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Pore water content in equilibrium with ice or gas hydrate in sediments

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Abstract

A new method is proposed for estimating the contents of liquid water in equilibrium with bulk ice and bulk gas hydrate in hydrophilic porous media. In this paper water content equilibrium with bulk ice is represented as unfrozen water, and water equilibrium with gas and gas hydrate is nonclathrate water.

The method consists in measuring moisture- and temperature-dependent pore water potential (and water activity) in natural sediments or synthetic porous samples at atmospheric pressure, with subsequent thermodynamic calculations of pressure- and temperature-dependent unfrozen and/or nonclathrate water contents using the measured data. The experiments are applied to synthetic samples with known pore sizes (controlled pore glasses, CPG) and natural kaolinite and polymineral clay samples. Water potential and thermodynamic activity are measured on a Decagon Devices WP4T meter. Thermodynamic calculations for water contents in hydrophilic porous media are performed using specially derived equations for temperature-dependent unfrozen water in equilibrium 'bulk ice - confined water' systems (at negative Celsius temperatures) and for nonclathrate water in equilibrium 'gas - bulk gas hydrate - confined water' systems depending on both temperature and pressure of gas hydrate former (methane, natural gas, etc.). The water contents in porous samples estimated with the new method show good agreement with the results of direct contact measurements for equilibrium water in contact with ice or gas hydrate at given temperatures and pressures.

Keywords: Phase equilibrium, unfrozen water, nonclathrate water, porous media, sediments, ice, gas hydrates.