QUARTZ SPHERE GROWN INTO A FACED CRYSTAL*

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ABSTRACT

A polished quartz sphere, subjected for 12 days to relatively high pressure and temperature in an alkaline solution with additional solid silica present, assumed through growth the morphology of a natural quartz crystal.

The crystal described below was grown from a polished quartz sphere used as a seed during an investigation† into the growing of synthetic quartz crystals by the Brush Development Company, Cleveland, Ohio. The crystal was grown in Run 25-3.

The polished sphere of optically clear quartz about 13.8 mm. in diameter was held near the top of a seven-inch deep autoclave by a silver wire. A quantity of quartzite fragments lay at the bottom under a solution of 3M sodium carbonate. The external temperatures were 376° C. at the top and 397° C. at the bottom, and the calculated pressure was about 700 atmospheres. During the period at the elevated temperature and pressure, the quartz at the bottom presumably dissolved slowly and formed a supersaturated solution in the cooler region at the top.

Similar development of a quartz sphere into a faced crystal was mentioned by Richard Nacken, one-time professor at the University of Frankfurt-am-Main, in a report on the "Synthesis of Oscillator Crystals" to the Nazi Government in 1944. This report was translated by the British Post Office Engineering Department and was made available by the U. S. Signal Corps. The translation is accompanied by a few figures, but those referring to the growth of the sphere are missing. The following is his description of the crystal:

"At points where the poles of the rhombohedral planes *r* $(10\bar{1}1)$ and *z* $(01\bar{1}1)$ of the quartz lie, bright and well-formed faces gradually extend. Along the crystallographic *c*-axis, growth was so rapid in both directions that a skeleton was formed. A basal plane was never observed; rhombohedral faces were always formed in the direction of this axis. Finally these also combine in a vertex bounded by the two rhombohedra, $\{10\bar{1}1\}$ and $\{01\bar{1}1\}$. Toward the equator a number of contiguous rhombohedral faces are formed, which lend a barrel-like appearance to the crystal, with striations parallel to the equatorial plane. . . . Only after a much longer period of crystallization are prism faces also formed."

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† The investigation was carried out under contract with the U. S. Army Signal Corps.

Nacken's sphere was fed from vitreous silica, which he himself determined to be ten times as soluble as crystalline quartz, and increased in weight from 3.3 grams to 5.3 grams in four days.

Our sphere or, more correctly, spheroid, had the following dimensions: 13.48 mm. in the direction of the *c*-axis, 13.76 mm. in the direction of one of the *a* crystal axes, and 13.86 mm. along a direction at right angles to the other two. It increased about 39% in weight, from 3.6 grams to 5.0 grams, during the 12 days. No skeletal growth is shown and the prism faces are about as large as the rhombohedral faces. The latter seem to be of identical dimensions. Under a magnification of thirty-six diameters, several solution-vapor inclusions, are visible just below the surface of the rhombohedral faces.

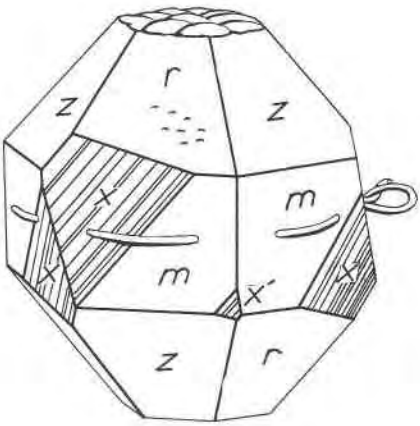

FIG. 1. Quartz crystal grown from sphere.

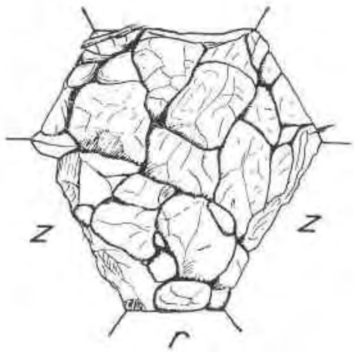

FIG. 2. Surface having the approximate position of the base.

The general appearance of the crystal strongly resembles a Herkimer County quartz crystal from which the apices have been broken (Fig. 1). The overall dimensions are 18 mm. (approximately) along the *c*-axis, 13.86 mm. between parallel prism faces, and 14.60 mm. between parallel rhombohedron faces. The distance between parallel prism faces is almost exactly the same as the equatorial diameter of the initial spheroid.

