GENERAL ELECTRIC

Research Laboratory

REPORT NO: RL-1156

THE FORMATION PRESSURE OF COESITE: A New High-Pressure, High-Temperature Crystalline Silica

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August 1954

CLASS 4

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Published by
Research Information Services Section
The Knolls
Schenectady, New York

Abstract: The formation pressure at 600ºC. of Coesite, a new dense crystalline silica, has been determined to be 33,000 ± 1000 atmospheres. A short description of the crystal is given.

THE FORMATION PRESSURE OF COESITE:
A New High-Pressure, High- Temperature Crystalline Silica

H. Tracy Hall

In the spring of 1953, we learned that the Norton Company had prepared a new crystalline silica with a density greater than that of quartz. It was made at a pressure near 35,000 atmospheres in the temperature range 500º-800ºC. On June 24, 1953, the new silica was first prepared in this laboratory. Information on the new was material published July 31, 1953, by L. Coes, Jr., of the Norton Company[1]. Recently, this dense silica has been named "Coesite."

Coesite has several interesting properties. Its density is 3.01 (that of quartz is 2.65). Its refractive index is 2.60, vs a value of 2.54 for quartz. It is unattacked by long boiling in concentrated HF solution.

The external features of the crystal have not hitherto been described. The crystals usually appear as shown at (3) of Fig. 1. They are almost always very thin. The crystal section marked (a) tapers to a razor

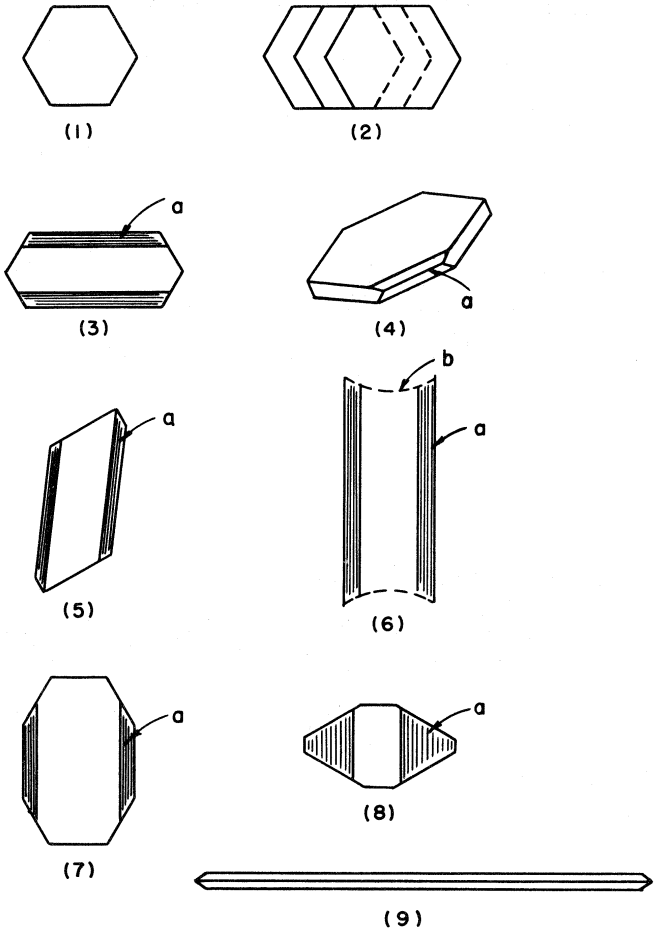

Fig. 1 External features of Coesite crystals.

edge and always appears bright under the microscope. Sometimes (a) cannot be seen and the crystal appears as a very thin hexagon as shown at (1). At times the hexagons are built up in layers as at (2), or they radiate from a point, forming a "bur."

[1] "A New Dense Crystalline Silica," Science, 118, 131-132 (1953).

Occasionally, the ends of the crystal are missing, as at (6). There are also exaggerated distortions such as (8) and (9). The largest crystals grown here are about 2000 m across and appear as at (3).

So far, Coesite has been of most interest in this laboratory as a pressure-calibration material for high-pressure, high-temperature equipment. A quick pressure check can be made by loading the reaction chamber with water glass, and setting the temperature near 600ºC and the press load to just slightly over 33,000 atmospheres. After five minutes at pressure and temperature, the contents are removed and examined under the microscope. If there are myriads of crystals present as at (3) of Fig. 1, the pressure was at least 33,000 atmospheres. If quartz is present, the pressure was less than 33,000 atmospheres. When the pressure is very close to 33, 000 atmospheres, quartz and Coesite may form together. Often, the quartz formed is too fine to be recognized but has been identified by x-ray. The Coesite, however, from scores of runs, has always been large enough to recognize readily at 100X magnification.

