REASSESSMENT OF THE QUARTZ M-ANEOS EQUATION OF STATE. K. M. Amodeo[1], E. J. Davies[1], D. K. Spaulding[1], S. T. Stewart[1], [1]University of California, Davis (kamodeo@ucdavis.edu).

Introduction: Planetary formation and evolution involve high energy impacts, melting and vaporizing surface material [1, 2]. Though not common in primitive material, SiO_2 can be found on the surfaces of differentiated bodies (e.g. Earth and Mars [3]) and can reasonably be used as an endmember case to determine general silicate behavior.

Reassessing and further developing the equation of state (EOS) for quartz is beneficial not only for the applied cases of impact models but also for use as a reference material. In shock experiments, quartz is often used to assess the temperature of other materials: these temperatures are therefore only as reliable as their reference.

Recently, M-ANEOS development has been successful with forsterite [4], reassessing the EOS model through comparison to observed temperatures. M-ANEOS [5] is an EOS model frequently used in the planetary science community spanning a significant range of temperatures and pressures achievable in natural impact events, but has limitations, especially regarding heat capacity.

The heat capacities used in M-ANEOS are appropriate for the solid phase, reaching the classical *3nR* Dulong-Petit limit; but, for example, in cases where melting and vaporization of material are fundamental processes, this limit is not appropriate. Figure 1 shows an example of the discrepancy between the M-ANEOS and experimentally determined [6] Hugoniot and vapor dome for quartz. Definition of the vapor dome is critical when determining final states of material, thus these differences will produce significant variability in the interpretation of planetary impact models.

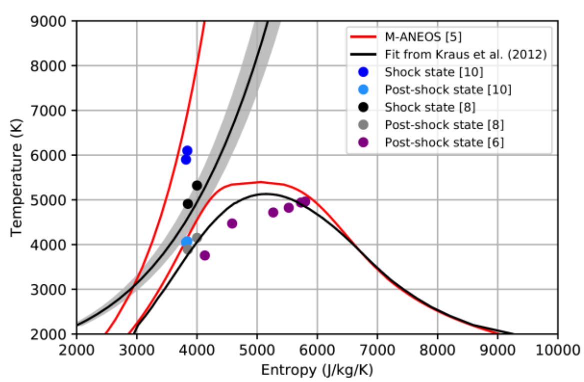

Figure 1. Plot of the Hugoniot and vapor dome for quartz from M-ANEOS (red line) and Kraus et al. (black line) with a 4% error region in gray. The blue shock and post-shock temperatures [10] compared to the purple temperatures [6] and black temperatures [8] illustrate the discrepancies between previously measured values, Notably, quartz melts around 4500 K, possibly contributing to the offset between these data.

Quartz reference temperatures: Some commonly referenced quartz temperature measurements have been made using gas guns [7, 8] and laser-driven shock experiments [9]. However, there is disagreement between these data sets for the location and temperature of super-heating quartz at the melting curve along the principal Hugoniot. More data is needed to explore the region experiencing super-heating and melting, especially to determine entropy from measured temperature.

A similar pressure range (~100-130 GPa) have been and are being explored using light gas gun experiments and multiple, broadband pyrometry systems to ensure self-consistent temperatures. These temperatures are then compared to M-ANEOS temperatures, ensuring better correspondence between modeled and observed temperatures.

Independent confirmation of these reference temperatures will ensure the most accurate observations will be used to improve quartz M- ANEOS model. Additionally, this study is employing an improved pyrometry system, determining temperature from multiple sources across a wide wavelength range.

Methods: Shock data were collected on the 80/25-mm two-stage light gas gun in UC Davis's Shock Compression Laboratory. This facility is capable of generating high-precision, planar shock waves through geologic materials at impact velocities of ~7 km s^{-1} (around 130 GPa in silica). Specialized diagnostic equipment permits measurement of velocity (hence pressure) as well as shock and post-shock temperature [11].

Samples were ~3 mm z-cut α-quartz. Experiments were performed both in and out of secondary vacuum capsules; Figure 2 shows a simple schematic of the experiment set up with a secondary vacuum capsule.

Temperature is measured using two distinct pyrometry systems. The first consists of four near-infrared (NIR) (1.8, 2.3, 3.5, and 4.8 μm) and two visible (615 and 850 nm) detectors. The second is a streaked visible spectroscopy (SVS) system covering a broad, continuous spectrum of visible wavelengths from 350 to 850 nm. The combination of these systems' wavelength range allows for better confirmation of temperatures through greybody fits from a few hundred to several thousand K.

M-ANEOS improvements follow those described in [4], including a new user-defined specific heat capacity, adjusted to correspond to available data. The original heat capacity used by M-ANEOS is $3N_0kT$, but there is a new term included to allow for adjustment to this term: $3f_{cv}N_0kT$. This term can be changed to matched observations or, if desired, can be set equal to 1, maintaining the initial heat capacity value.

Results: We performed shock temperature measurements on the principal Hugoniot of α-quartz and post-shock release. Preliminary results show relatively good agreements between the quartz references and values from this study. The pyrometry systems agree within error on shock and post shock temperatures and show good agreement when fit to an ideal greybody. However, wavelength-dependent absorption and reflectivity corrections are in progress. Further work will be done on assessment of peak pressures and temperatures as well as the implementation of these observations into the M-ANEOS model.

Conclusion: Quartz M-ANEOS improvements have a number of useful applications including better reference temperatures for shocked materials and calculated values for modeling planetary formation and evolution.

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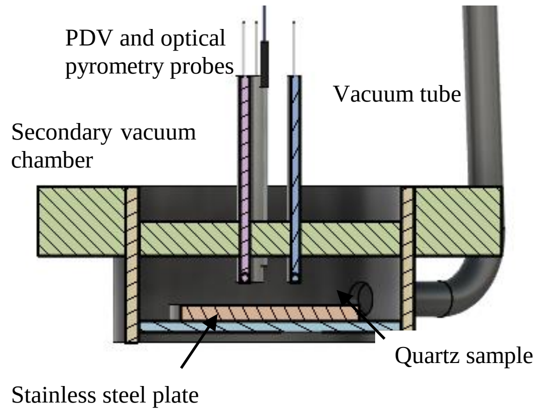

Figure 2. Schematic of a quartz shot in a secondary vacuum chamber. The sample is shocked through an impact of two stainless steel plates. Shock velocity is measured in the quartz using three PDV fiber optic probes. An additional optical probe is observing the sample's radiance, which is then measured on the NIR, visible and SVS pyrometry systems.