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Flowing Fluid Electric Conductivity Logging Method as a Tool to Characterize the Hydraulic Conducitivity Strucure of a Target Layer for CO2 Injection

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Understanding of the detailed permeability structure and internal heterogeneity of the target layers of CO2 injection is important for any successful injection project. Yet, determining this structure by traditional hydraulic testing may be prohibitively cumbersome and expensive, while information obtained from core logs may not give a full picture of the connected permeability.

Flowing FEC (Fluid electric conductivity) method provides a quick way of determining the hydraulic conductivity structure of a reservoir layer. In combination with traditional pumping tests that can provide overall interval transmissivities, the method can be used for obtaining a more detailed picture of the distribution of the transmissivities, information that is crucial for CO2 injection experiments where the internal heterogeneity of the target layer may greatly influence the distribution of CO2. The method has been previously been successfully applied to several applications, ranging from granitic rock to mudstone formations (Doughty et al., 2008; Tsang and Doughty, 2003) and is here being used for preliminary hydraulic characterization of the target CO2 injection layer of the Heletz, Israel, the main injection site of the MUSTANG project.

In this approach the wellbore water is first replaced by water of a constant salinity distinctly different from that of formation water. Next, the well is shut in and an electric conductivity probe is used to scan the FEC of borehole fluid as a function of depth. After this, the well is pumped at constant rate, during which a series FEC logs at successive times are obtained. At depth locations where water enters the borehole, the logs display peaks. Analysis of the time evolution and skewness of these peaks allows estimation of the flow rate qi and salinity C, and further, if two or more logs are taken at different well flow rates, the initial ambient pressure heads hi of each individual inflow/feed point I can also be estimated. The depth resolution of the inflow locations is typically 10cm. These data can used to define the detailed transmissivity/permeability structure of the reservoir layer.

The present presentation discusses the application of the method for characterizing the target layer of the Heletz injection experiment, in terms of the data, model analysis and comparison of the results to those from core samples.

Tsang, C. F. and C. Doughty, Multirate flowing fluid electric conductivity logging method, Water Resources Research, 39, 12, 1354-1362 (10.1029/2003WR002308), 2003.

Doughty, C., C.-F. Tsang, K. Hatanaka, S. Yabuuchi, and H. Kurikami. Application of direct-fitting, mass integral, and multirate methods to analysis of flowing fluid electric conductivity logs from Horonobe, Japan, Water Resour. Res., Vol. 44, doi:10.1029/2007WR006441, 2008.