Electrical monitoring of dynamic drainage and imbibition processes in rock-fluid-gas systems

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SUMMARY

Understanding physico-chemical interactions and quantification of reaction kinetics during dynamic processes in multi-phase systems and their impact on the electric conductivity can help to interpretation EM-monitoring data. Therefor a multistage experimental setup was developed and performed on different reactive and non-reactive rock-fluid-gas systems.
The results shows that the real part of the el. conductivity decreases by about -90% in the dewatered states and after imbibition the el. conductivity increases differently depending on material and measuring height. A combination of reactive materials show the strongest conductivity changes after cycles of dynamic processes.

Keywords: Spectral Induced Polarization, carbonate rocks, non-equilibrium condition

ABSTRACT

Carbonate rocks host large fossil oil and natural gas deposits and are targets for Enhanced Oil Recovery and Carbon Capture and Storage applications. Although electromagnetic methods can be used for monitoring. The understanding of the electrical properties of carbonates is still incomplete due to their heterogeneous pore space and reactivity towards aqueous phases, especially in the presence of CO_2 (dissolution and precipitation processes).
Therefore, a systematic multistage experimental procedure was developed as well as the successful realization of test series on different multiphase systems for electrical monitoring and characterization of dynamic processes.
In each case, a combination of sand or carbonate as rock matrix, and nitrogen or CO_2 as gas component was used for the individual experiments. Thus, the combinations of rock matrix and gas can be divided into subsystems with different degrees of reactivity.
It can be seen that the carbonate systems show a strong response to the pressure increase, depending on their chemical reactivity potential. The sand systems, on the other hand, show no reaction to the pressure increase (inert matrix). The subsequent dynamic processes can cause significant changes in the characteristics of the complex conductivity spectra, where the chemical reactivity of the individual components plays an important role.
The results help to understand the physicochemical understanding and quantification of the reaction kinetics during long-term surface aging of carbonate rocks exposed to CO_2. A model-based relationship between complex electrical properties and long-term reaction kinetics for named conditions supports geoelectrical monitoring and enables prediction of parameter contrasts.

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Journal article

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