Effects of damage zone around fault planes on fluid and heat fluxes : first results

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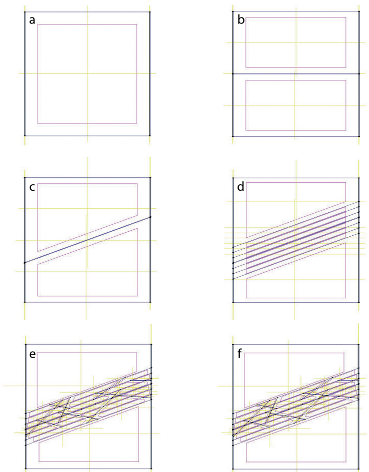

figure 1, structure

A fault zone is now defined with three parts: the fault core, the damage zone and the protolith (Caine et al., 1996). In the EGS concept, fluid flow uses the fault and fractures network to move through the hot rock. After, measurement of the physical properties of each part of fault zones, different numerical models run in the aim to test the rule of these different rock volumes on the fluid, and heat transfers. The soft Code_Bright developed by Univertitat Polytechinca de Catalunia is a THM modeller (Olivella et al., 1996)

A set of six fault zone models are defined and presented in the figure 1(structure) and 2 (numerical mesh). In all models, on the right there is the injection borehole and on the left the production one. a.- un simple block without fracture, b.- a single horizontal fault links the both boreholes. c.- an oblique fault zone links the both borehole. d.- an oblique fault zone with an associated damage zone, composed by three zones. e.- the same structure than d, with oblique fracture cross cutting the damage zone. f.- the same structure than d, but the central part of the fault zone is sealed. Properties of the different parts are presented in table1 (Surma, 2003; Surma and Géraud, 2003)

The size of the block is 25 metres square. The tested rock volume is located at 4500 metres depth, the fluid pressure is 45MPa at the top and 45.25 MPa at the bottom, temperature is 180°C at the top and 180.75°C at the bottom, and the salinity is 0.09kg.kg^{-1}. The concentration of the injected fluid is 0.01, its temperature is 60°C. All of the views are obtained after 30 days of run, except for figures 4b, 5b, 6c obtained after 60 days of run.

Model element	Porosity (%)	Permeability (m^2)	Thermal capacity (J.kg^{-1}.K^{-1})	Thermal conductivity dry (W.m^{-1}.K^{-1})	Thermal conductivity wet (W.m^{-1}.K^{-1})
Rock	0.5	10^{-19}	816	2.56	2.69
Fault/fracture	15	10^{-13}	1308	3 .49	2.8
DZ1	8	10^{-15}	1071	2.56	2.78
DZ2	4	10^{-16}	935	2.56	2.75
DZ3	2	10^{-18}	867	2.56	2.72

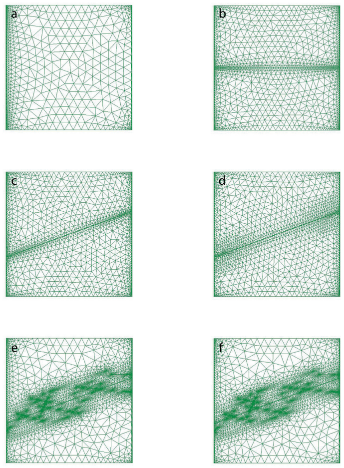

figure 2, mesh

Distribution of fluid pressure, figure 3, The damage zone increases the volume of rock affected by the fluid pressure pulse. Fractures within the damage zone induce a low effect, and the sealing part, increase the pressure gradient between the injection borehole and the sealing zone.

Distribution of the temperature, figure 4a. The development of a damage zone decreases the propagation of the low temperature volume. Increasing the exchange between fluid and rock. Fractures in the fault zone increase these heat exchanges. The sealing increases the thickness of the cooling zone. These effects are more important after 60 days of run figure 4b.

Distribution of the heat flux figures 5a and 5b. Damage zones localize heat fluxes. Secondary fractures develop the highest gradient, especially for fractures bypassing the sealing zone.

Fluid concentration figures 6a and 6b. The damage zone acts as a buffer volume, concentration of fluid flowing in the fault conduit is progressively increases from the protolith area. Fractures increase the development of the affected zone.

Fluid fluxes, figure 7. Only fluxes along the horizontal are mapped. The transfer properties of the matrix damage zone are lowest than the fault gouge one, indeed fluxes are mainly localised within the fault gouge zone of fault and fractures.