The pressure required to form Coesite was determined as follows: The "belt"[2] (with Carboloy pistons and chamber) was employed as the high-pressure, high-temperature apparatus. The pressure developed within the chamber of the "belt" as a function of press load was determined by observing transitions in bismuth, thallium, cesium, and barium (see Reference 2 for details). The calibration plot is

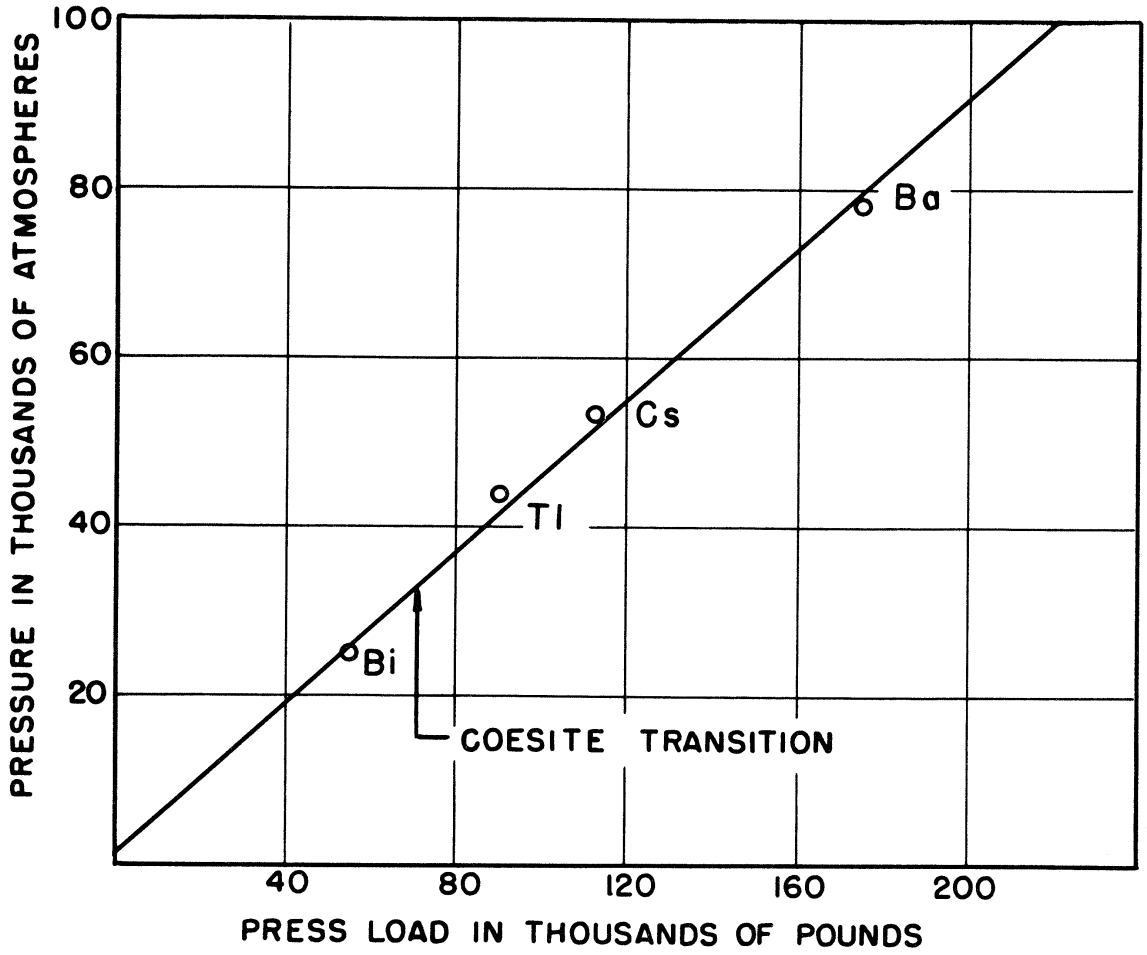

Fig. 2 Pressure calibration for "belt" high-pressure, high-temperature apparatus.

shown in Fig. 2. To make Coesite, the reaction chamber was filled with a viscous solution of water glass. The chamber was brought to pressure and then to temperature at 600ºC (see Reference 2 for temperature

[2] H. T. Hall, "The Belt," Ultra-High-Pressure, High -Temperature Apparatus, G-E Research Lab. Rept. No. RL-1064, March 1954.

calibration). Examination after each run gave the information in Table I. The results indicate that the transition pressure for formation of Coesite only lies somewhere between 70,000 and 71,500 pounds at 600ºC. From Fig. 2, this corresponds to a pressure of about 33,000 ± 1000 atmospheres. Coes' apparatus, which has a top pressure near 45,000 atmospheres, is calibrated on the basis of one point; i.e., the bismuth transition. He gives the Coesite transition pressure as 35,000 ± 2000 atmospheres.

TABLE I

Results of High-Pressure, High- Temperature Runs with Water Glass

Press Load (lb)	Results
63,000	Only quartz and unidentified fibrous bundles present
65,000	About 1 Coesite crystal to 1000 quartz crystals present
68,000	Mostly quartz –some Coesite
70,000	Mostly Coesite—some quartz
71,500	Coesite only
73,500	Coesite only
108,000	Coesite only

In addition to growing Coesite from water glass, the material has been produced by the oxidation of silicon or silicon carbide. The presence of a mineralizing agent such as water or diammonium hydrogen phosphate aids crystal formation. Reaction chambers of tantalum, nickel, graphite and lead (lead is solid at 540ºC and 35,000 atmospheres) have been employed without observable effect on Coesite formation.

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