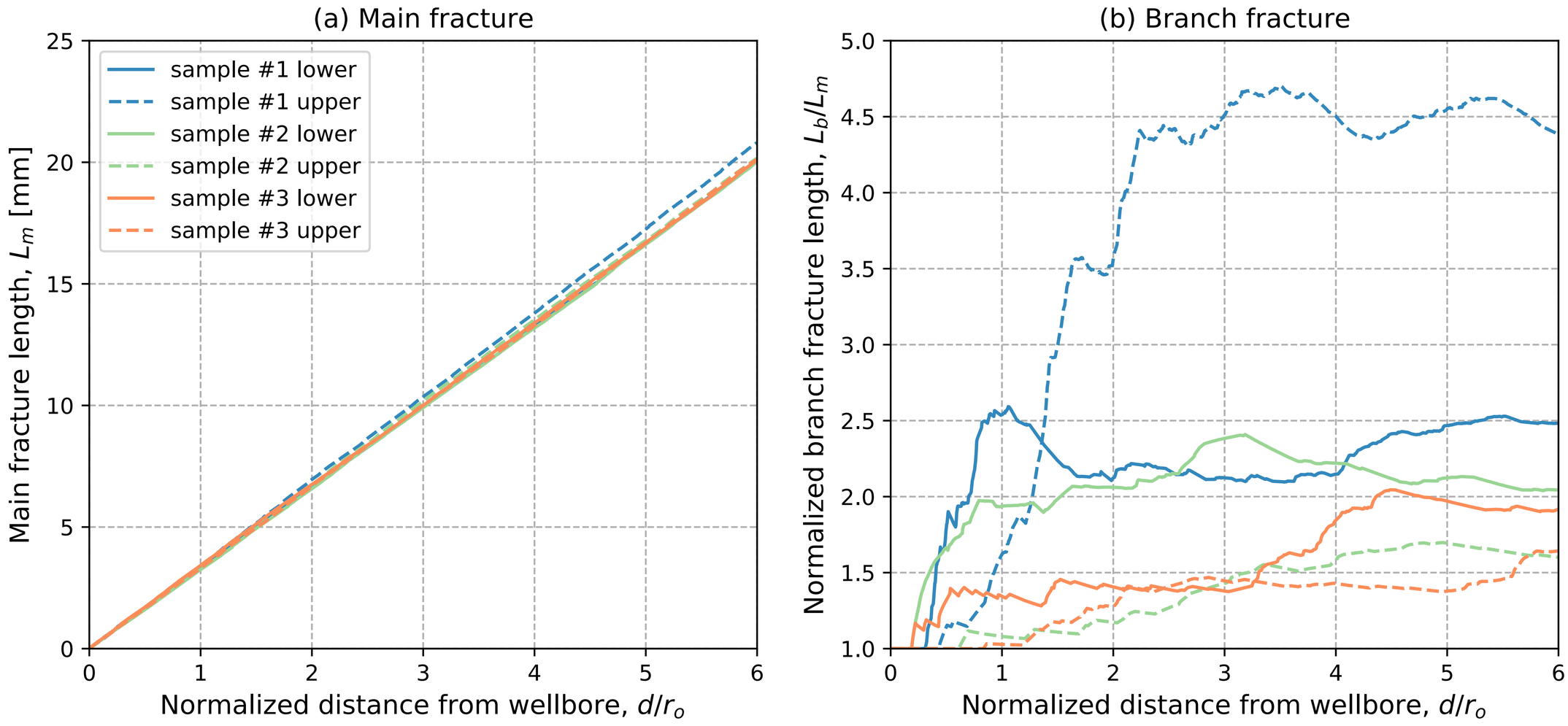
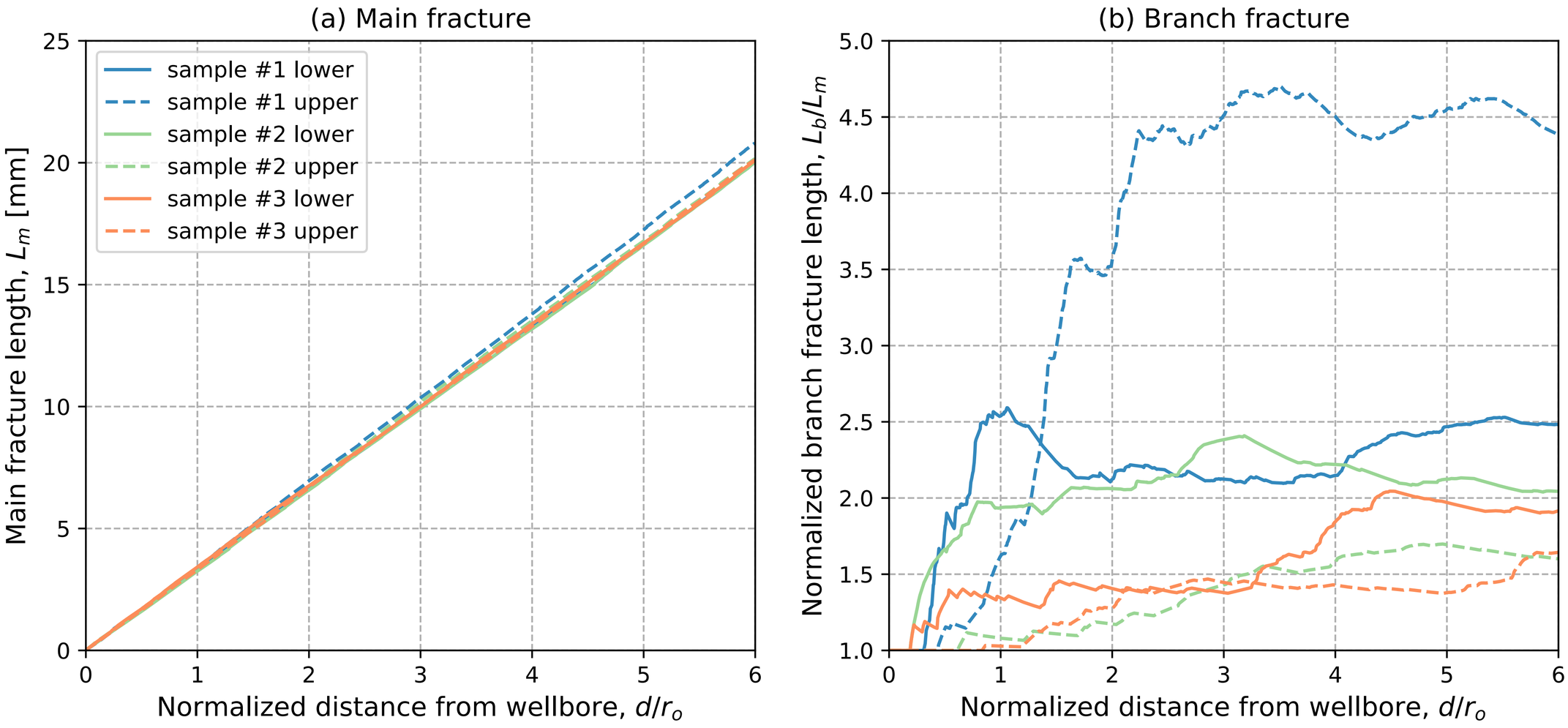




