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Tables of Room Temperature Electrical Properties for Selected Rocks and Minerals with Dielectric Permittivity Statistics

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Over the last 9 years, the data of this report has been accumulated by the author. Figures 1 through 3 summarize in histograms the statistics of the dielectric permittivity. Table 1 lists the DC electrical conductivity and relative dielectric permittivity with the recommended specific gravity (grain density) of 347 minerals. Table 2 lists the measured dry bulk density, DC electrical conductivity, relative dielectric permittivity and dielectric loss tangent for 372 rocks and minerals.

Figures 1 through 3 illustrate histograms of the density-reduced relative dielectric permittivity according to the formula

$$k_r = k^{1/D}$$

where k_r is the density-reduced relative dielectric permittivity from a relative dielectric permittivity, k, measured at a density of D gm/cm^3. In all three figures, the top box identifies the sample types, the width of the histogram bins for counting purposes ("Div.=" in dimensionless k_r units), the total number of measurements ("No.="), the skewness, mean, standard deviation, mode, and median of the distribution (with these terms defined as in Meyer, 1975). The main plot is the histogram and a smooth line running average over nearest-neighbor bins. The vertical axis is percent of samples in a given bin relative to the total number of samples, and the horizontal axis is the density-reduced relative dielectric permittivity. The inset plot in the upper right corner illustrates the percentage of samples (vertical axis) falling between the mode-x and the mode+x where x is the horizontal axis. Thus, in Figure 1, 90 percent of all lunar samples have a density-reduced relative dielectric permittivity falling between 1.92-0.27 and 1.92+0.27.

Figure 1 represents the statistics of data from lunar sample measurements as published in Olhoeft and Strangway (1975) and Sill and Ward (1977). Figure 2 represents the statistics of the data from Table 1. Figure 3 represents the statistics of the data from Table 2.

It is remarkable that the diverse materials represented in Figures 1 through 3 all have a relative dielectric permittivity that is given roughly by

