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3D convection in a fractured porous medium : influence of fracture network parameters and comparison to homogeneous approach.

Cécile Mezon (1,2), Valeri Mourzenko (3), Jean François Thovert (3), Raphael Antoine (4), Fabrice Fontaine (2), Anthony Finizola (2), and Pierre Michel Adler (1)

(1) UPMC - Metis, Paris, France (mezoncecile@gmail.com), (2) Université de La Réunion - LGSR - IPGP, Saint-Denis la Réunion, France, (3) Institut Pprime, CNRS, SP2MI, Futuroscope Chasseneuil, France, (4) CEREMA, Rouen, France

In the crust, fractures/faults can provide preferential pathways for fluid flow or act as barriers preventing the flow across these structures. In hydrothermal systems (usually found in fractured rock masses), these discontinuities may play a critical role at various scales, controlling fluid flows and heat transfer.

The thermal convection is numerically computed in 3D fluid satured isotropically fractured porous media. Fractures are inserted as 2D convex polygons, which are randomly located. The fluid is assumed to satisfy 2D and 3D Darcy's law in the fractures and in the porous medium, respectively; exchanges take place between these two structures.
First, checks were performed on an unfractured porous medium and the convection cells do start for the theoretical value of Ra, namely 4pi^2. 2D convection was verified up to Ra=800.
Second, all fractured simulations were made for Rayleigh numbers (Ra) $<$ 150, cubic boxes and closed-top conditions.
The influence of parameters such as fracture aperture (or fracture transmissivity) and fracture density on the heat released by the whole system is studied. Then, the effective permeability of each fractured system is calculated. This last calculation enables the comparison between all fractured models and models of homogeneous medium with the same macroscopic properties.

First, the heat increase released by the system as a function of fracture transmissivity and fracture density is determined.
Second, results show that the effective approach is valid for low Ra ($<$ 70), and that the mismatch between the full calculations and the effective medium approach for Ra higher than 70 depends on the fracture density in a crucial way.
Third, the study also reveals that equivalent properties could be deduced from these computations in order to estimate the heat released by a fractured system from an homogeneous approach.