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Analysis of Wellbore Integrity using DTS Monitoring and Numerical Modelling in the Practice of ATES

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Abstract

Surplus heat as stored in an ATES (Aquifer Thermal Energy Storage) system in summer could partly meet the increasing demand of energy in winter. Better assessment on the wellbore integrity permits sustainable operation of such systems. Therefore, an artesian flow test including alternated outflow- and shut-in stages was conducted in a research well located in Berlin, Germany. In this test, artesian flow of 16.8 ˚ C from Jurassic sand at depths from 220 m to 230 m was produced at 14 ˚ C and at a flow rate of 3.6m³/h from the annular space between the production casing and the anchor casing. The temperature in the near wellbore region was concurrently monitored using the distributed temperature sensing (DTS) techniques with the fiber optical cable as deployed behind the anchor casing. The monitored temperature-depth profiling helped positioning the centralizers deployed along the depth, and revealed the deployment-related micro-annuli in the annular cement. By numerical modelling it is manifested that the micro-annuli as filled with water hindered the heat transition through the annular cement to the rock formation in the artesian flow stages, and enhanced the cooling in the near-wellbore materials in the subsequent shut-in stages, respectively. In addition, it was shown that the artesian flow heated up the near-wellbore region from above a depth of 220m and the heat transferred to the upper wellbore was distributed into the subsurface via heat conduction during the shut-in stages.

