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New controlled rapid quench technique in a 1 atm infrared image furnace

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ABSTRACT

We describe a new quench technique that allows for controlled and reproducible constant quench rates exceeding 100 °C/s in the temperature range of 1400–700 °C and ~10 °C/s in the range 1400–200 °C at 1 atm total pressure. Our technique uses a 1 atm infrared image furnace and a blower unit capable of discharging cooling air through the infrared furnace at speeds approaching 100 m/s. The control protocol consists of operating the furnace at a constant power setting, sufficient to reach the highest desired temperature, and modulating the blower output continuously; blower output is controlled via a silicon-controlled rectifier (SCR) using a proportional-integral-derivative (PID) algorithm on a personal computer (PC). A special autotuning procedure was used that enables the fine-tuning of PID parameters necessary for precise temperature control. Temperatures are controlled to ±1 °C over the entire temperature range under isothermal conditions and to within 10 °C of the setpoint during quench. The range of accessible quench rates using our technique opens up new temperature-time paths for quantitative study. Potential applications include detailed studies on chemical diffusion and the kinetics of bubble and crystal formation under conditions of rapid temperature changes. Such studies have direct relevance to the crystallization, degassing, and structural relaxation of silicate melts during rapid temperature changes such as those encountered during volcanic eruptions.