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Experimental measurements of the thermoelectric coupling coefficient in NaCl-brine saturated sandstone cores

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Spontaneous potentials in geophysical systems may arise from electrokinetic, thermoelectric and electrochemical effects. Geophysical applications of spontaneous potential measurements include monitoring in oil fields, geothermal activity, and volcanic activity forecasting and earthquake prediction. However, few studies of the thermoelectric potential have been reported. These studies provide a limited number of measurements of the thermoelectric potential coupling coefficient, and a restricted description of the experimental conditions and methodology. The aim of this study is to measure the thermoelectric potential coupling coefficient in sandstone samples saturated with NaCl-brine over a range of salinities, using a well constrained experimental setup.

The experimental apparatus consists of two reservoirs connected by a horizontal rubber sleeve which is used as the sample holder. Both reservoirs and pipe are filled with NaCl-brine of the desired salinity and are thermally isolated and placed in a Faraday enclosure. The temperatures in both reservoirs are regulated by means of a submerged heater and a cooling pump, so the temperature difference across the sample, and the temperature at the sample centre, can be controlled independently. Measurements are performed using thermocouples and Ag|AgCl reference electrodes which are connected to a data acquisition system. The thermocouples are located at both faces of the sample facing the fluid, at the central cross-section of the sample and in the reservoirs. The electrodes are located at both faces of the sample facing the fluid. In order to investigate the influence of the temperature on the reference electrodes, the thermoelectric coupling coefficient is measured in an additional apparatus which consists of a vertical column filled with NaCl-brine, heated from the top. These measurements are compared with the measurements performed on the first experimental apparatus in order to allow the determination of the potential arising from the thermoelectric coupling in the rock sample alone.

We report systematic measurements of the thermoelectric coupling coefficient over a range of temperatures difference up to 50K across the sample, in seven different experimental sets performed over seven brine salinities ranging from 5x10-3 to 1 M. It is shown that the thermoelectric potential responds linearly to the applied temperature difference across the sample, from which the thermoelectric potential coupling coefficient can be determined. The thermoelectric coupling coefficient is found to depend on the logarithm of salinity. The coupling coefficient decreases as the salinity increases, from 0.8 mV/K at 5x10-3 M to 0.25 mV/K at 1 M. It is found that the thermoelectric coupling coefficient depends on the temperature at the central cross-section of the sample. The coupling coefficient decreases as the temperature at the central cross-section of the sample increases.