Field Test

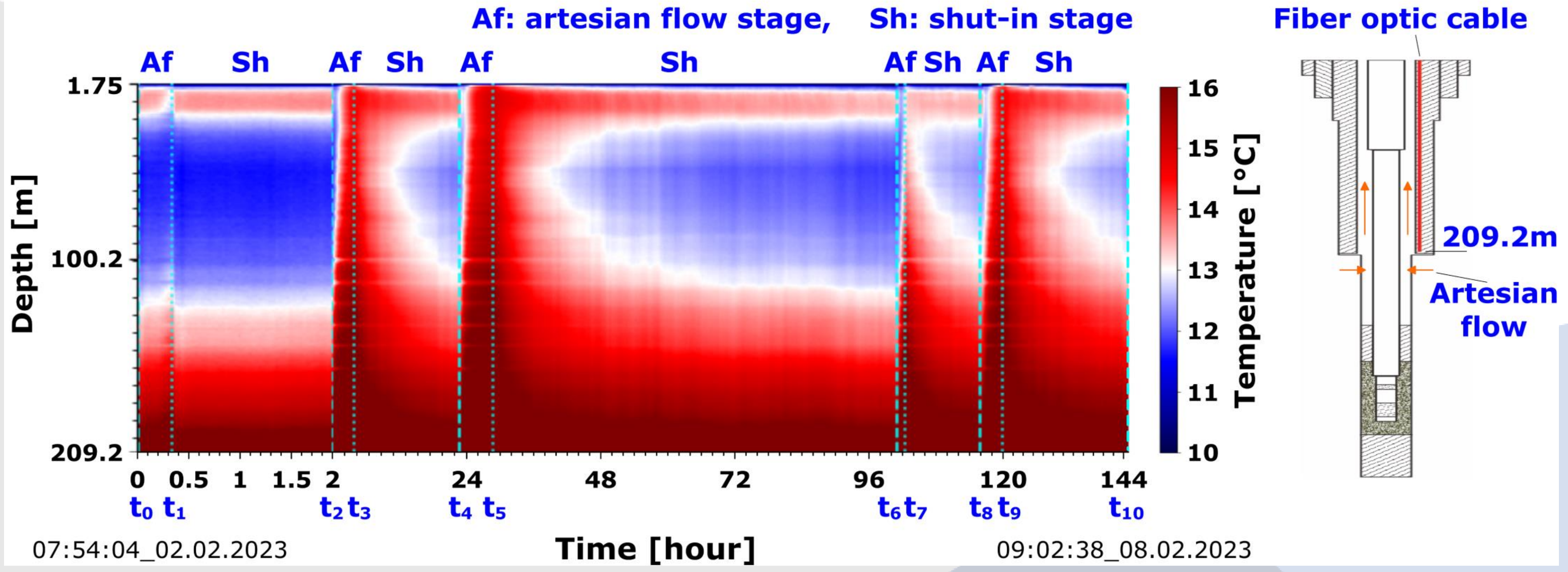
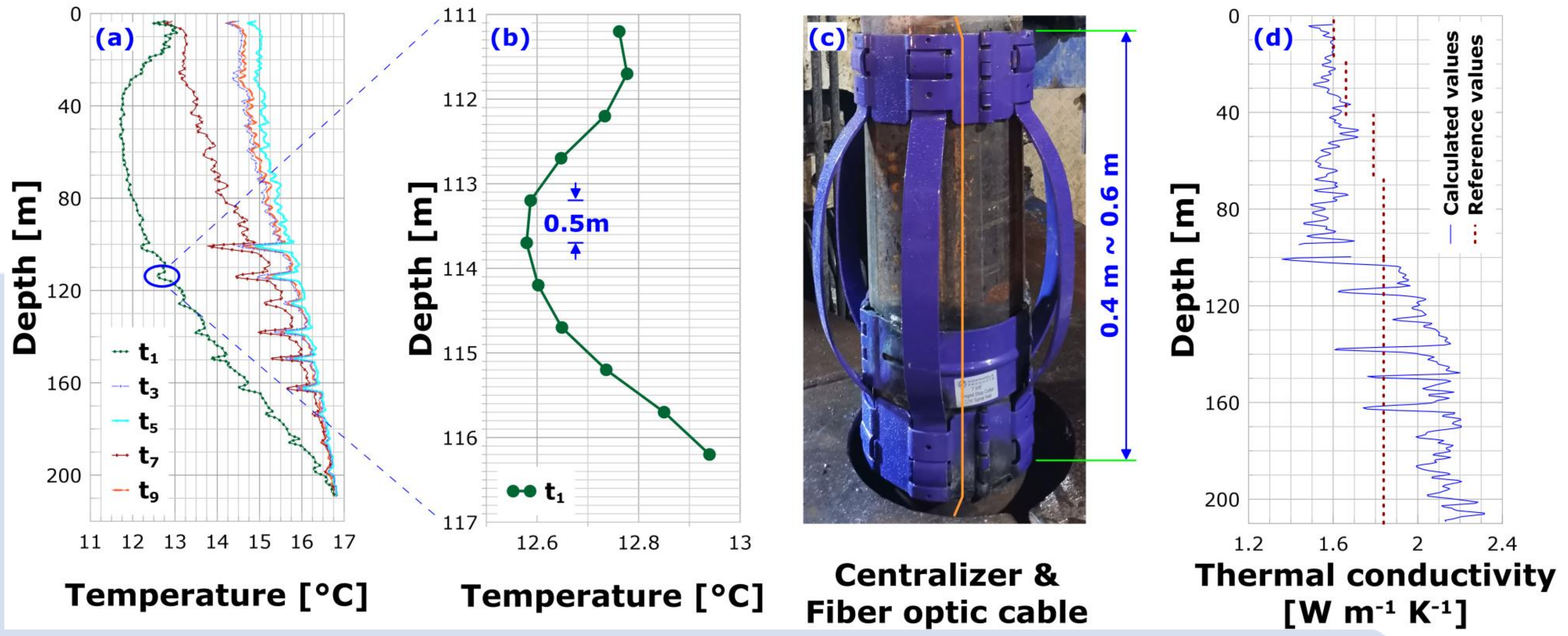


Fig. 1 Temperature profiling in the subsurface as measured using the fiber optic cable deployed behind the anchor casing in a research well in Berlin, Germany during an artesian flow test. t_{0-10} denote studied time instants.

