Effect of Pressure and Temperature on the Reversal Transitions of Stishovite

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INTRODUCTION

Stishovite (SiO_2) was first synthesized by Stishov and Popova (1961) in the region of 1200-1400 °C and approximately 160-180 kbars. Following this accomplishment, Chao, Fahey, Littler, and Milton (1962) detected stishovite in the coesite extracted from the impacted sandstone at Meteor Crater, Arizona. The latter authors, taking note of the conditions for synthesis, indicated that the presence of stishovite in the sandstone could only have been the result of meteoritic impact.

The synthesis has since been repeated by other researchers and the crystal system has been determined to be tetragonal (Chao, et al. 1962) with a rutile structure (Stishov and Belov 1962). This is the only known example of a structure with silicon in 6-fold coordination with oxygen. As expected, it is the densest form of silica with a specific gravity of 4.28 (Chao, et al. 1962) and a correspondingly high mean refractive index of 1.806 (Skinner and Fahey 1963).

The other polymorphs of interest in this study are coesite, quartz, and a short range order (SRO) transitional phase, all of which have Si in 4-fold coordination with oxygen and appear in the phase diagram as indicated in Figure 1. The SRO phase is not included because it is a metastable disordered material that may be formed during transitions. It has properties similar to those of silica glass (Dachille and Roy 1962 a; Skinner and Fahey 1963).

The temperature dependence of the reversal transitions of stishovite to the lower pressure polymorphs has been recorded by various authors. Stishov and Popova (1961) reported the conversion of synthetic stishovite to cristobalite at 900 °C and 1 atm. Dachille, Zeto and Roy (1963) noted the formation of a SRO phase as low as 350 °C at 1 atm. and of cristobalite and quartz above 1100 °C at 1 atm. A study of the effect of temperature on natural stishovite was also made

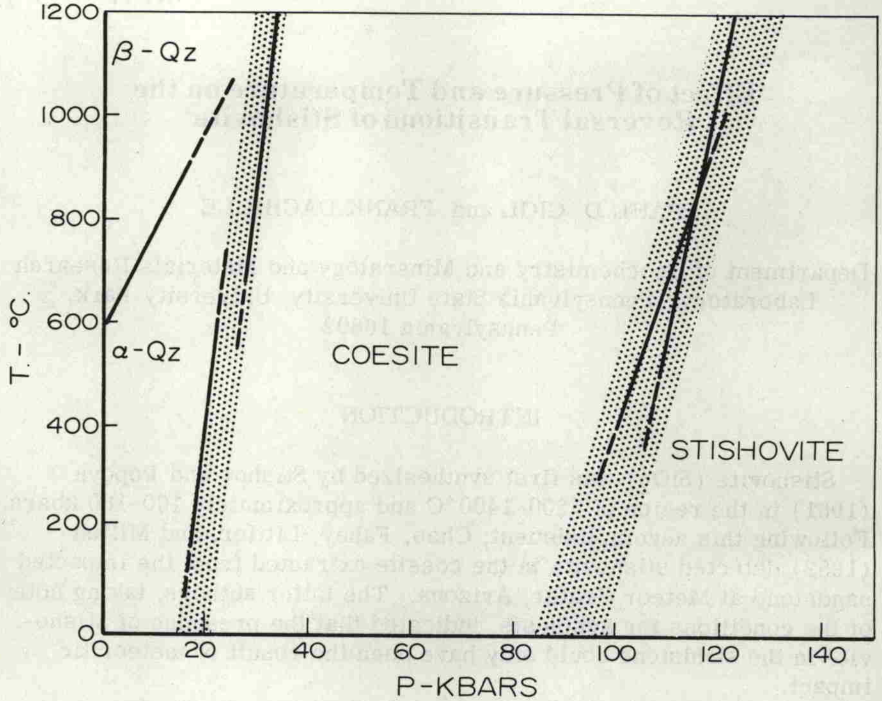

FIGURE 1—P-t diagram of silica system with representative phase boundaries. α-β quartz boundary by Yoder (1950). Quartz-Coesite boundary (lower temperature) by Dachille and Roy (1959a) and the other by Boyd and England (1960). Coesite-stishovite boundary (lower temperature) by Ostrovsky (1966) and the other by Stishov and Popova (1963).

by Skinner and Fahey (1963). The inversion rate to silica glass (SRO phase as used in this paper) was determined at various temperatures and a model for nucleation and growth was postulated by them.

When considered with regard to theoretical temperature and pressure gradients in the earth, the work concerning the persistence of stishovite gives support to the hypothesis that its presence at the earth's surface could only have been the result of meteoritic impact. This paper explores this thesis further by studying the influence of various pressure-temperature (p-t) conditions on the reversal transitions of stishovite. The parameters of shear stresses and mineralizers were also utilized in a number of experiments.