Distributed Acoustic Sensing (DAS) as a Distributed Hydraulic Sensor

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Distributed Acoustic Sensing (DAS) instruments were originally intended to measure oscillatory strain (vibration) at frequencies of 1 Hertz or more. Recently, the ability to measure much lower frequencies has opened the possibility of using DAS as a strain sensor in boreholes. A fiber optic cable that is mechanically coupled to a geologic formation will strain in response to hydraulic stresses in pores and fractures. Because DAS measures dynamic strain along the entire length of a fiber optic cable, it is capable of both locating hydraulically active features and quantifying the hydraulic stress in the formation. We present field experiments in which a fiber optic cable was mechanically coupled to a crystalline rock borehole. The formation was stressed hydraulically at a second well using alternating injection and pumping. The DAS instrument measured oscillating strain at the location of a fracture zone known to be hydraulically active. The experiment was repeated in two wells using multiple periods of hydraulic stressing. Nanostrain was measured in response to head changes as small as 2 mm of water. These results suggest that fiber optic cable embedded in geologic formations may be used to map hydraulic connections in three dimensions. A great advantage of this approach is that strain and, therefore, hydraulic stress can be measured without beforehand knowledge of the fracture network. The technology has obvious applications in oil and gas, geothermal energy, and remediation of groundwater in fractured bedrock.

Keywords: distributed acoustic sensing, borehole geophysics, fractured bedrock, geothermal, rock strain