Data Analyses – Effect of Centralizers

Fig. 2 The analyses of DTS data for positioning the centralizers and for evaluating the related influence on the properties of the near-wellbore materials.



Numerical Simulation – Modelled Near-wellbore Domain

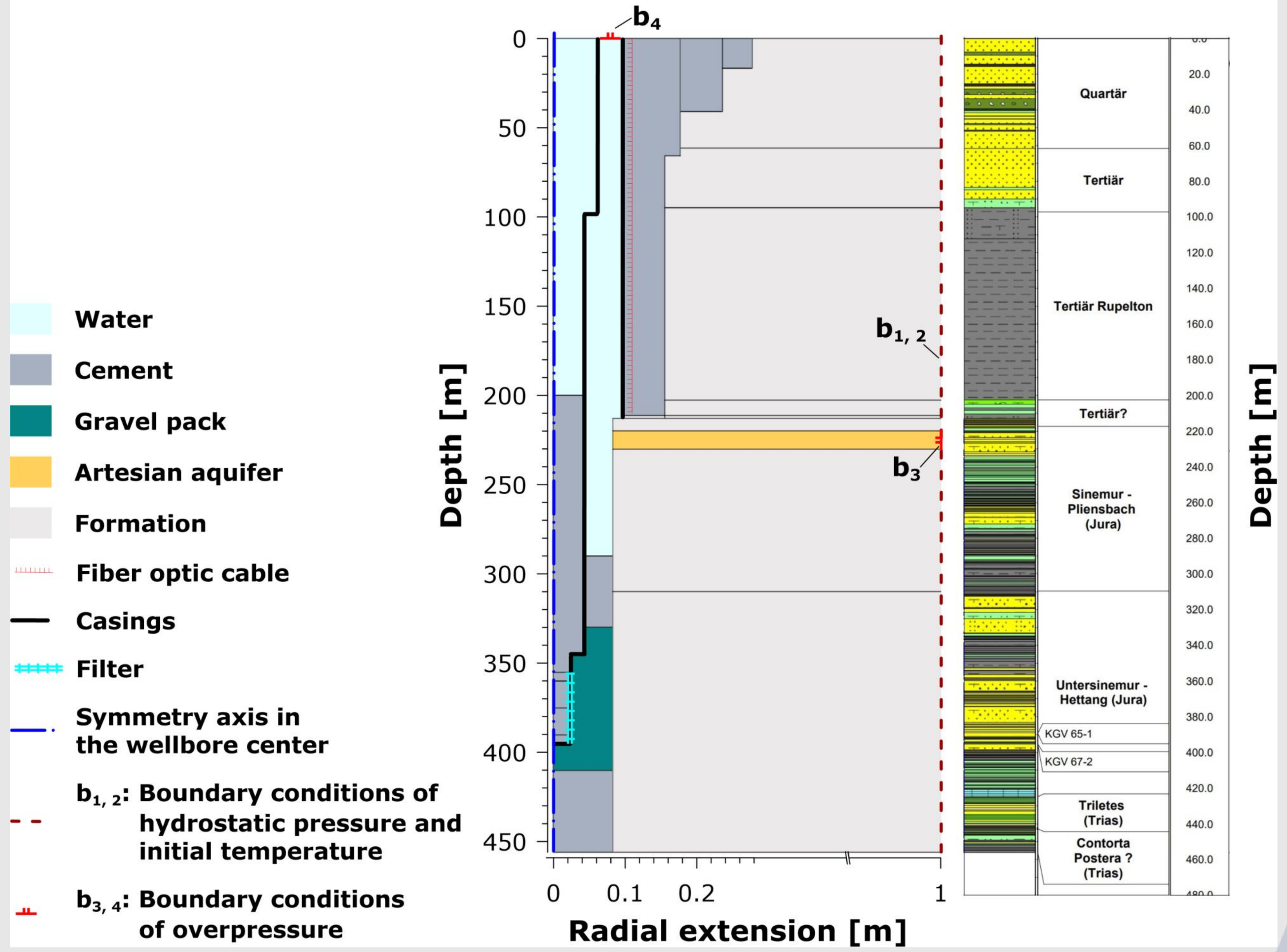


Fig. 3 Schematic diagram showing the modelled near-wellbore domain.

