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Memorandum

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Electrical Properties of Salt Cored from Carlsbad, New Mexico

by

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Electrical Properties of Salt Cored from Carlsbad, New Mexico

by Gary R. Olhoeft

The electrical properties of halite salt cored from 786 meters deep in the ERDA #9 corehole at Carlsbad, New Mexico, have been measured at 3 percent relative humidity and a temperature of 295 K over a frequency range from 10 to 10^6 Hz and at DC. The core was cut into four subsamples having a thin disc geometry with a thickness of 1.7 cm and a diameter of 10.6 cm. Measurements were performed on a General Radio 1621 bridge, a Hewlett-Packard 4270A bridge, and a Guildline 9520 teraohmmeter.* The sample holder was a three-terminal brass configuration with a 3.8 cm diameter guarded electrode under an 8.5 kPa uniaxial load. Accuracy of measurements was $\pm$0.65 percent in dielectric permittivity and $\pm$5 percent in resistivity magnitude.

The salt crystals in the core were found, by visible and near-infrared spectroscopy, to have undetectable impurity levels within the crystals (G. Hunt, USGS, oral communication, 1978). However, the cracks and grain boundaries contained large amounts of impurities. Whether these impurities were introduced by the coring process or were previously there is not known. To illustrate the variation of impurity content, Figure 1 is a photograph of the four subsamples on a light table.

Table 1 lists the electrical properties of the four subsamples versus frequency, as well as the calipered bulk density and a ranking of the opacity of the samples. Measurements of single-crystal NaCl by von Hippel (1954, p.302) indicate a dielectric permittivity of 5.90, independent of frequency, and a resistivity of 3×10^{11} ohm-m at 10^2 Hz. Thus, the impurities have significantly altered the electrical properties, as shown in Table 1. As the origin of the impurities is subject to speculation, further conclusions are not possible.

von Hippel, A.R., 1954, Dielectric Materials and Applications: Cambridge, M.I.T. Press, 438 p.

*Manufacturer's names are given for illustrative purposes only and do not imply endorsement or recommendation by the U.S. Geological Survey.

Figure 1

Photograph of the four subsamples on a light table. Subsample -1 is in the upper left corner, -2 in the upper right, -3 in the lower left, and -4 in the lower right.

TABLE 1

ERDA #9 corehole salt from a 786-meter depth, Carlsbad, New Mexico

[3% relative humidity, 295 K temperature, 8.5 kPa uniaxial load]

Frequency	Subsample -1	Subsample -2	Subsample -3	Subsample -4
Real part of the complex resistivity [ohm-m]				
DC	1.57×10^8	3.58×10^7	1.09×10^8	7.92×10^7
10 Hz	5.40×10^6	5.72×10^6	6.75×10^6	1.61×10^6
10^2	7.22×10^5	1.86×10^6	5.16×10^5	5.87×10^5
10^3	1.20×10^5	1.28×10^5	8.27×10^4	8.58×10^4
10^4	3.49×10^4	2.65×10^4	2.43×10^4	1.76×10^4
10^5	6.32×10^3	6.93×10^3	5.86×10^3	5.15×10^3
10^6	5.25×10^2	5.32×10^2	5.43×10^2	6.63×10^2
Real relative dielectric permittivity				
10 Hz	159.9	85.21	132.0	466.3
10^2	91.30	48.28	91.15	147.8
10^3	57.14	37.82	62.38	83.76
10^4	23.55	24.34	31.41	42.26
10^5	11.16	10.73	13.03	16.48
10^6	7.432 (7.652)	7.012 (7.608)	8.312 (8.512)	8.705 (9.319)*
Loss tangent				
10 Hz	1.2464	3.3953	1.1411	1.8633
10^2	0.4365	0.9362	0.2827	0.7664
10^3	0.4630	0.2909	0.3158	0.4997
10^4	0.6510	0.4239	0.5564	0.5286
10^5	0.4820	0.5301	0.5565	0.7131
10^6	0.2285 (0.2318)	0.2175 (0.2266)	0.2694 (0.2724)	0.3639 (0.3754)*
Calipered bulk density [crystallographic density of NaCl = 2.163]				
[kg/dm^3]	2.132	2.076	2.139	2.097
Opacity**	5.4	10.7 (least opaque)	1.0	2.2

*10^6 Hz data normalized to constant density of 2.163 kg/dm^3.

**Opacity number is amount of light coming through sample relative to subsample -3 (most opaque) corrected for sample thicknesses, measured with camera light meter.