Conceptual design of an apparatus for measuring frequency-dependent streaming potential of porous media

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Electro-kinetic phenomena link fluid flow and electrical flow in porous and fractured media such that a hydraulic flow will generate an electrical current and vice versa. Such a link is likely to be extremely useful, especially in the development of the theory of the electro-seismic method. However, surprisingly little experimental determination, numerical modeling and theoretical development have taken place, and what exists is for steady state flow. There have been only a few attempts at making experimental determinations of the frequency-dependent streaming potential coupling coefficient because of their difficulty, and only one rare measurement made on rocks.

Here we have considered six different approaches to making laboratory determinations of the frequency-dependent streaming potential coupling coefficient. In each case, we have quantified the practical difficulties involved in each method. We conclude that the electro-magnetic drive and the piezo-electric are the only approaches that are practicable with current technology.

We have also constructed a simplified trial apparatus using the electro-magnetic drive to test the conceptual design with samples in the form of sands and beads. Tests with this apparatus on Ottawa sandstone and glass bead packs have shown that high quality measurements of the frequency-dependent streaming potential coupling coefficient can be made, and we are currently extending its frequency range. Tests have indicated that it is important to acertain whether the measured frequency-dependent streaming potential coupling coefficient is independent of the volume of fluid passing through the sample per cycle.

We have used our experience with the trial apparatus to design a new apparatus for a 1 cm diameter sample, and with the help of an engineering approach we have determined the range of possible sample permeabilities for samples between 0.5 and 2 cm in length. The new cell will have a maximum confining pressure of compressed nitrogen of 4.5 Mpa and is made from stainless steel and nylon. The pressures each side of the sample are measured by a specialized dynamic pressure transducers with a frequency range of 80 mHz to 170 kHz. The streaming potentials are measured with miniature non-polarising Ag/AgCl electrodes from Cypress Systems. Currently this apparatus is being evaluated.