Results – Simulated Temperature Profiling vs. Time

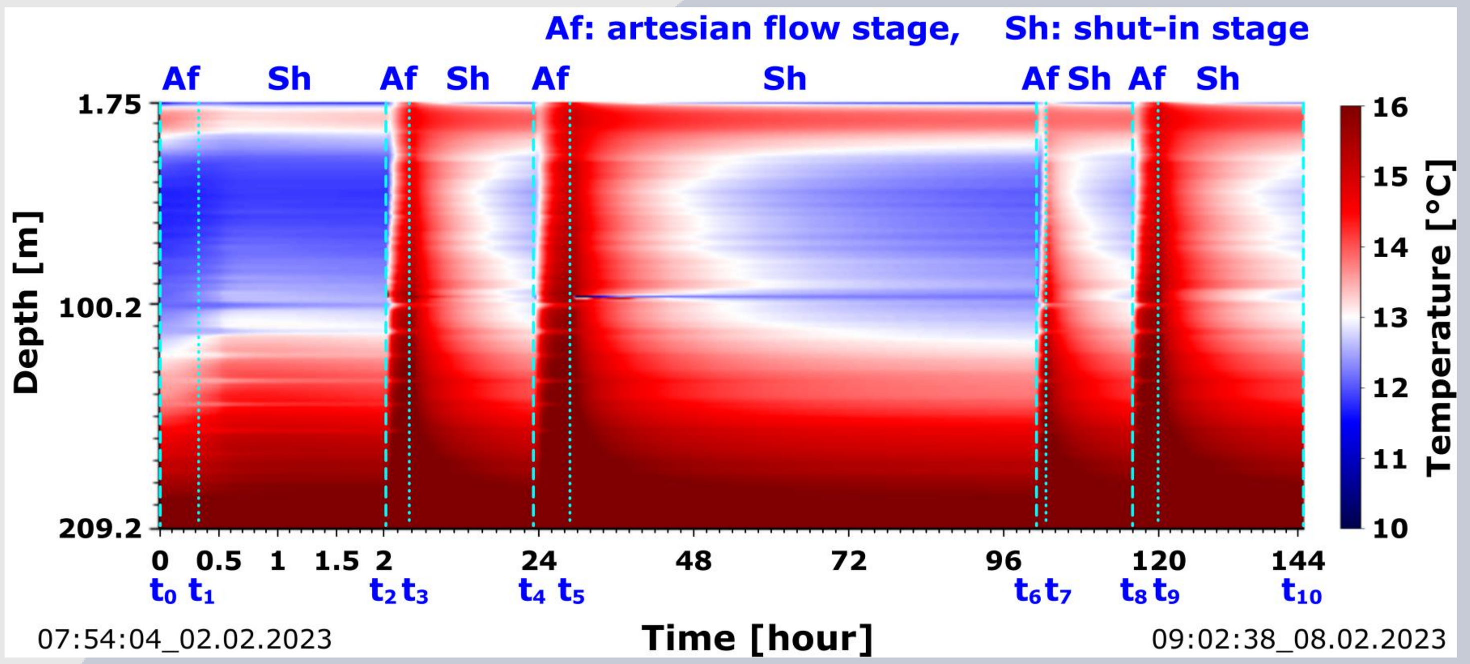


Fig. 4 Numerically simulated temperature profiling in the research well in Berlin, Germany during the artesian flow test.

