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Characteristics and mechanism of CO_2-based fracturing of granite in conventional and superhot geothermal environments

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Creation of fractured reservoir for enhanced geothermal system (EGS) in granitic rock at unconventional superhot geothermal environments (>400°C) has been found possible by injection of low viscosity supercritical water (Watanabe et al., 2017, Geoph. Res. Lett.; Watanabe et al., 2019, Sci. Rep.). Accordingly, the complex cloud-fracture network is formed through stimulation of pre-existing microfractures by the low viscosity (<50 μPa⋅s) water. Nonetheless, water reactivity to rock forming minerals (Brown, 2000, Proc. 25th wksh. Resv. Engr.) and its high water footprint (Wilkins et al., 2016, Environ. Sci. Technol.) hinder water application. Therefore, CO_2 is proposed to replace water, since it less reactive to rock forming minerals (Brown, 2000), and can reduce water footprint (Wilkins et al., 2016). CO_2 has also low viscosity at conventional (c.a. 150 – 300°C) and superhot geothermal temperatures (based on Heidaryan et al., 2011, J. Supercrit. Fluid), which motivates to create similarly complex fracture pattern in those geothermal environments. A set of traditional-triaxial stress fracturing experiments was performed on cylindrical granite samples subjected to 200 – 450-°C temperature and varying differential stress to determine characteristics and mechanism of CO_2-based fracturing in conventional and superhot geothermal environments. The experiments demonstrated that complex fracture pattern was formed at low pressure in all experimental-stress state and temperature. Breakdown pressure was also found to decrease with increasing differential stress. Hence, it was hypothesized that fracturing mechanism by injection of CO_2 is governed by Griffith fracture theory. To unveil the fracturing process in detail, a CO_2-based fracturing experiment was conducted on cubical granite sample with a realistic true-triaxial stress state and 300-°C temperature. The later experiment confirmed the above-mentioned hypothesis and showed that the fracturing occurs gradually.