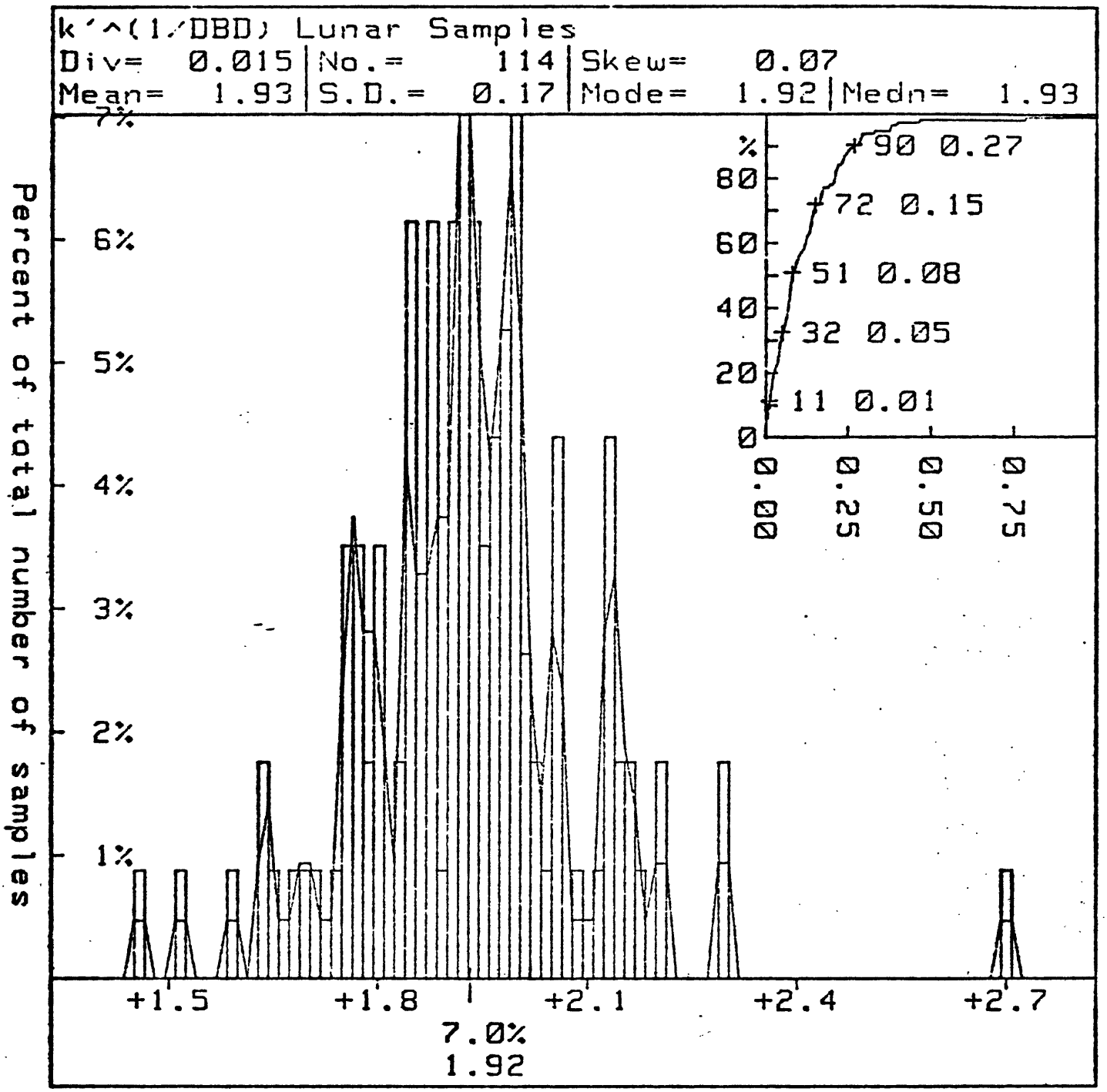
$$k = 2^D$$

where k is the relative dielectric permittivity at a dry bulk density of D gm/cm^3. The notable exceptions are those materials with large amounts of chemically bound or adsorbed water. Water has a density-reduced relative dielectric permittivity of 78 as a liquid and 3.4 as a solid from frequencies of 10^5 Hz to 10^9 Hz.

Most materials fall near a density-reduced relative dielectric permittivity of 2 as the electronic polarization mechanism is the only one of importance with the density of electrons in the material the determining factor. In water, the water molecules and OH redicals are highly polar contributing largely to the dielectric permittivity through the molecular orienation polarization mechanism in addition to electronic polarization. Thus, wet materials and highly hydrated materials (such as montmorillonite clay) strongly reflect this molecular polarization in their dielectric permittivities.

A few other minerals that are highly conducting metallic or semiconducting materials also deviate from the above expression due to the free-electron nature of their structures. Also, ferroelectric materials are exceptions due to the dominance of their spontaneous structurally-related electrical polarizations.

