Review of geochemical problems and mitigation during the production of geothermal reservoirs

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Introduction

In many geothermal fields worldwide, production and reinjection of hot brines modify the temperature and pressure conditions around the wells. This induces geochemical processes within the reservoir and/or along the well casings and the surface pipelines. Some geothermal fluids are relatively benign even at high temperature, whereas others can cause numerous problems due to either a high salinity or a high content of particular gases or dissolved solids. Permeability decrease, well and pipeline partial plugging or metal corrosion are the main consequences of these chemical processes. If they are not taken seriously into consideration and solved, the outcome can be a production decrease, a high maintenance cost, or even the loss of a well.

Mineral scaling

Due to the high solubility of silica at high temperature, silica scaling is a frequent problem in geothermal plants. Amorphous silica precipitates after flashing or cooling of the fluid in surface pipelines or reinjection wells. Silica can be removed from the fluid and exploited commercially as a by-product. Carbonate scaling occurs in carbonate reservoirs and CO_2-rich fluids. Other minerals can form scales, such as anhydrite, sulphides and oxides.

Metal corrosion

Various types of corrosion are observed on well casings and surface pipelines, due to dissolved H_2S and CO_2, high chloride content or gas exsolution. Numerous laboratory experiments on the corrosion processes have been performed, but the results often differ from on-site monitoring experiments of the corrosion processes.

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Liquid carbonates investigated by First-principles Molecular Dynamics simulations

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The Earth mantle is mainly composed of silicates and its carbon contents is very low, of the order of 10 to 500 ppmw [1]. However carbon and its oxidized forms as carbonates and CO_2, likely play a crucial role in the dynamics and chemical differentiation of the mantle. The onset of partial melting at about 300km deep in the mantle, corresponds to the formation of liquid carbonates or carbonatites. In the astenosphere, the observed electrical conductivity anomalies [2] could originate from carbonatitic magmas exhibiting a very large conductivity, about 100 to 100 000 times that of olivine. However the physical and chemical properties of carbonatites at mantle conditions are poorly known and some theoretical guidance could be useful in this context.

We present a First-principles Molecular Dynamics simulation study of liquid $CaCO_3$. Its structural and transport properties have been investigated in the (T, P) range 1000-2000K and 0-6 GPa. Diffusion constants are found in good agreement with available data on viscosity [3]. Surprisingly CO_3^{2-} units diffuse nearly as fast as the Ca^{2+} cations. Because of the fast dynamics into the melt it was also possible to estimate the ionic conductivity. For the investigated thermodynamic conditions, we found an ionic conductivity close to 100 $S.\ m^{-1}$, in agreement with the available experimental data [2]. The local structure around the CO_3^{2-} anions has been studied in details and appears to be quite complex, sharing some similarities with the crystalline polymorphs calcite and aragonite. Simulation data on vibrational spectroscopy of liquid $CaCO_3$ will also be presented.

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