Results – Simulated Temperature Field at Studied Time Instants

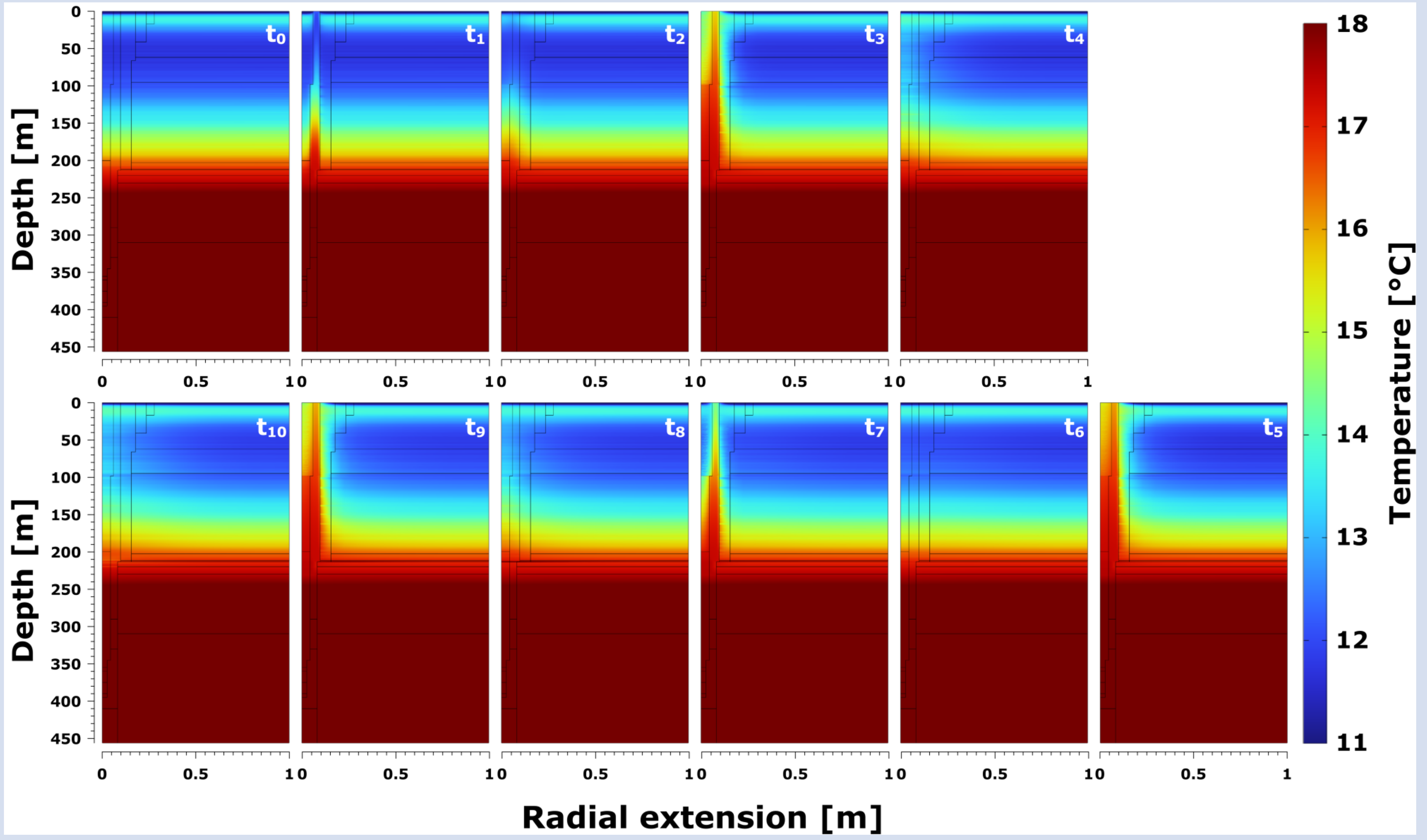


Fig. 5 Diagrams illustrating the near-wellbore temperature field at studied time instants during the artesian flow test.

