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Topography , aquifer depth and temperature anomalies

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Soil temperatures can be altered by water circulation. We present, in this work, a model simulating some aquifers occurring in South Portugal where thermal gradient values obtained for heat flow density determination range between 22 and 30 degrees per kilometer. However, it is easy to find places where we get temperatures of about 30 Celsius degrees at depths of 100 meters.
The region studied shows a smooth topography due to intensive erosion, but it was affected by alpine and hercinian orogenies. As a result, we have a high topography in depth, with folds and wrinkles that can reach depths of several kilometers. Aquifers existing in this region can reach high depths and return to depths near the surface, but hot springs in the area are scarce. Water temperature raises in depth, and if the speed is high enough we can have high temperatures near the surface, due to water circulation. The ability of the flow system to transmit the fluid depends on topography relief, rock permeability and basal heat flow.
We used a two dimensional 4 km deep and 55 Km wide model. As a boundary condition at the surface we used a medium temperature value of 15˚C for the region. At lateral boundaries we considered no horizontal heat flow. At the lower boundary we used a vertical heat flow of 60 mW / m2. We did not consider sources or sinks of heat or fluid in the model. Two dimensional velocity vectors were used in the model except in the lower boundary where we considered null vertical components of fluid velocity.
The equations used are those from fluid movement in stationary regime and heat transfer by conduction and advection in a saturated medium, with liquid fluid. We considered that fractures in the medium can be simulated by an equivalent porous medium. Thermal conductivity values for the water and the rocks can vary in space and with the temperature. Porosities used have high values in the region of the aquifer, low values in the lower region of the model and intermediate values in the upper regions. A fixed value for specific heat capacity of water was used. For water viscosity and density we considered a dependence on temperature.
The results obtained show that temperature anomaly values depend on water ascending velocity, and on the depth of the aquifer. The anomaly can be detected above the aquifer originating anomalous thermal gradient values which can indicate the depth of the aquifer.