**EPFL**

Rock Heterogeneity and Fractures

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Hydraulic fracturing has a wide range of applications. It is widely studied and modelled to better understand all the possible situations and foresee possible advantage in the industry. This work proposes a **new volume control solver**, using an indirect method and a hierarchical matrix, to reduce the size and time of computation. The first application was a **three layers case** with a central layer (medium of injection) with a lower toughness. It put into question the Perkins, Kern and Nordgren's model in toughness dominated propagation (PKN-K) and its assumptions while showing which parameters are driving the system. The propagation into a new layer seems to always happen, independently of the toughness ratio. The time required to enter the new medium is however dependent of that value.
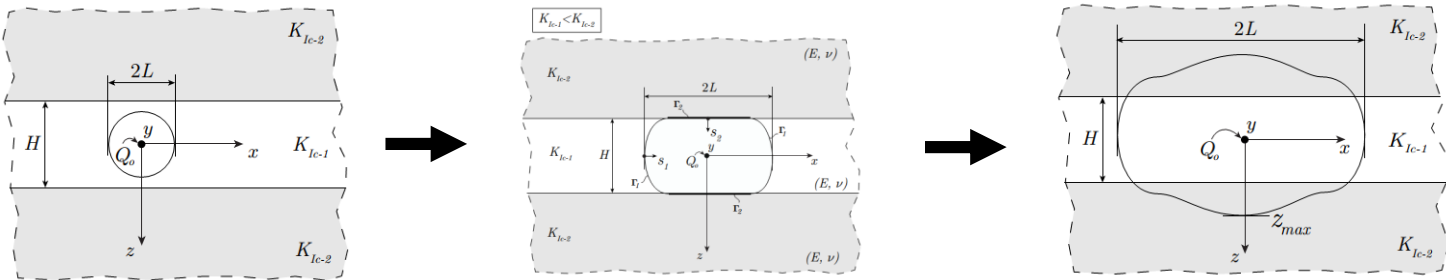
Graph on the right shows how the new volume control solver (VC solver) improves the time of computation, lowering the complexity from $O(n^3)$ to $O(n \log(n))$.

In addition, the constant time of computation per timestep implies that the Hmat size drives the computation time, hence one could predict the overall time of simulation.

Lastly, the Hmat combined with an iterative solver keeps a good relative error in comparison with the analytical solution (of a radial crack in homogeneous medium). The VC solver is a success has it reached the expected goals of time and size efficiency !

Computation time needed depending on the number of cells in the crack
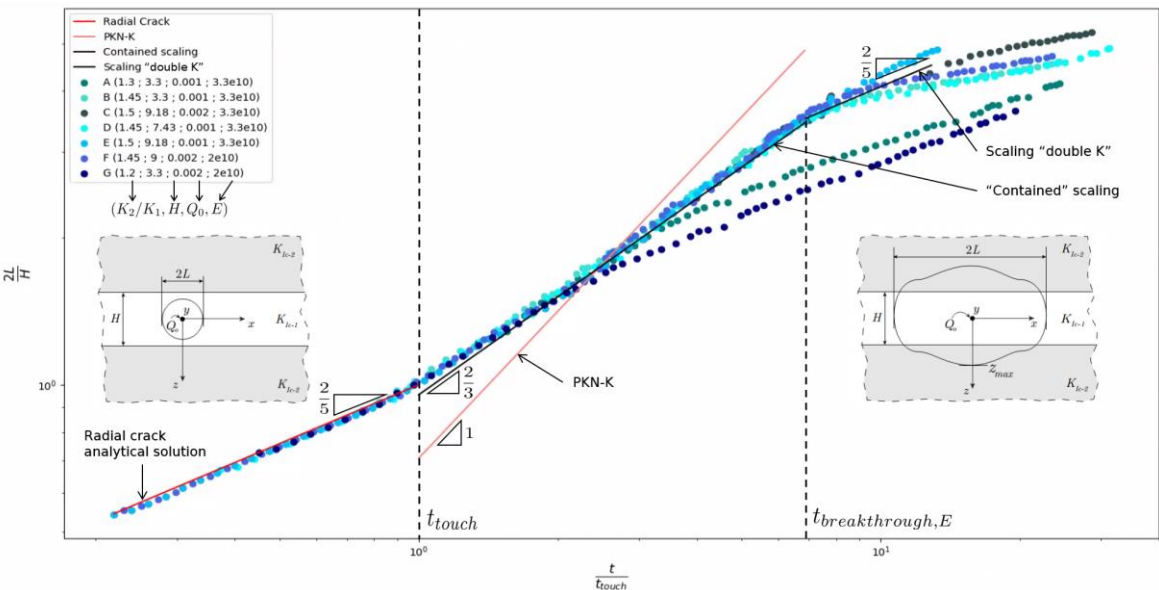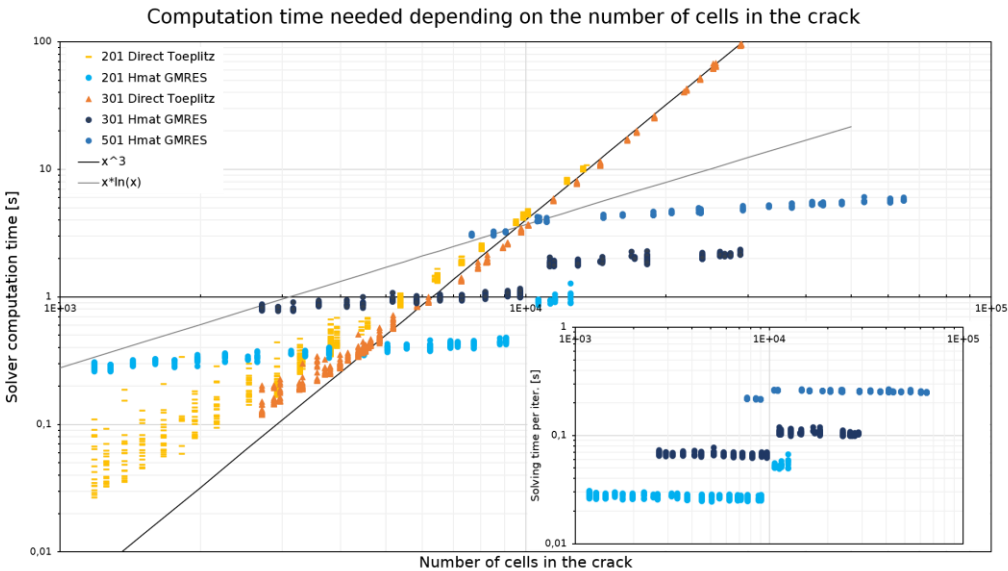
In the three layers set up, the analytical solution fits well before the propagation reaches the new media. After, the scaling developed is coherent with the propagation.

However, it is not the case of the PKN model than proposes a totally different trend. After the time of breakthrough, the scaling is not working well though. It seems the trendline slightly diverges from the supposed 2/5.

In the end, the propagation shows the PKN model is not working well while the scaling needs improvements.

In the end, the volume control was a success and is able to deal with complex case in a fully toughness dominated mode. It would be great to start developing a similar solver, this time adding the viscosity, as it would help solve a broader range of problems. On the other hand, the three layers case still presents some blurred zone. The scaling implemented could be a good match on the long term but not for the phase right after the breakthrough. In addition, some parameters other than the toughness ratio could be investigated to develop a new scaling.