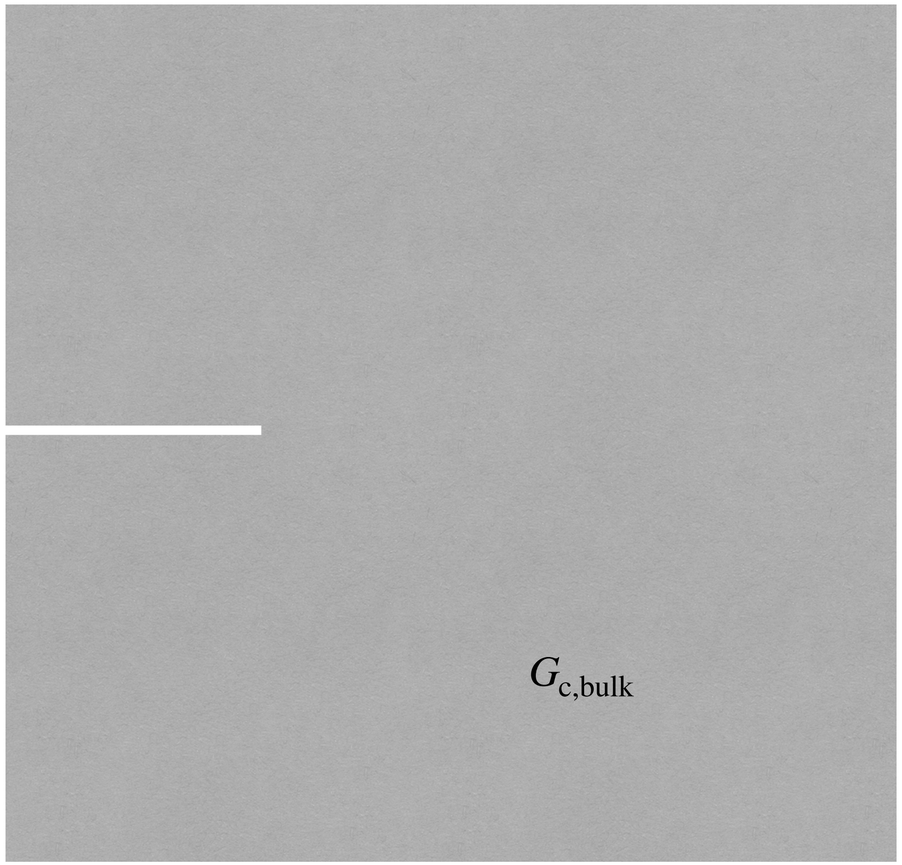

(a) Main fracture
sample #1 lower
sample #1 upper
sample #2 lower
sample #2 upper
sample #3 lower
sample #3 upper
Main fracture length, L_m [mm]
Normalized distance from wellbore, d/r_o
0
5
10
15
20
25
0
1
2
3
4
5
6


(a) Main fracture
sample #1 lower
sample #1 upper
sample #2 lower
sample #2 upper
sample #3 lower
sample #3 upper
Main fracture length, L_m [mm]
Normalized distance from wellbore, d/r_o
(b) Branch fracture
Normalized branch fracture length, L_b/L_m
Normalized distance from wellbore, d/r_o



Fracture complexity increases with distance

Fracture path determination



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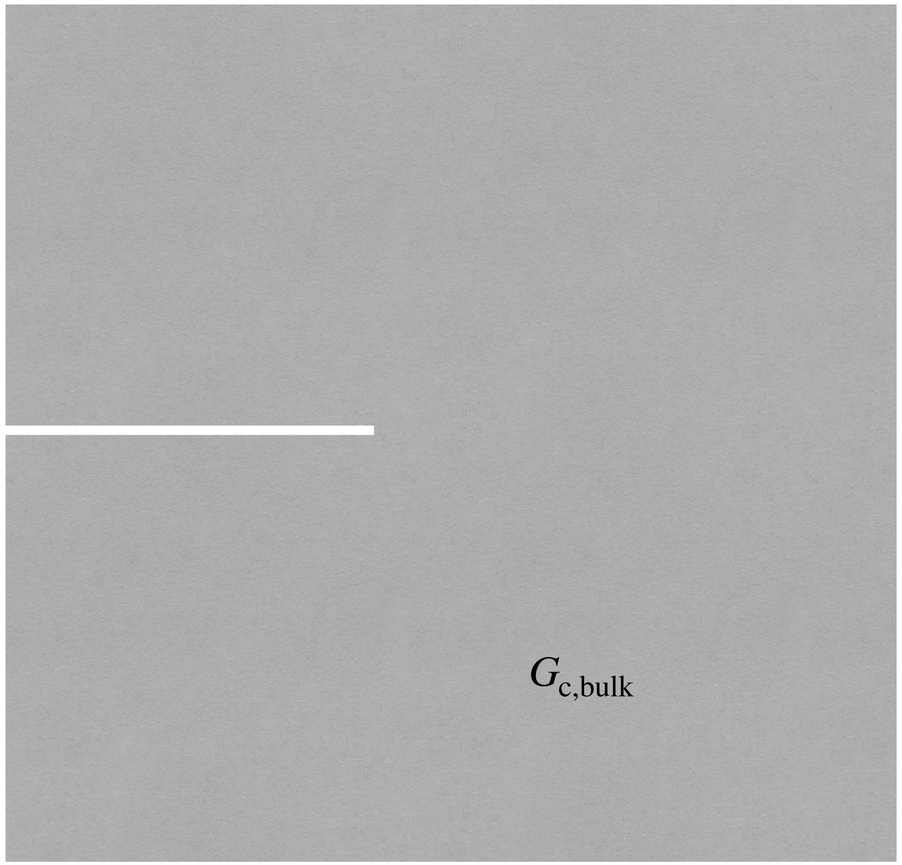

