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A transient divided-bar method for simultaneous measurements of thermal conductivity and thermal diffusivity

Thue S. Bording, Søren B. Nielsen, and Niels Balling

Department of Geoscience, Aarhus University, Aarhus, Denmark (niels.balling@geo.au.dk)

Accurate information on thermal conductivity and thermal diffusivity of materials is of central importance in relation to geoscience and engineering problems involving the transfer of heat. Within the geosciences, this applies to all aspects regarding the determination of terrestrial heat flow and subsurface temperature modelling. Several methods, including the classical divided-bar technique, are available for laboratory measurements of thermal conductivity, and much fewer for thermal diffusivity. We have generalized the divided-bar technique to the transient case, in which thermal conductivity and volumetric heat capacity, and thereby also thermal diffusivity, are measured simultaneously. As the density of samples is easily determined independently, specific heat capacity may also be determined. Finite element formulation provides a flexible forward solution for heat transfer across the bar and thermal properties are estimated by inverse Monte Carlo modelling. This methodology enables a proper quantification of experimental uncertainties on measured thermal properties.

The developed methodology was applied to laboratory measurements of various materials, including a standard ceramic material and different rock samples, and measuring results were compared with results applying traditional steady-state divided-bar and an independent line-source method. All measurements show highly consistent results and with excellent reproducibility and high accuracy. For conductivity, uncertainty is typically 1-3 %, and for diffusivity uncertainty may be reduced to about 3-5 %. The main uncertainty originates from the presence of thermal contact resistance associated with the internal interfaces of the bar. They are not resolved during inversion, and it is highly important that they are minimized by careful sample preparation.