Figure 1



Density-reduced relative dielectric permittivity

Figure 2

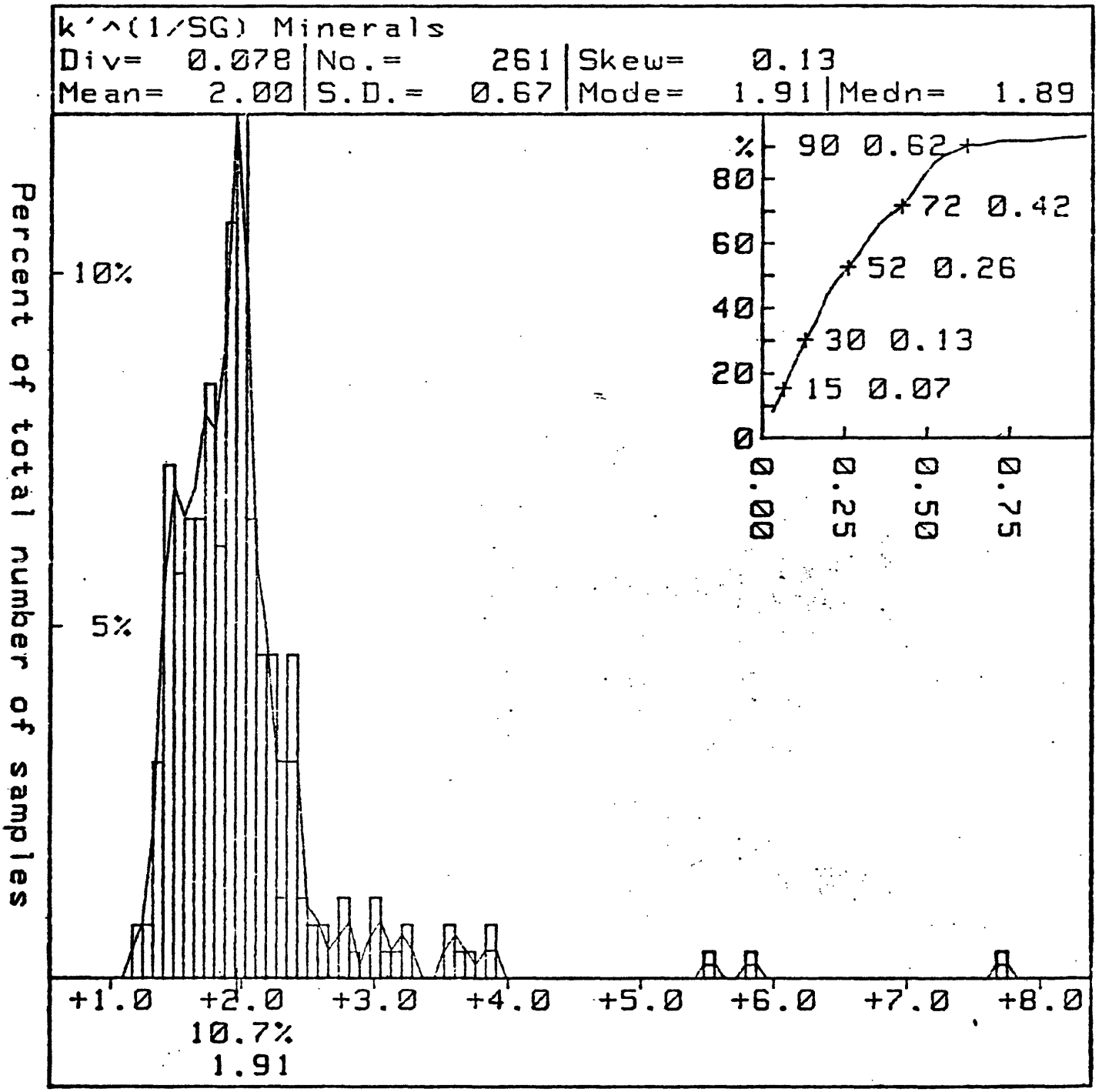

k'^(1/SG) Minerals
Div= 0.078 | No.= 261 | Skew= 0.13
Mean= 2.00 | S.D.= 0.67 | Mode= 1.91 | Medn= 1.89
Percent of total number of samples
10%
5%
%
90 0.62
72 0.42
52 0.26
30 0.13
15 0.07
80
60
40
20
0
+1.0
+2.0
+3.0
+4.0
+5.0
+6.0
+7.0
+8.0
10.7%
1.91
density-reduced relative dielectric permittivity