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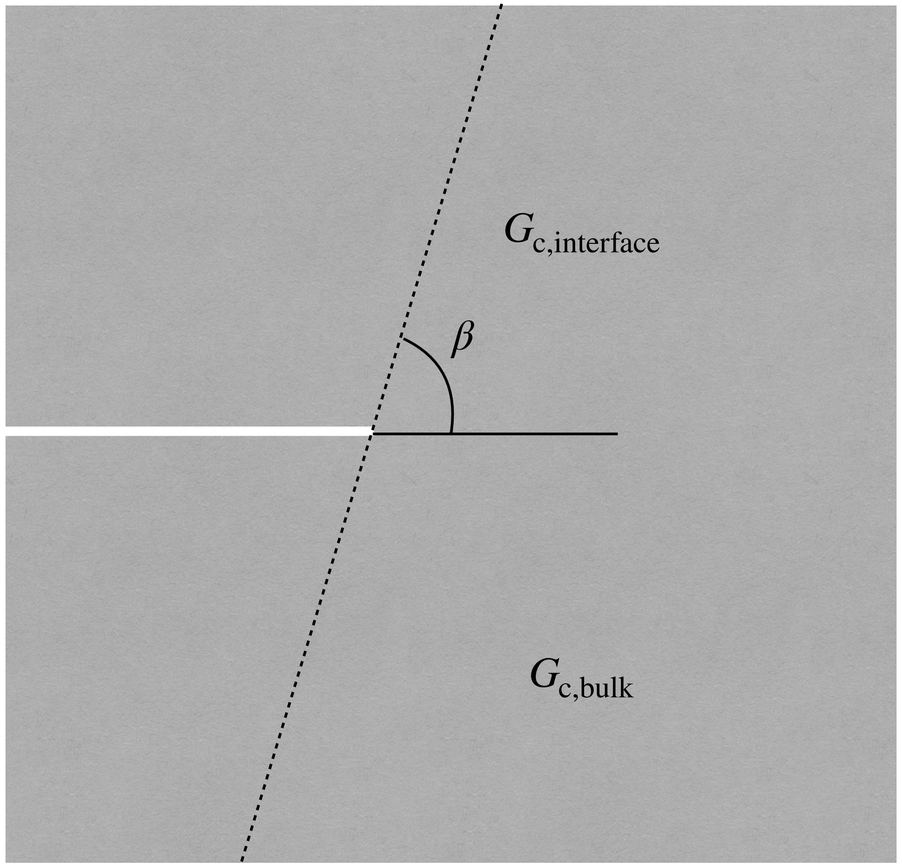

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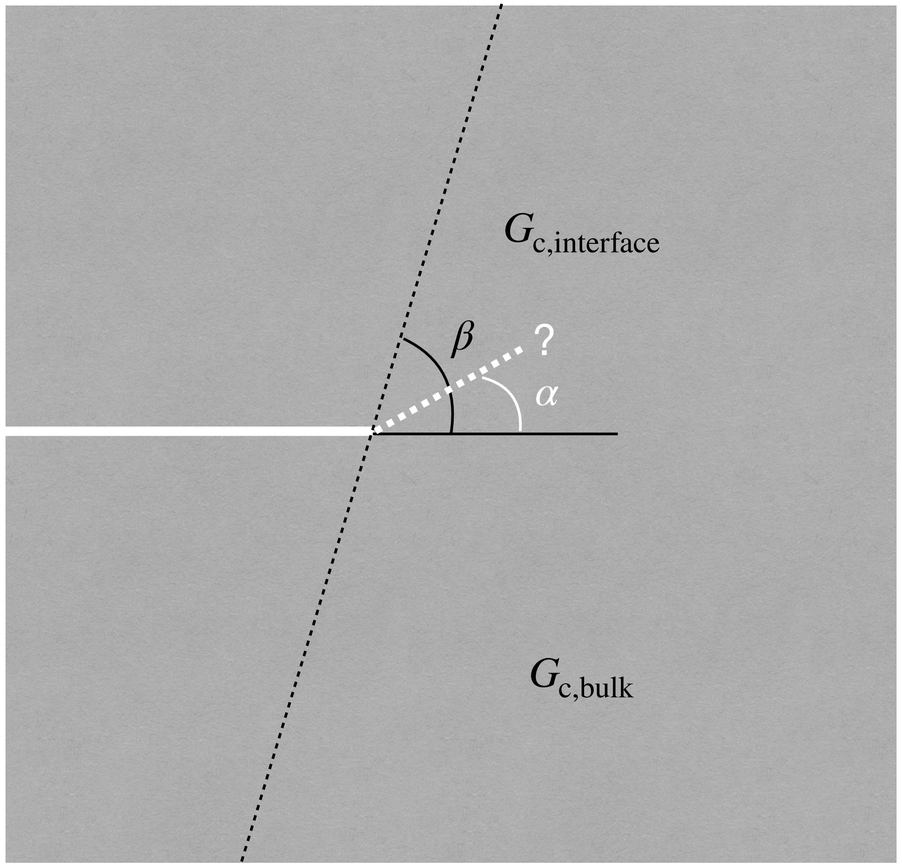

