

MEASUREMENT OF POST-SHOCK TEMPERATURES IN SILICATES, Susan A. Raikes and Thomas J. Ahrens, Seismological Laboratory, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125.

Residual brightness temperatures in samples of quartz, forsterite, and Bamble bronzite, shocked to pressures in the range 5-30 GPa (50-300 kbar) have been measured using a recently developed experimental technique. Initial results, based on the assumption that the shocked samples radiate as black bodies, indicate that temperatures are higher than would be calculated using theories based on the hydrodynamic irreversible work model.

The experimental apparatus is illustrated schematically in Figure 1; the experimental technique, and its application to aluminum and stainless steel, is described in detail in Raikes and Ahrens [1]. Briefly, a known shock state, determined using the impedance match method, is produced in a sample by the impact of a gun-launched flyer-plate. The back (free) surface of the sample is monitored by an infrared radiation detector whose amplified output is recorded by an oscilloscope, triggered by the impact of the projectile with the shorting target, writing at 5 μ s/div. Initial experiments were performed using a filtered InSb detector, rise time ~ 0.5 μ s, operating in the wavelength band 4.5-5.75 μ , and temperatures determined assuming that the silicate behaved as a black body. This is a reasonable assumption for quartz [2]; any corrections necessary for the other materials will be determined by measurements of their emissivities, which are now in progress. In addition, non-black body effects and possible emissivity changes under shock are currently being investigated by the use of a second detector, HgCdTe, operating in the band 7-13 μ , to determine further brightness temperatures and also two-color temperatures (see, e.g. [3]). (This band includes the silicate absorption peak at ~ 9 μ .)

The records of detector output are extremely reproducible. In the silicates they show, typically, a sharp peak at approximately the arrival time of the shock wave at the free surface, followed by rapid decay to a constant level taken to represent the residual temperature. Temperatures determined for quartz (natural single crystal, cut \perp c-axis), forsterite (synthetic single crystal, cut \perp c-axis), and Bamble bronzite are plotted in Figure 2. The origin of the peak is not clearly understood; it may be related to triboluminescence [4] or perhaps to the shock temperature. Also shown in Figure 2a) are Wackerle's [5] calculated values for shock and post-shock temperatures, corrected for an initial temperature of 23°C. Since these were calculated using the equilibrium Hugoniot, assuming hydrodynamic conditions, and do not include the effects of the Hugoniot elastic limit, or the properties of the high pressure phase, the closeness of the values is surprising. Similar calculations for forsterite and enstatite yield temperatures substantially lower than those measured.

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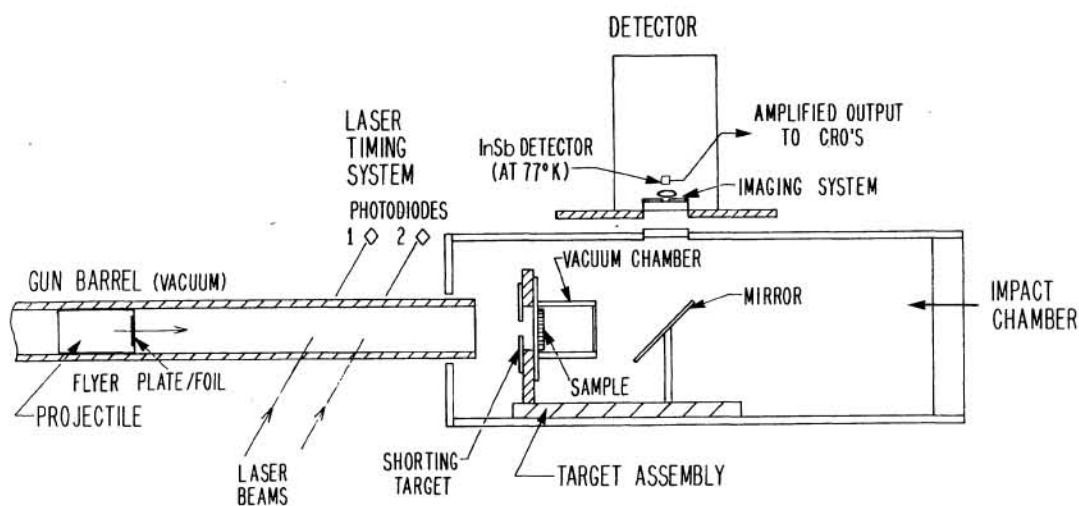


Figure 1. Schematic diagram of experimental apparatus.

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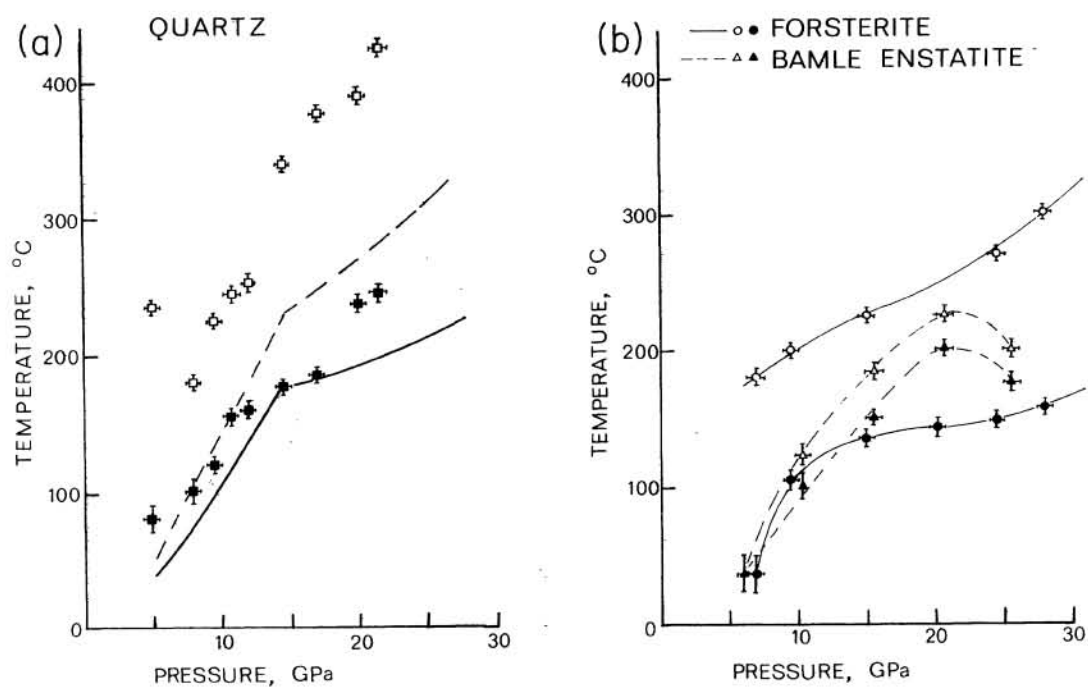


Figure 2. Measured values of post-shock temperatures. Open symbols indicate the peak value, and closed symbols the residual temperature.

- a) Values for quartz. Also shown are Wackerle's calculated values for shock (dashed line) and post-shock (solid line) temperatures.
- b) Values for forsterite and Bamble enstatite (bronzite).