

## The Effect of Heating-Liquid Nitrogen Cooling on Fracture Toughness of Anisotropic Rock

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**Abstract :** In geothermal energy production, the method of liquid nitrogen (LN<sub>2</sub>) fracturing in hot, dry rock is one of the most effective methods to increase the permeability of the reservoir. The geothermal reservoirs mainly consist of hard rocks such as granites and metamorphic rocks like gneiss with high temperatures. Gneiss, as a metamorphic rock, experiences a high level of inherent anisotropy. This type of anisotropy is considered as the nature of rocks, which affects the mechanical behavior of rocks. The aim of this study is to investigate the effects of heating-liquid nitrogen (LN<sub>2</sub>) cooling treatment and rock anisotropy on the fracture toughness of gneiss. For this aim, a series of semi-circular bend (SCB) tests were carried out on specimens of gneiss with different anisotropy plane angles (0°, 30°, 60°, and 90°). In this study, gneiss specimens were exposed to heating-cooling treatment through gradual heating to 100°C followed by LN<sub>2</sub> cooling. Results indicate that the fracture toughness of treated samples is lower than that of untreated samples, and with increasing the anisotropy plane angle, the fracture toughness increases. The scanning electron microscope (SEM) technique is also implemented to evaluate the fracture process zone (FPZ) ahead of the crack tip.

**Keywords :** heating-cooling, anisotropic rock, fracture toughness, liquid nitrogen

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