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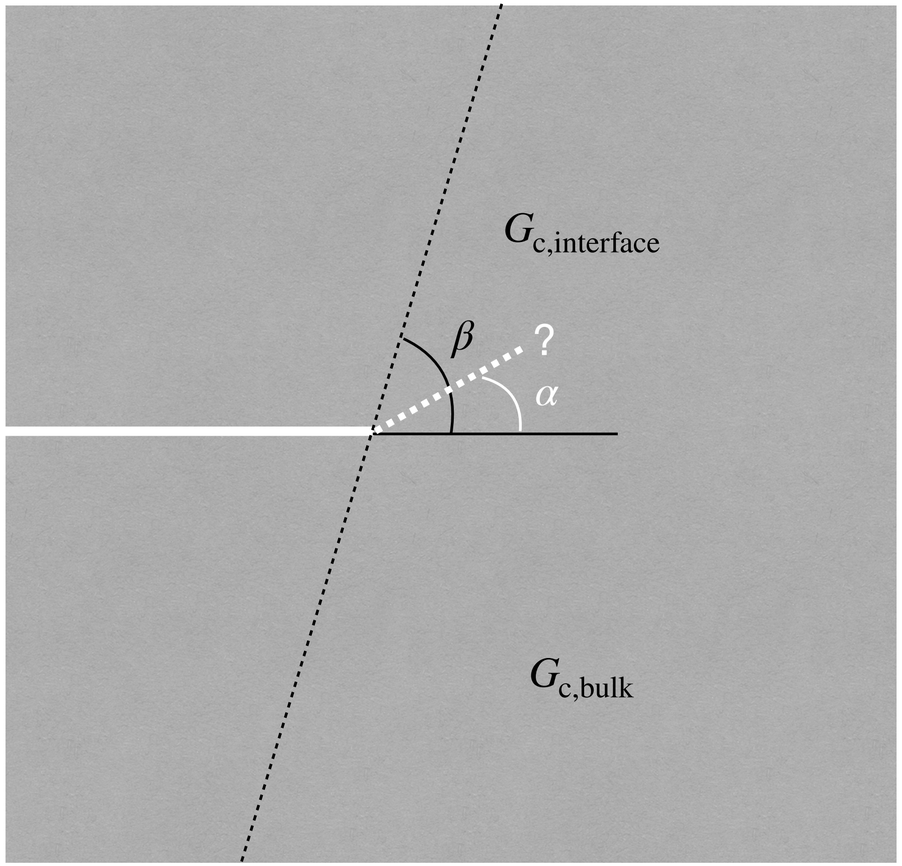


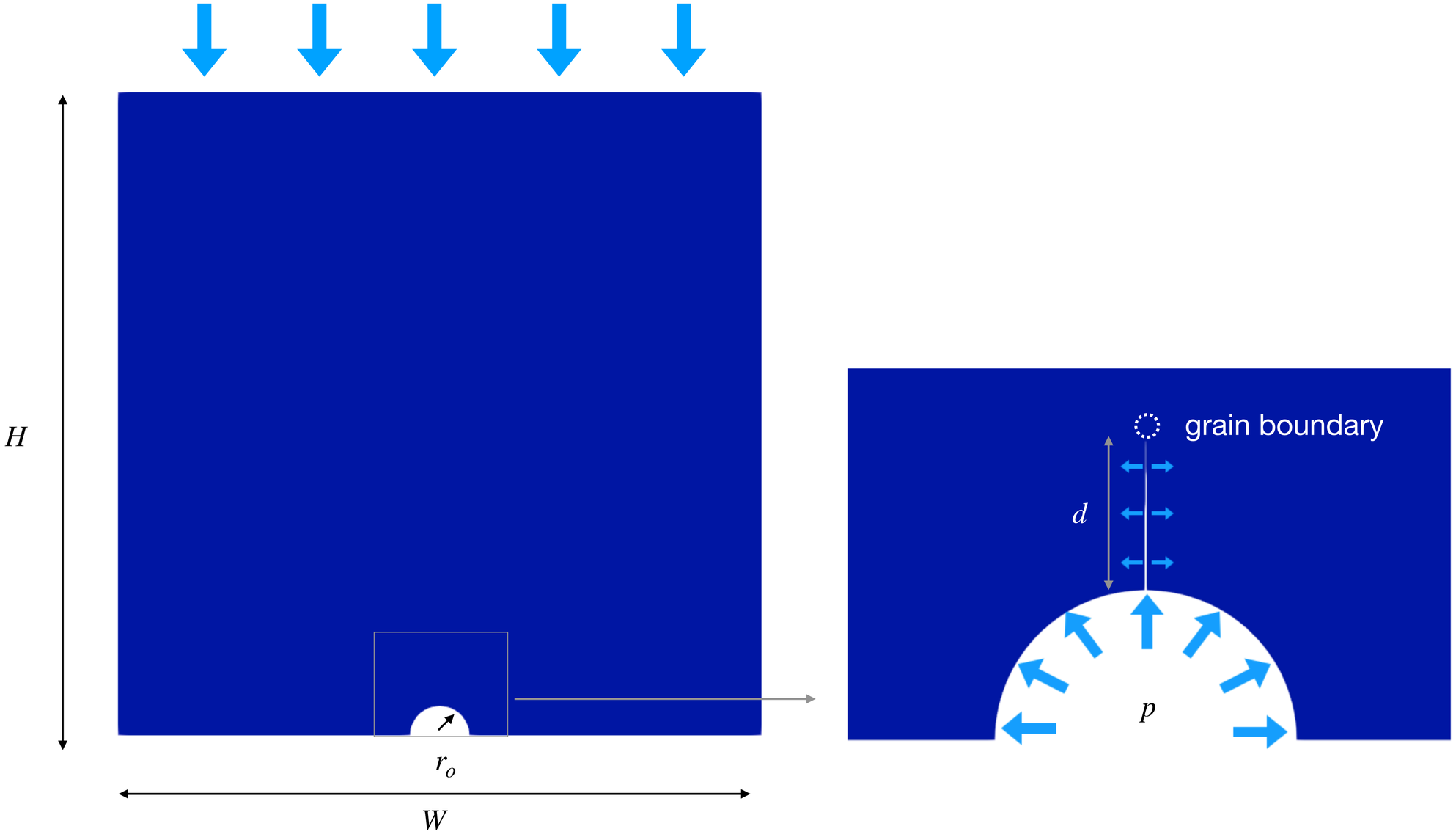
$$\max_{\alpha \in [0,2\pi)} \frac{\mathcal{G}(\alpha)}{G_c(\alpha)}$$

energy release rate

fracture toughness

He and Hutchinson (1989)

