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3D monitoring of hydrate formation and dissociation using a cylindrical ERT

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In the framework of the SUGAR-project (submarine gas hydrate reservoirs) innovative methods and approaches for the production of methane from hydrate-bearing reservoirs are studied. For this purpose a large reservoir simulator (LARS), allowing the formation and dissociation of gas hydrates under simulated in-situ conditions, was realized. Prior experiments within the LARS suggested higher hydrate formation rates in the boundary regions within the cylindrical reservoir, which is in agreement to the observed temperature distribution in the sediment sample. However, for improvement and validation of numerical reservoir modeling a sufficient quantitative understanding of the spatial distribution of hydrate formation and dissociation with respect to time is required. Since hydrate can be considered as an insulator, the resistivity in the reservoir will change with hydrate saturation. Thus, significant differences regarding the electrical properties within the investigated reservoir are expected and suggest the application of an electrical tomographic system. Tomographic measurements constitute a popular technique for high resolution imaging of various geometries. Therefore, a cylindrical electrical resistance tomography (ERT) composed of 25 electrode rings featuring 15 electrodes each, is implemented into the LARS. In advance, a number of numerical simulations has been carried out to optimize the electrode arrangement providing the best resolution for the resistivity tomography. As the present phases (sediment, liquid, hydrates, and gas) cover a wide range of electrical properties, the ERT allows the monitoring of the spatial distribution of the various phases during the experiments. These data serve as basis for numerical simulations of production scenarios in the LARS and the field.
At a confining pressure of 12 – 15 MPa and a pore pressure of 8 - 11 MPa hydrate is formed at 278 K from methane-saturated water (no free gas phase) within the sediment sample until a sufficient hydrate saturation is reached. During this period, tomographical measurements are frequently performed to monitor the evolution of hydrate formation within the sediment's pore space with respect to time.
The subsequent hydrate dissociation is initialized by pressure reduction close to equilibrium conditions of methane hydrate and takes several days. Thereby it is desired to maintain a continuous dissociation of the hydrate phase to both methane and water. This process is accompanied by frequently performed tomographical measurements to monitor the spatial progress of the phase transition.