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A dynamic Stern layer model to explain high salinity zeta potential measurements on sandstones

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Exploring the electrical properties of the mineral-water interface for interpreting geophysical electrical measurements is a very challenging work because of the low specific surface area of minerals such as quartz or calcite. Only few methods exist to probe the properties of the electrical double layer (EDL) compensating the surface charge of minerals. Among them, there is the streaming potential (SP) method where the applied water pressure difference generates a pore water flow displacing the mobile counter-ions in excess in the EDL, hence creating a measurable electrical potential difference, the streaming potential. During SP measurements, the exact position of the shear plane from the mineral surface is not known and it is widely accepted that the shear plane is located between the compact Stern layer and the diffuse layer. In our study, we show that the assumption that there is no water flow in the Stern layer has no physical basis for sandstones in contact with a NaCl electrolyte because water molecules around counter-ions in the Stern layer may have bulk-like properties. Using a basic Stern model to simulate surface complexation reactions and considering water flow in the Stern layer, we reproduced the zeta potential measurements on sandstones over a large salinity range from about 10^{-2} to 5.5 M NaCl. The “anomalous” high salinity zeta potential data can not be reproduced by a surface complexation model considering water flow only in the diffuse layer. Our ability to explain these measurements suggests that the shear plane may be located between the mineral surface and the Stern layer, i.e. closer to the surface than previously thought, which may have strong implications for the modelling of the surface electrical properties of the minerals.