The forms displayed are the rhombohedrons $r\{10\bar{1}1\}$ and $z\{01\bar{1}1\}$, the prism, $m\{10\bar{1}0\}$, and the trigonal trapezohedron, $x\{51\bar{6}1\}$. The common form *s* is entirely lacking, but on two edges between *r* and *m* faces traces of the rhombohedron $\{20\bar{2}1\}$ are present. The rhombohedrons *r* and *z* are almost equally developed, giving the crystal a pyramidal aspect. Viewed along the extension of the *c*-axis, the nearly equal development of the rhombohedrons and of the six prism faces gives the outline of the crystal almost perfect hexagonal symmetry. The trigonal trapezohedral faces are, however, unequally developed, but their arrangement on the crystal shows it to be a left-hand individual. A single small trigonal trapezohedral face, x', in the twin position indicates twinning according to the Dauphiné law.

The rhombohedron faces display numerous minute imperfections, although they appear on casual inspection to be smooth and plane. Present on all the rhombohedron faces, but differing in size and number, are tiny protuberances. A few of these protuberances display microscopic terminal faces parallel to the rhombohedron upon which they occur, but in most cases they are rounded and featureless. In a few instances, the protuberance is the center of a system of concentric growth lines marking the boundaries of very shallow terraces. A few depressed areas of terrace growth can be seen under the binocular microscope which resemble a contour map of a theater-headed valley. Vicinal faces are common.

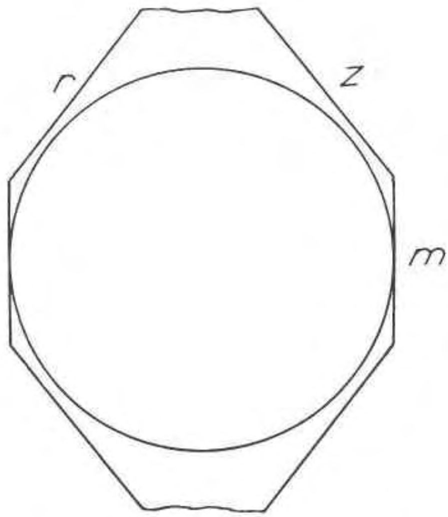

FIG. 3. Cross section of crystal and initial sphere.

The prism faces are essentially plane surfaces, free from the imperfections described above and lacking the usual horizontal striations. The x faces are deeply striated by oscillatory combination with the prism.

All edges and solid angles are sharp and show no skeletal growth, except at the ends of the c-axis. Here growth was incomplete and the rhombohedron faces terminate in a ragged, somewhat cracked and fissured edge bounding a pseudo-basal surface. This surface 4 to 5 mm. in diameter, although complex in detail (see Fig. 2), has in a gross way the position of the base. Examination on the optical goniometer reveals, however, that no trace of a reflecting surface parallel to {0001} exists. The surface is seen to consist instead of rudely rounded hummocks having in places a vague triangular shape parallel to one of the terminating rhombohedrons.

In order that the sphere could be suspended in the autoclave, it was notched at points around its equator so that a single loop of silver wire could hold it in place. New growth has completely filled in the notches, but a series of minute inclusions outline them in places. No such inclusions, however, mark the boundary between the initial spherical surface and the newly added quartz. Inasmuch as the silver wire emerges from the crystal at the center of each prism face, it is reasonable to assume that the prism faces are tangent to the initial sphere and that growth normal to them has been negligible. Moreover, the distance between the three pairs of prism faces is the same, 13.86 mm., equal to the diameter of the sphere.

A consideration of the dimensions of the crystal and of the initial sphere (Fig. 3) shows that growth took place most rapidly in the direction of the *c*-axis and was accomplished by addition of material to the rhombohedral faces. If the experiment had continued longer until the rhombohedral faces met at a point, further growth would undoubtedly have given rise to unequal development of the *r* and *z* forms.

Thanks are due to Dr. T. J. Turobinski who suggested the experiment and furnished the sphere, to Mr. Andrew R. Sobek who carried out the processing, and to Mr. Henry E. Wenden who aided in the crystal drawings.