Energy dissipation computation



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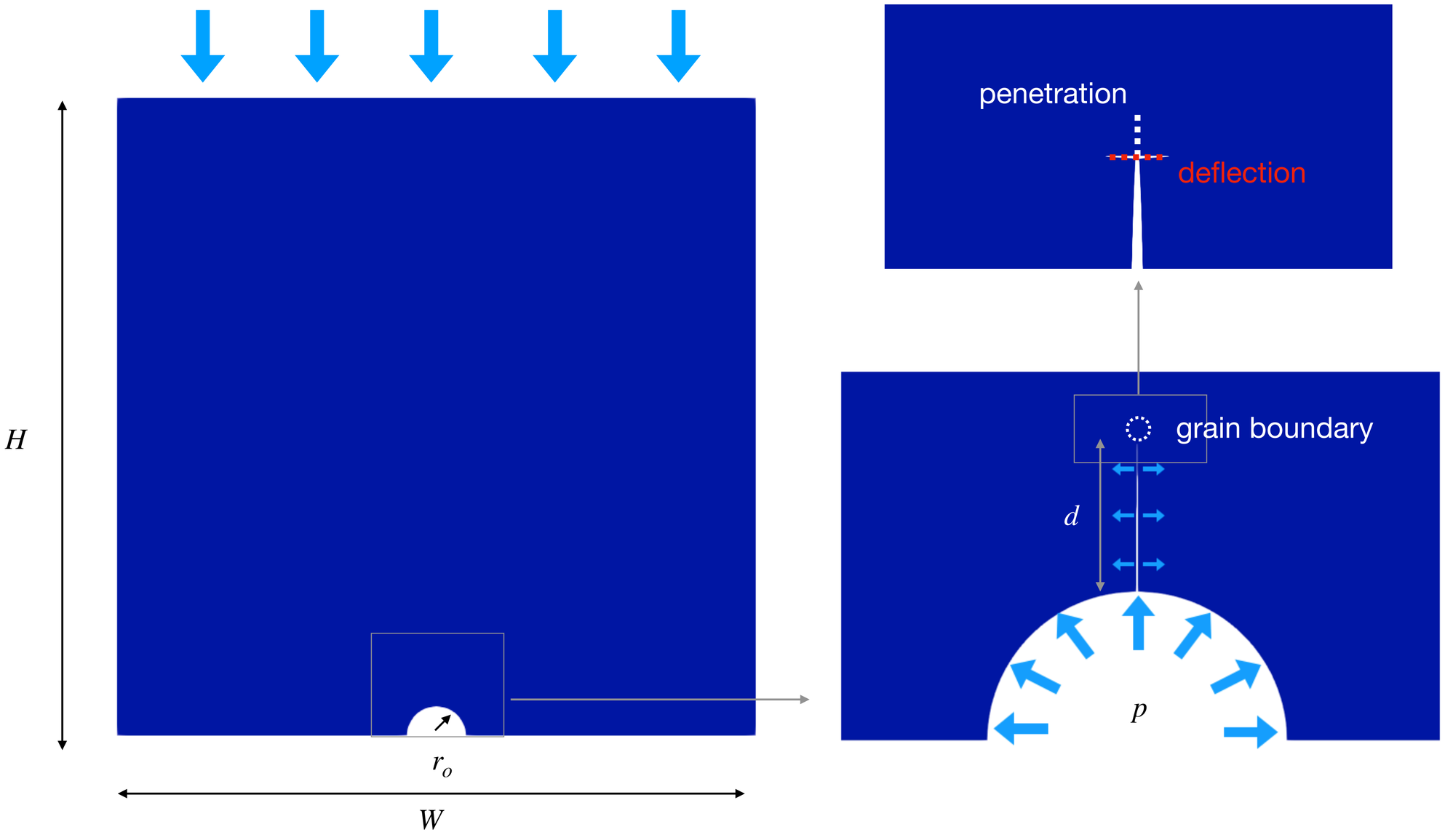
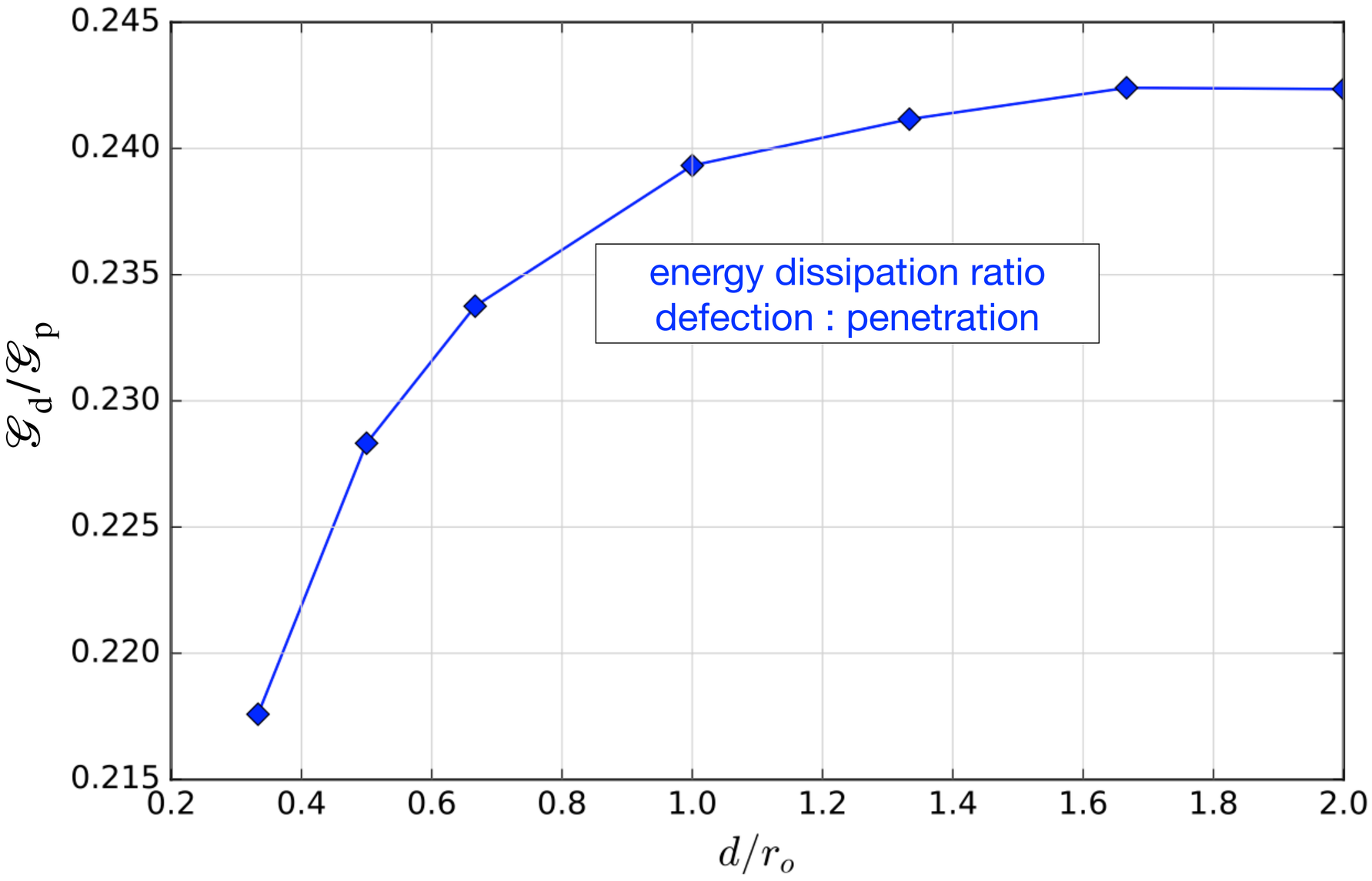


