Geophysical Research Abstracts, Vol. 9, 05360, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05360

Permeability enhancement by seismic waves: the importance of local heterogeneities

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Seismic waves increase permeability. Two out of four wells of the Pinon Flat Observatory, Southern California, changed their response to Earth tides after the passage of the seismic waves generated by regional earthquakes (Elkhoury2006). This is due a change in permeability of the rock penetrated by the borehole.

We investigate the mechanisms at the origin of these permeability changes.

By studying the response of the boreholes to other excitations like the barometric loading or the response to coseismic changes, we refine better the relationship between permeability and the spectral response of the borehole to external excitation. The phase lag of the tidal response is due to the storativity of the well and to the fluid diffusion to the surface. The two wells sensitive to seismic waves range in a transition zone where the change in permeability have a large impact on the tidal response.

We quantify the amplitude of the flow to borehole necessary to sustain the water level in the hole. Near the borehole, this flow may be sufficient to unclog the fractures of the medium and increase the permeability. These changes local to the borehole are sufficient to alter substantially the borehole response to tides.

Our mechanism relies on the difference of storativity between the borehole and the surrounding rocks and may appear specific to the borehole region. This mechanism may also apply for a rough fracture whose change in aperture creates an heterogeneity in storativity along the fracture.