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Printed Circuit Boards with Integrated Heat Carrier Channels for Deep Geothermal Resources

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The exploration of deep geothermal resources is still very expensive. A large amount of these costs is caused by the drilling process. The high price results from a high failure risk, slow drilling progress and a large amount of manual work. To develop deep heat mining to a sizeable contribution to the European energy portfolio, the exploration process has to become a lot cheaper. One step to achieve lower costs is to monitor and automate the drilling process. Therefore, electronic components such as sensors and data processing units must be integrated into the Bottom Hole Assembly (BHA).

The integration of electronics into the BHA faces the challenge of high ambient temperatures. The project "Packaging of Electronic Components for High Temperature Applications" within the "Geothermal Energy and High Performance-Drilling Collaborative Research Program (gebo)" develops a system of heat carrier channels integrated in printed circuit boards (PCB). These channels can be perfused with fluids such as water, oil or gas and provide high heat convection rates. Such PCBs will be able to withstand high ambient temperatures up to 250 °C.

We have simulated, manufactured and are currently testing prototype boards with integrated heat carrier channels featuring a thickness of only 1.6 mm. As a simulation scenario, we chose a board measuring 25 mm x 100 mm, dimensions suitable for integration into a BHA. An ambient temperature of 250 °C was used. The simulation results presented in this contribution illustrate that cooling of the whole board as well as cooling of hotspots is possible. The cooling channel layout being the key for high convection rates was meticulously studied and optimized. Parameters such as necessary flow rate and fluid pressure were adjusted accordingly. Preliminary experiments validate the demonstrated and discussed simulation results.

With the proposed cooling system, it is possible to integrate microelectronic components into the BHA for drilling applications in hot rock. Sensors and data processing units for measurement and logging can be used while drilling, thus providing a better data source for automation, navigation and planning. This will help to optimize drilling costs and to minimize failure risks.