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The effect of fluid compressibility and elastic rock properties on deformation of geothermal reservoirs

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A geothermal reservoir deforms when the extraction of pore fluid exceeds reservoir recharge, causing a decrease in pore pressure. The magnitude of this deformation is related to the amount of pore fluid that is extracted. Based on flawed assumptions, the volume of fluid extraction and the reservoir's volume change estimated from observations of surface deformation are sometimes mistakenly expected to be equivalent. This leads to differences in the values of volume change being solely attributed to reservoir recharge which may result in incorrect interpretations of reservoir conditions. We derive, for a simplified scenario, an expression for the ratio of pore fluid- and reservoir volume change. We apply this relationship to three different case studies to illustrate under which circumstances the relation between reservoir deformation and the amount of extracted fluid is able to help us learn more about reservoir conditions. We show that even though all of our examples are high temperature two-phase geothermal systems, they react to fluid extraction in different ways. We attribute this to some systems exhibiting deformation related to two-phase fluid compressibility while others show behavior associated with single-phase fluid compressibility.