THE DENSITY OF ROCK SALT AND CALCITE

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Abstract

Crystals as perfect as could be secured were obtained from a variety of sources, and densities were measured by weighing them when suspended in paraffine oil or water respectively. The weights were calibrated and correction was made for the buoyancy of the air. The measurements are accurate to .2 mg cm^{-3} for rock salt and to .1 mg cm^{-3} for calcite. Variations in density were observed between different parts of the same crystal, as well as between different crystals, which are larger than the experimental error. The estimated uncertainty of the mean density is taken as the probable variation of the individual samples from the mean density. The mean result for 7 good crystals of rock salt is 2.1632 ± .0004 gm cm^{-3}, and for 6 crystals of calcite, 2.7102 ± .0004 gm cm^{-3}, at 20°C.

In order to increase the precision of absolute x-ray wave-lengths, we have undertaken the redetermination of the densities of rock salt and calcite. For this purpose we have secured samples as perfect as we could obtain, from a variety of different sources. Some of these were loaned to us by the National Museum at Washington, to whom we wish to express our grateful acknowledgment.

Our experimental method was in its essentials that described by D. C. Miller.[1] The weights used were carefully calibrated, and the weighings were corrected for the buoyancy of the air. The density of calcite was determined by suspension in freshly boiled distilled water, whose density was used as the standard. For rock salt, paraffine oil was used in order not to dissolve the crystal. The density of the oil was compared with that of water through the medium of a plumb bob, which consisted in one set of measurements of fused quartz, in another of Pyrex glass and in a third of a calcite crystal. Because of the comparatively large thermal expansion coefficient of the oil, the density determinations for rock salt were not as precise as those for calcite.

The results of the measurements on nearly perfect crystals are given in the following table. We have not counted measurements on crystals in which serious imperfections were observed. In reducing the results to 0°C, we have taken Benoit's values for the thermal expansion coefficient of calcite[2] as $+0.0000251$ $deg.^{-1}$ parallel with the crystal axis and -0.0000056 $deg.^{-1}$ perpendicular to the axis. It follows that $\rho_0 =$

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[1] D. C. Miller, "Laboratory Physics" (1903) pp. 120-123.

[2] Cf Kaye and Laby, "Physical and Chemical Constants" (1911) p. 53.

$\rho(1+.0000139t)$ where t is the centigrade temperature. Similarly for rock salt,[3] $\rho_0=\rho(1+.0001212\,t)$. The average temperature at which the measurements were made was about 23°.

TABLE I

Densities of rock salt and calcite
I and II refer to two parts of the same crystal.

Rock salt		Calcite	
Origin	Density (0°C)	Origin	Density (0°C)
Michigan I	2.1687	Missouri	2.7114
Michigan II	2.1683	U. S. A.	2.7110
Arizona I	2.1687	Iceland	2.7111
Arizona II	2.1683	Iceland	2.7098*
Germany I	2.1687	Unknown	2.7109
Germany II	2.1676*	Unknown	2.7112
Unknown	2.1687		
Mean	2.1685	Mean	2.7110

* Weighted 1/2 in calculating mean.

In the case of calcite the determinations of the density of the individual samples were made within a probable error of ±.0001 gm cm^{-3}, and for rock salt within ±.0002 gm cm^{-3}. The experiments thus indicate that different samples of apparently perfect crystals vary in density by amounts greater than the experimental error of our measurements. No chemical analysis was attempted to search for possible impurities which might account for these variations. One of the samples of rock salt (Michigan I) was however tested by Mr. C. C. Van Voorhis for occluded water, by melting in an evacuated Pyrex tube and drawing the liberated gases over phosphorous pentoxide. A similar test with no salt present showed that, if any moisture was occluded in the rock salt, it was an amount small compared with that which escaped from the Pyrex container, even though this had previously been baked out at a high temperature.

In view of these variations in density from one part of an apparently perfect crystal to another, we are unable to determine which value represents the true density of a perfect crystal. As an estimate of the probable error in the value of the density we are therefore on safer ground if we choose the probable variation of the density of any individual crystal from the mean value for all crystals. Thus we determine the following densities:

Calcite: $\rho=2.7110\pm.0004$ gm cm^{-3} at 0° C.
$=2.7102\pm.0004$ gm cm^{-3} at 20° C.

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[3] Cf Landolt, Bornstein, Roth, "Tabellen" (1912), p. 336.

Rock salt: $\rho = 2.1685 \pm .0004$ gm cm^{-3} at 0°C.
$= 2.1632 \pm .0004$ gm cm^{-3} at 20°C.

These values are compared with those given by other authorities, in Table II.

TABLE II

Values for the density of calcite and rock salt

	Authority	Date	Density
Calcite	Clarke[4]	1873	2.723
	Schroeder[5]	1874	2.702
	Retgers[6]	1890	2.712
	Dana[7]	1892	2.65 ± .05
	Bragg[8]	1915	2.71
	Compton[9]	1916	2.7116 ± .0004 (at 18°)
	Ledeaux, Lebard and Dauvillier[10]	1919	2.7125 ± .0015
	This determination	1925	2.7102 ± .0004 (at 20°)
Rock salt	Clarke[9]	1873	2.135
	Retgers[11]	1889	2.167 (at 17°)
	Dana[7]	1892	2.15 ± .05
	Krickmeyer[12]	1896	2.174 (at 20°)
	Haigh[13]	1912	2.170 (at 20°)
	Moseley[14]	1913	2.167
	Baxter and Wallace[15]	1916	2.161
	This determination	1925	2.1632 ± .0004 (at 20°)

A calculation of the grating spaces of rock salt and calcite based on this determination of their densities is described elsewhere in this journal.[16]

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[4] Clarke, "Constants of Nature" (1873) v. 1, p. 30.

[5] Schroeder, "Neue Handbuch f. Minerologie" (1874) p. 805.

[6] Retgers, Zeits. Phys. Chem. **6**, 193 (1890).

[7] Dana, "System of Minerology" (1892).

[8] W. H. Bragg and W. L. Bragg, "X-rays and Crystal Structure" (1915) p. 115.

[9] A. H. Compton, Phys. Rev. **7**, 646 (1916). In this measurement no correction was made for the buoyancy of the air. Such a correction makes this value agree well with the present determination.

[10] Ledeaux, Lebard and Dauvillier, Compt. Rend. Nov. 24, 1919. This value is based chiefly on that by A. H. Compton,[9] and is hence also subject to a correction for the buoyancy of the air.

[11] Retgers, Zeits. Phys. Chem. **3**, 289 (1889)

[12] Krickmeyer, Zeits. Phys. Chem., **21**, 53 (1896).

[13] Haigh, J. Am. Chem. Soc. **34**, 1137 (1912)

[14] H. G. J. Moseley, Phil. Mag. **26**, 1024 (1913).

[15] Baxter and Wallace, J. Am. Chem. Soc. **38**, 26 (1916).

[16] A. H. Compton, H. N. Beets and O. K. DeFoe, in this issue, p. 625.