Validation

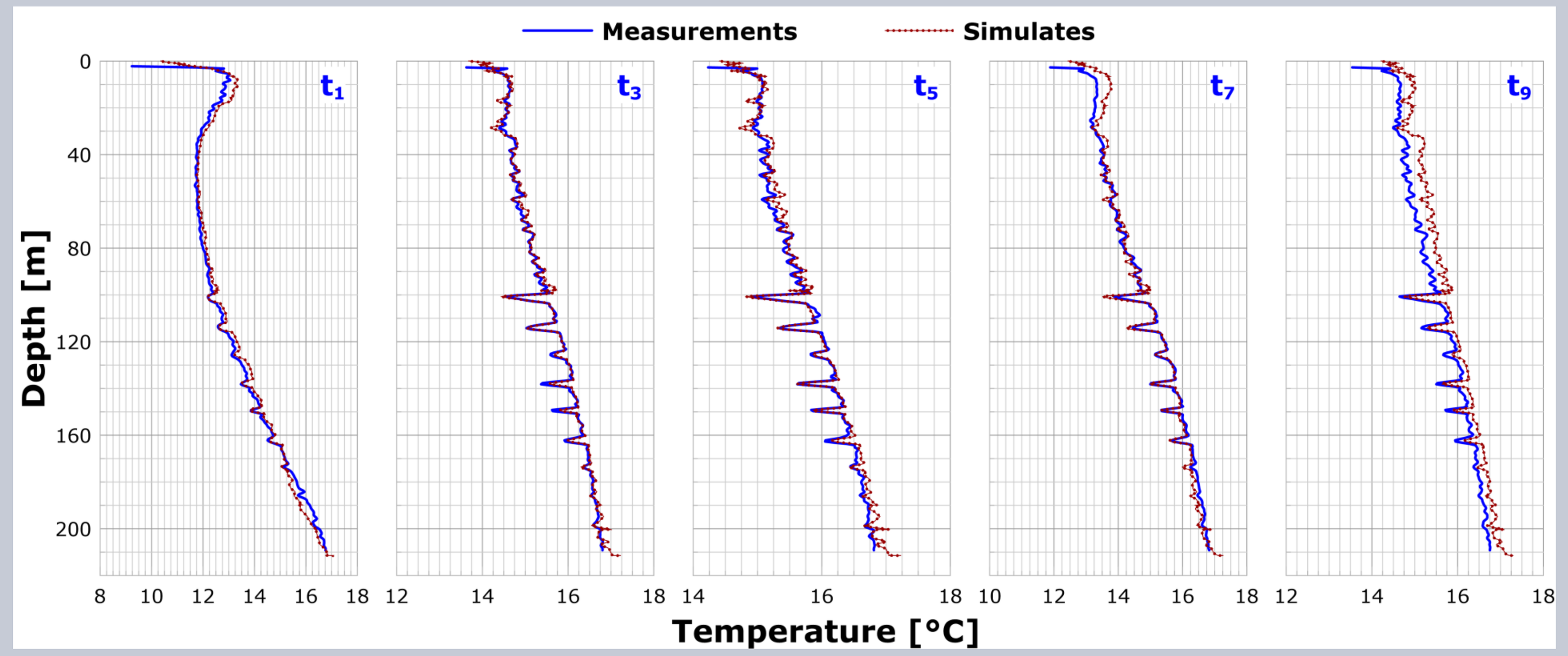


Fig. 6 Comparison of the simulated temperature-depth profiles behind the anchor casing to the DTS-monitored data at studied time instants. The consistence of the simulates to the measurements validated the present developed numerical model.

Conclusion

The DTS-monitored temperature profiling in the near wellbore subsurface permits positioning the centralizers and the deployment-related micro-annuli in the annular cement between the anchor casing and the rock formation. These micro-annuli as filled with water hindered the heat transition from the wellbore to the subsurface. The present developed numerical model is effective in evaluating the geometry of the micro-annuli, and enables the assessment on wellbore integrity.

Acknowledgement

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