Influence of fluid-assisted micro-crack healing on fault permeability structure

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Micro-cracks in fault damage zones can heal through diffusive mass transfer driven by differences in chemical potential, with rates controlled by temperature and pressure. The diffusion of pore fluid pressure in fault damage zones accelerates mass diffusion and assists healing processes. In this work, we use fluid flow model coupled with heat transfer and crack healing to investigate, through different scenarios, the role of subsurface warm fluid migration, along damage zones, in enhancing healing and re-shaping the fault permeability structure. Our results show that if the flow communication exists between the bed and only one side of the damage zone and not the other side, it leads to an asymmetric permeability structure caused by healing in the side circulated by fluids (ex: Rapolano geothermal area, Italy). Another scenario is when the damage zone adjacent to the fault core is not the interval with the highest permeability, as conventionally expected, which is the case of the Alpine Fault, New Zealand. As shown by our simulations, this can be due to healing by diffusive mass transfer, favored by the localized high geothermal gradients and the upward fluid migration through the fault relay structure.