Computed energy dissipation



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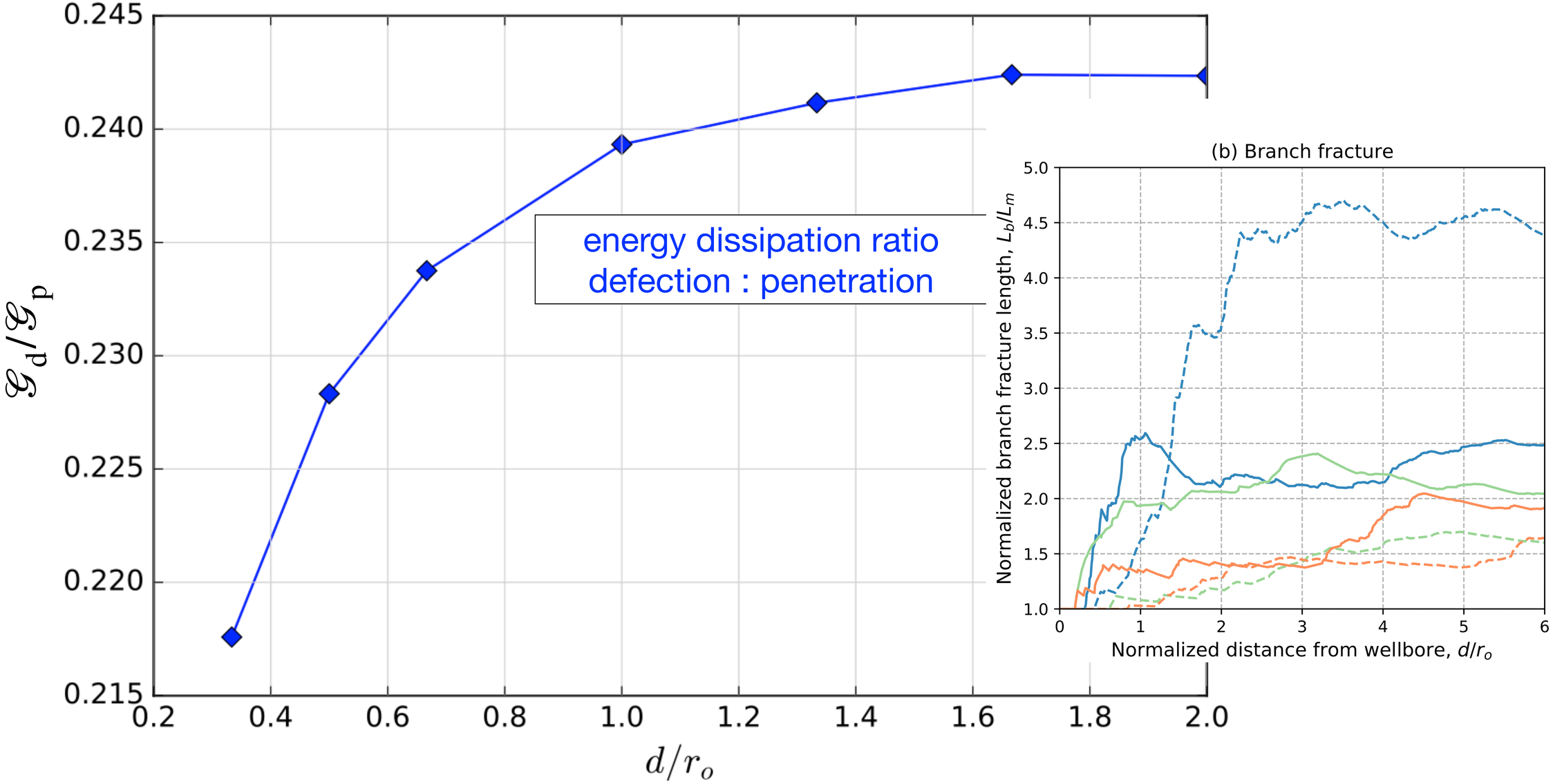
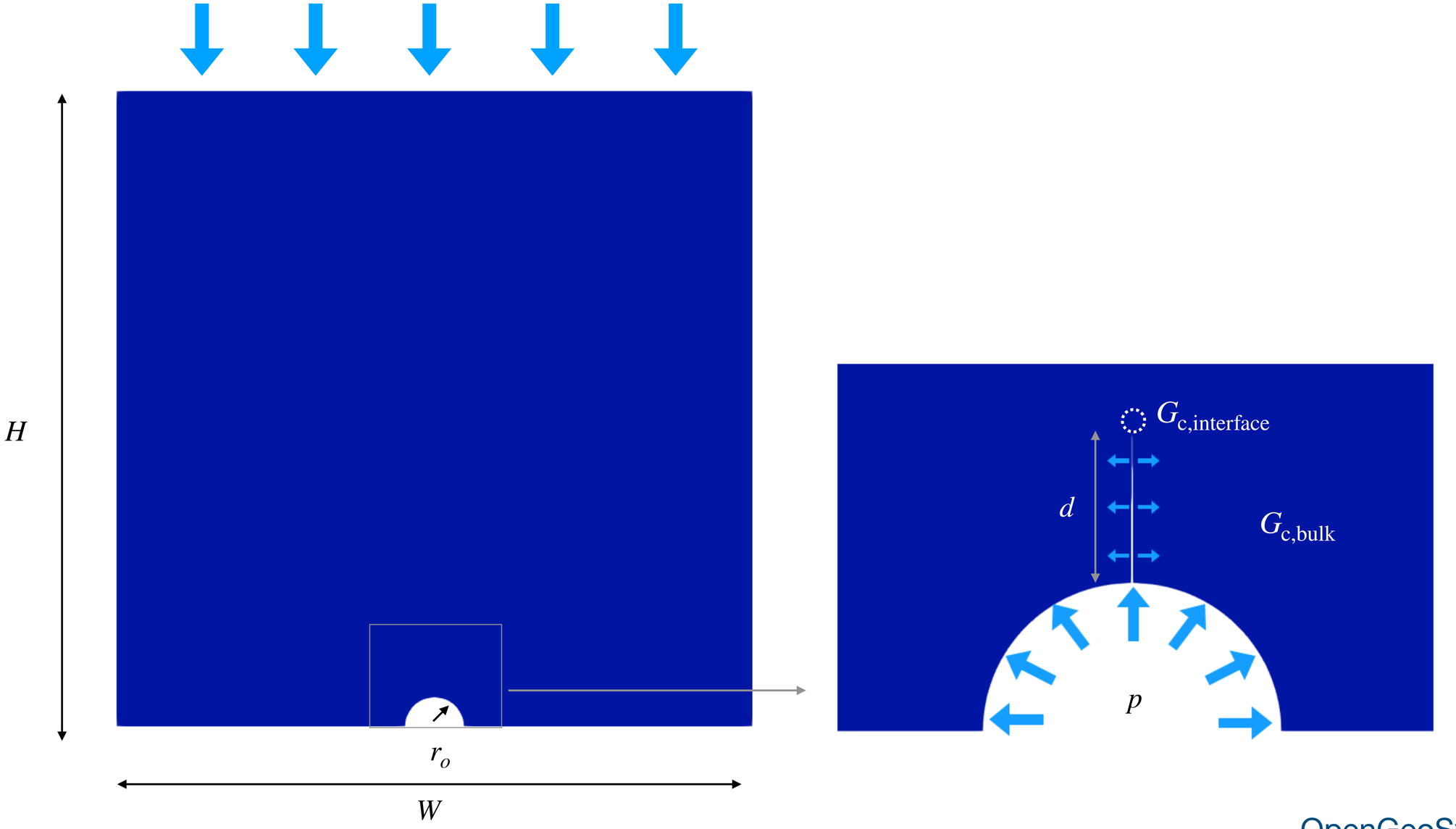
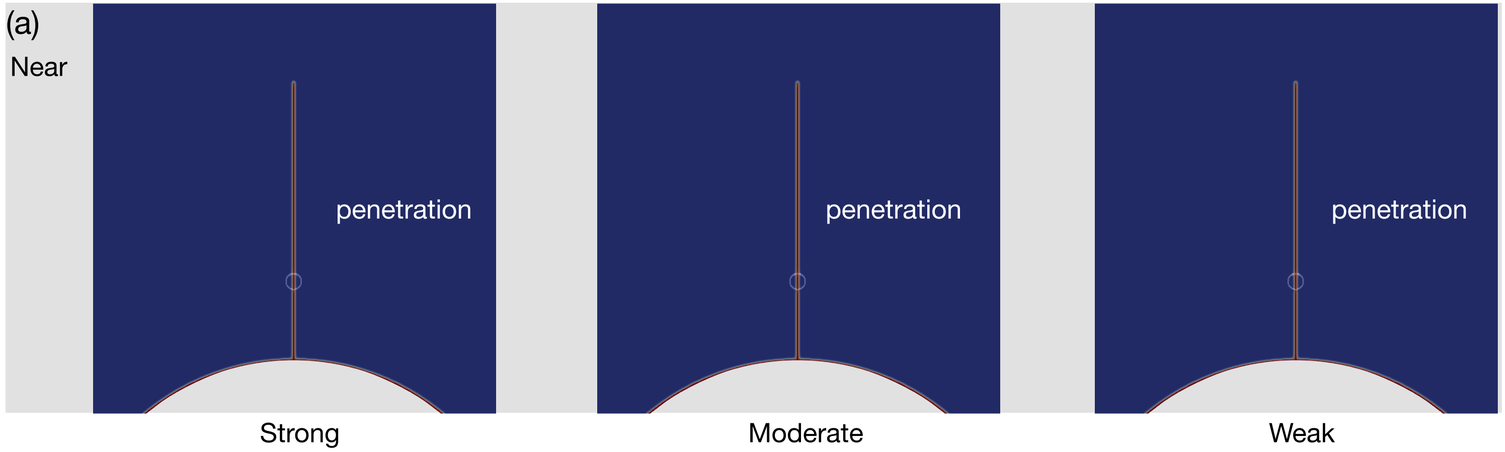