Caine J.S., Evans J.P. and Forster C.B., 1996. Fault zone architecture and permeability structure. Geology, 24(11): 1025-1028.

Olivella S., Gens A., Carrera J. and Alonso E.E., 1996. Numerical formulation for a simulator (code_bright) for the coupled analysis of saline media. Engeneering computations, 13(7): 87-112.

Surma, F., 2003. Relation entre les caractéristiques minéralogiques, chimiques et physiques des matériaux granitiques du site géothermique de Soultz sous Forêts. PhD Thesis, Université Louis Pasteur, strasbourg, 321 pp.

Surma, F. and Géraud, Y., 2003. Porosity and thermal conductivity of the Soultz sous Forêts granite. *PAGEOPH*,, 160: 1125-1136.

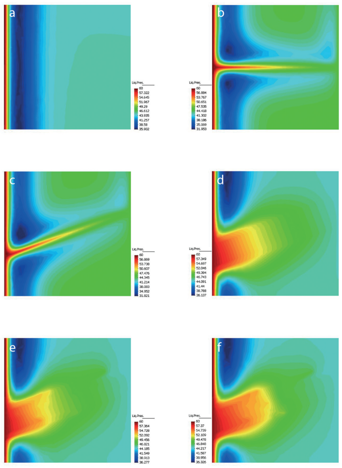

figure 3 fluid pressure

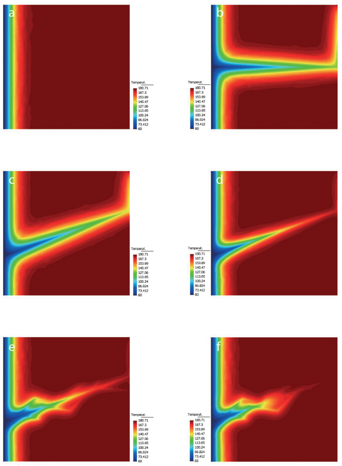

figure 4a temperature

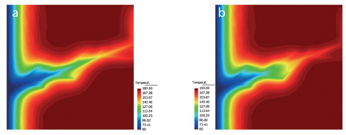

figure 4b temperature

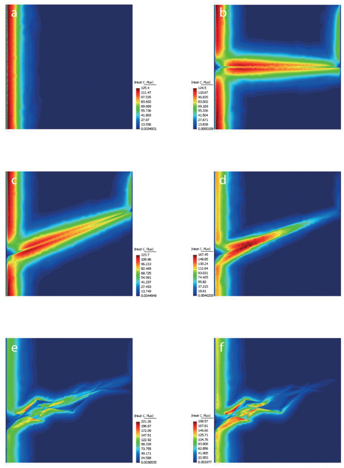

figure 5a

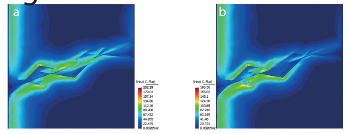

figure 5b heat fluxes

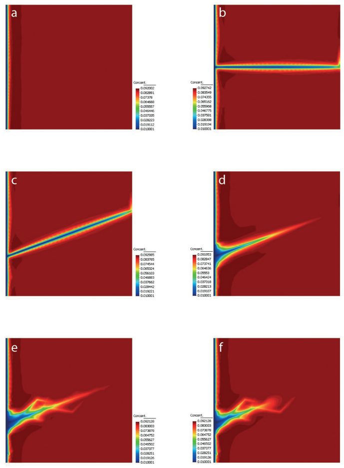

figure 6a

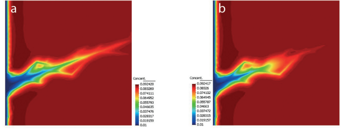

figure 6b salinity

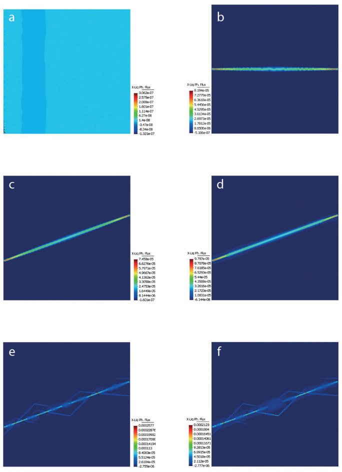

figure 7 fluid fluxes