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High-Low Quartz Inversion: Determination to 35 Kilobars

LEWIS H. COHEN

Department of Geological Sciences, University of California
Riverside, California 92502

WILLIAM KLEMENT, JR.[1]

Department of Physics, University of California
Berkeley, California 94720

The high–low quartz inversion has been determined over the range 6 to 35 kb by means of differential thermal analysis in piston-cylinder apparatus, with chromel-alumel, Platinel II, and Pt versus Pt + 10% Rh thermocouples. The transition temperature initially rises at the rate of ~26 deg kb^{-1}; the curvature, $-d^2T/dp^2$, is less than ~0.4 deg kb^{-2}, in contrast with the reports of Gibson and of Yoder for the inversion at lower pressures. Comparison with selected data for the quartz-coesite transition suggests an intersection with the high-low quartz inversion near ~1400°C and ~37 kb. The several thermodynamic constraints involved if the inversion is first order (and this is not established at present) are discussed in the context of the present results.

Introduction. The many zero pressure investigations of the high–low quartz inversion and the associated physical properties have made this transition a classic problem. Further understanding of this geologically and technologically important material requires determination of its properties at elevated pressures, as well as at zero pressure. Because of the importance of the problem and the desire to examine further the thermodynamics of the inversion, an attempt was made to extend the determination of the inversion to higher pressures and to sort out the diverging data of *Gibson* [1928] and *Yoder* [1950]. This paper reports an investigation of the transition in the range 6 to 35 kb by differential thermal analysis (DTA) with three different types of thermocouples. There is an uncertainty in the accurate location of the phase boundary because of the lack of reliable corrections for the effects of pressure on thermocouple emf. Nevertheless, the concordance of the present results, obtained with the several thermocouples, is sufficient for using these data in a detailed discussion of the thermodynamics of the transition.

Experiments and results. Pressure was generated in a piston-cylinder apparatus, with a furnace design similar to that described by *Klement et al.* [1966]. Single-crystal specimens were cut from the sample of natural quartz used by *Kennedy et al.* [1962]. For each experiment two crystals, 4.6 mm in diameter and ~0.7 mm thick, were placed together in the plane normal to the furnace axis. A butt-welded thermocouple junction (0.3 mm wire) was positioned between the crystals in a groove ~0.5 mm wide. The reference junction was separated from the butt-weld by the crystal thickness plus ~0.4 mm of talc. Sleeves of boron nitride or alsimag insulated the thermocouple-sample assembly from the graphite heater. Talc or boron nitride was used in the rest of the furnace.

The temperature difference across the sample (i.e., between the thermocouples) was only several degrees, for constant power input, over the entire experimental range. Temperature was varied at rates of ~2 to 20 deg sec^{-1}. DTA signals appeared to be much the same as those observed for melting and solid-solid first-order transitions [*Cohen et al.*, 1966*a*]. Reproducibilities of ±2° were frequently obtained in a given run for both heating and cooling signals; no systematic differences in the temperatures of the signals on heating or cooling were observed.

Accurate knowledge of pressure requires pre-

[1] Now at Department of Engineering, University of California, Los Angeles, California 90024.