Numerical simulation (phase-field model)



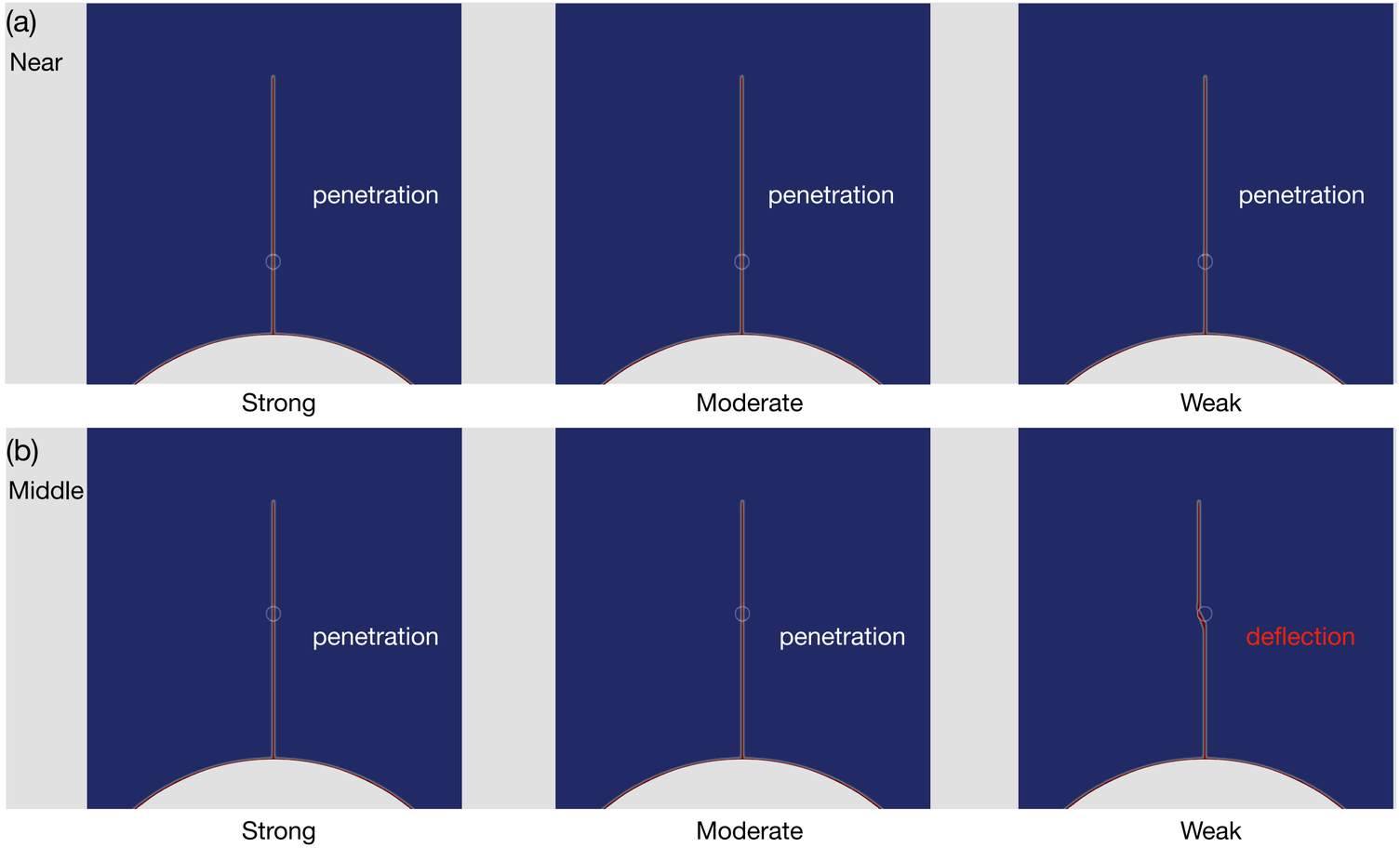
OpenGeoSys (www.opengeosys.org)



Strong: $$\frac{G_{\mathrm{c,interface}}}{G_{\mathrm{c,bulk}}} = 0.2$$

Moderate: $$\frac{G_{\mathrm{c,interface}}}{G_{\mathrm{c,bulk}}} = 0.1$$

Weak: $$\frac{G_{\mathrm{c,interface}}}{G_{\mathrm{c,bulk}}} = 0.05$$



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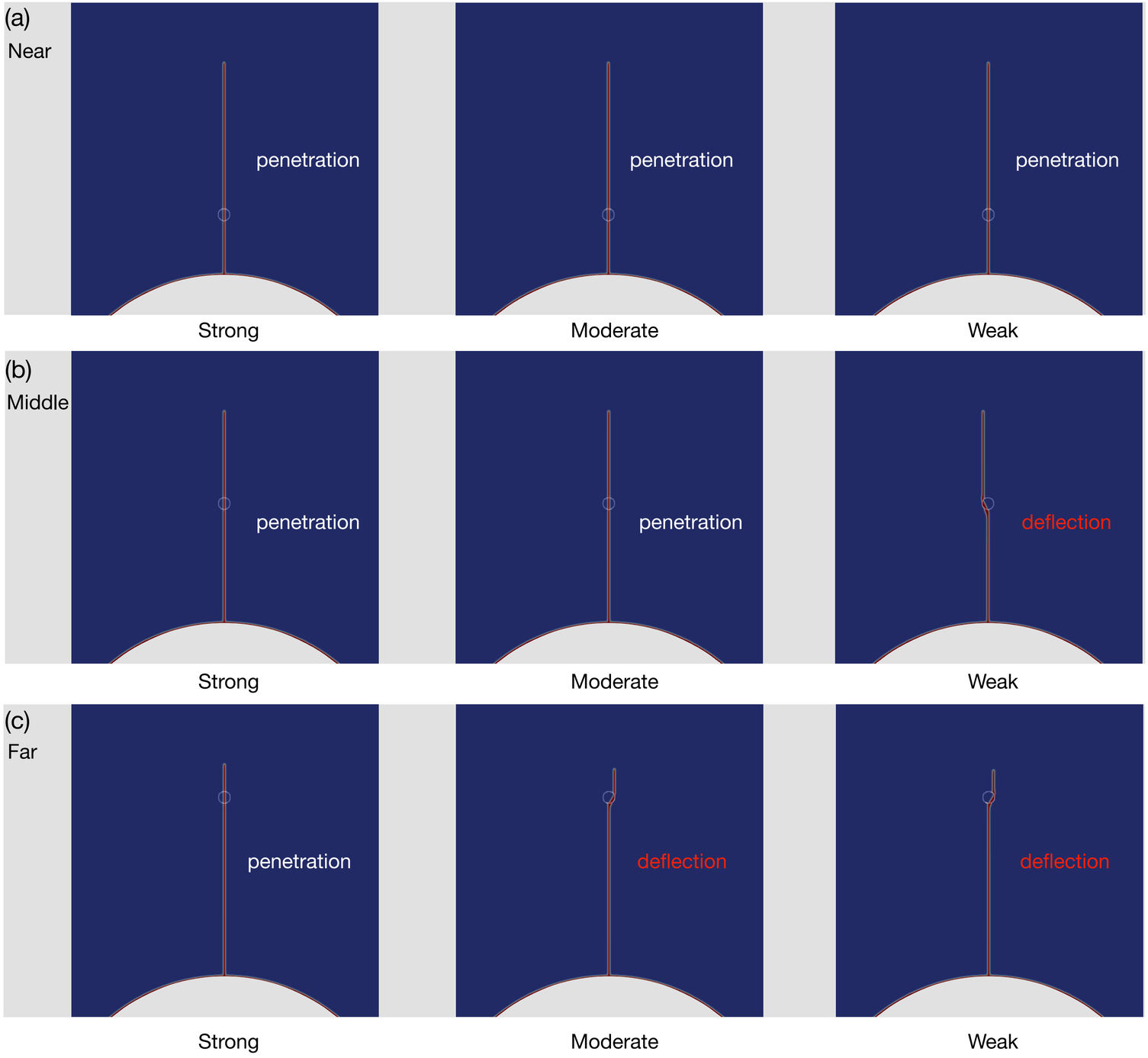

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Conclusions

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- Fracture path should be determined based on the energy dissipation rather than interface characteristics.