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Transport of thermal water from well to thermal baths

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The main problem in building a thermal bath is having a hot spring or a thermal well located in an appropriate position for customer access; since Roman age, thermal baths were distributed in the whole empire and often road and cities were built all around afterwards. Nowadays, the perspectives are changed and occasionally the thermal resource is required to be transported with a pipeline system from the main source to the spa. Nevertheless, the geothermal fluid may show problems of corrosion and scaling during transport.
In the Ambra valley, central Italy, a geothermal well has recently been drilled and it discharges a Ca(Mg)-SO4, CO_2-rich water at the temperature of 41 °C, that could be used for supplying a new spa in the surrounding areas of the well itself. The main problem is that the producing well is located in a forest tree ca. 4 km far away from the nearest structure suitable to host the thermal bath.
In this study, we illustrate the pipeline design from the producing well to the spa, constraining the physical and geochemical parameters to reduce scaling and corrosion phenomena. The starting point is the thermal well that has a flow rate ranging from 22 up to 25 L/sec. The thermal fluid is heavily precipitating calcite (50-100 ton/month) due to the calcite-CO_2 equilibrium in the reservoir, where a partial pressure of 11 bar of CO_2 is present. One of the most vexing problems in investigating scaling processed during the fluid transport in the pipeline is that there is not a proper software package for multiphase fluid flow in pipes characterized by such a complex chemistry. As a consequence, we used a modified TOUGHREACT with Pitzer database, arranged to use Darcy-Weisbach equation, and applying "fictitious" material properties in order to give the proper y- z- velocity profile in comparison to the analytical solution for laminar fluid flow in pipes.
This investigation gave as a result the lowest CO_2 partial pressure to be kept in the pipeline (nearly 2.5 bar) to avoid uncontrolled calcite precipitation, and accordingly the pipeline path was designed. Non-linear phenomena that may originate calcite precipitation, such as phase separation and pressure waves, were discussed. The pipeline and the thermal bath are planned to be built next year.