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A numerical model for steady-state temperature distributions in solid-medium high-pressure cell assemblies

JOHN HERNLUND,[1,2] KURT LEINENWEBER,[3,*] DARREN LOCKE,[1,4] AND JAMES A. TYBURCZY[1]

[1]Department of Geological Sciences, Arizona State University, Tempe, Arizona 85287-1404, U.S.A.
[2]Current address: Department of Earth and Space Sciences, University of California, Los Angeles, Los Angeles, California 90095-1567, U.S.A.
[3]Department of Chemistry and Biochemistry, Arizona State University, Tempe, Arizona 85287-1404, U.S.A.
[4]Current Address: Mineral Physics Institute, Stony Brook University, Earth and Space Sciences Building 255, Stony Brook, New York 11794-2100, U.S.A.

ABSTRACT

We present a numerical model for calculating the temperature distribution inside resistance-heated high-pressure solid-medium axi-symmetric cell assemblies that incorporates both composition- and temperature-dependent thermal conductivity. The code was validated using both analytic solutions of simplified thermal diffusion problems and comparisons to actual laboratory experiments and was found to be reliable in matching the temperature characteristics of multi-anvil experiments. Calculations for various cell assembly designs resulted in temperature fields that are consistent with experimental measurements of thermal gradients. These calculations also illustrated the influence of temperature-dependence of thermal conductivity, an important and often-overlooked property, on the thermal profiles. This model may be used to fine-tune the design of cell assemblies, either to minimize thermal gradients or to produce a desired temperature distribution. The four "typical" multi-anvil cells that we used to demonstrate this technique have temperature profiles across the sample that range from 25 to 75 °C when the thermocouple temperature is 1200 °C. The thermocouple in all four is in a region where the temperature gradient is on the order of 100 °C per millimeter, which could lead to experimental temperature uncertainties that are correlated with the thermocouple location.

Keywords: Multi-anvil, high pressure, thermal gradients, temperature, numerical modeling