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pH dependence of mineral dissolution and permeability enhancement of intermediate to basic volcanic rocks by chelating agent flooding under geothermal conditions

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The use of Enhanced Geothermal Systems (EGS) has been recognized as a viable source of renewable energy in regions with high geothermal temperatures. Nevertheless, geothermal reservoirs may experience reduced permeability during exploration or operation. Research on chelating agents in geothermal environments has been widely disseminated as a complementary method to conventional methods such as hydraulic and chemical stimulation. Previous studies reported fast and significant improvements in permeability in granitic and volcanic rocks using aqueous solutions of glutamic L-diacetate acid (GLDA) under acidic conditions. However, no studies have been conducted with chelating agents applied to volcanic rocks at different pH conditions, since pH determines the ionic species in the solution, and thus, the chemical interactions taking place in a system. Furthermore, the dissolution of minerals in these conditions was not quantified for modeling purposes. In the present study, an aqueous solution of the chelating agent GLDA at various pH conditions (2-10) was applied to improve the permeability of single-fractured intermediate to basic volcanic rocks. According to the results, permeability increases about up 4.3-fold under weak acid (pH 4) conditions, while it increases about 36-fold under alkaline (pH 10) conditions, due primarily to the formation of voids caused by mineral dissolution or groundmass dissolution, respectively. Moreover, channeled samples with mirror-conditions revealed that the formation of voids at acidic conditions was as deep as 135 μm by the selective dissolution of hematite, whereas an average of 4-μm dissolution of quartz was promoted at alkaline conditions. Although the depth of voids formed in alkaline conditions is less than the case of acidic, quartz composes the matrix that surrounds the phenocrysts of volcanic rocks, promoting a preferential fluid path that improved the permeability further at alkaline conditions. This study is the first step in spreading the use of this chemical stimulation technique to different volcanic-rock geothermal systems.

Keywords: EGS, chelating agents, permeability enhancement, andesitic rock, selective dissolution of minerals.