Figure 3

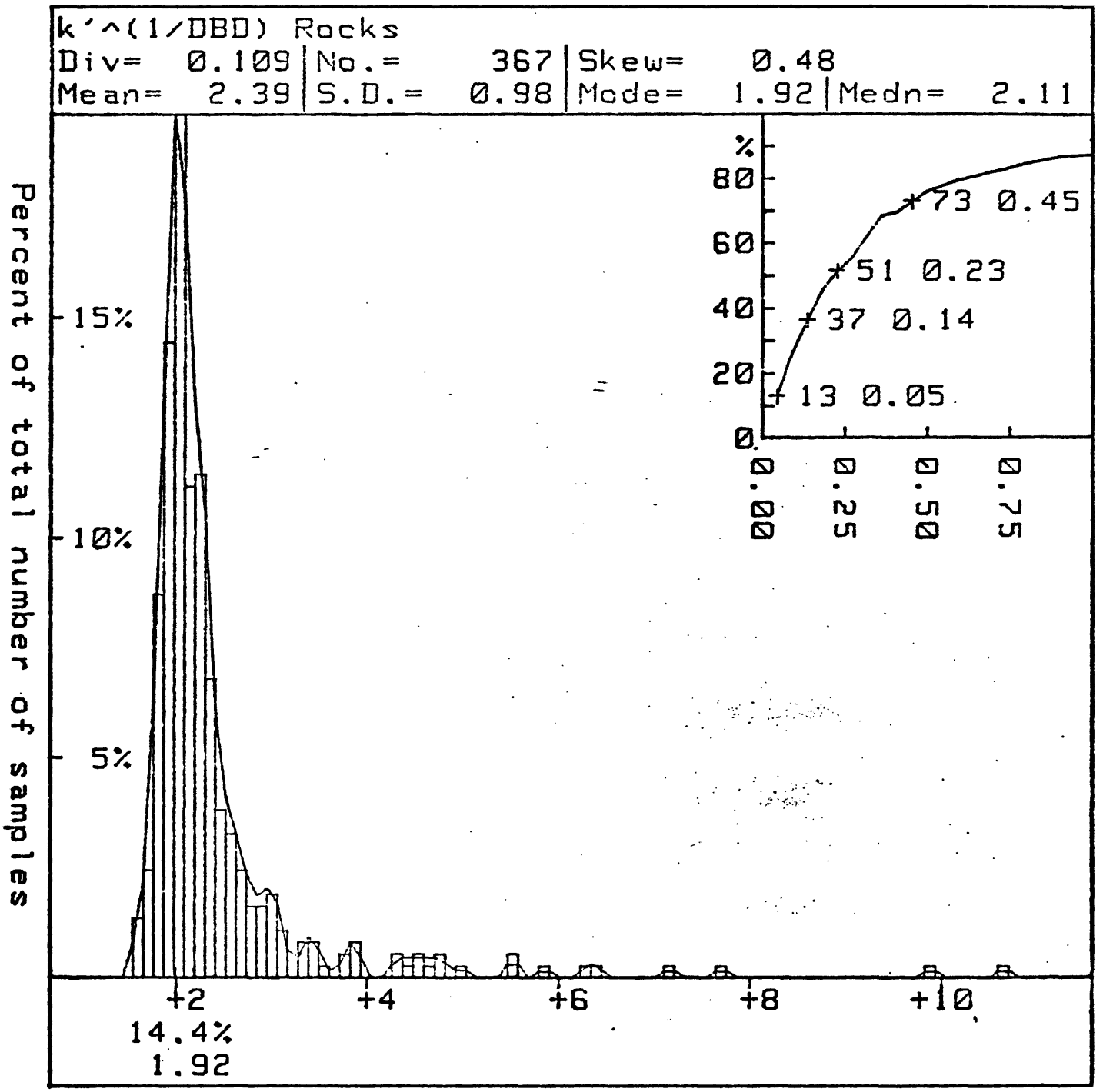

k'^(1/DBD) Rocks
Div= 0.109 | No.= 367 | Skew= 0.48
Mean= 2.39 | S.D.= 0.98 | Mode= 1.92 | Medn= 2.11
Percent of total number of samples
15%
10%
5%
%
80
60
40
20
0
73 0.45
51 0.23
37 0.14
13 0.05
0.00
0.25
0.50
0.75
+2
+4
+6
+8
+10
14.4%
1.92
density-reduced relative dielectric permittivity

Table 1 lists the recommended values of zero porosity density in gm/cm^3 (specific gravity), DC electrical conductivity in mho/m, and relative dielectric permittivity at or below 1 MHz. Minerals are arranged alphabetically by name, with the chemical formula given, and a number in brackets for those minerals whose tabulated values were derived from Table 2. The remaining values were culled from the literature. In addition to minerals, a variety of elements (in their reference state) and common chemical compounds are shown for comparison.

Mineral names and chemical formulas are according to Aballain and others (1968).

Table 1

Name/Description	Density gm/cc	DC cond. Mho/m	Dielectric k @ 1 Mhz
Acanthite/Argentite Ag2S	7.248	+1.0E+02	
Albite NaAlSi3O8 [14.8]	2.620	+2.1E-09	6.95
Allanite (Ca,Ce)2(Fe2+,Fe3+)Al2[O/OH/SiO4/SiO7] [293.6]	3.800	+1.2E-10	13.50
Almandine Fe3Al2Si3O12	4.318		4.30
Altaite PbTe SEMICONDUCTOR	8.246	+1.0E+04	450.00
Aluminum Al [REF]	2.698	+3.7E+07	
Aluminum antimonide AlSb SEMICONDUCTOR	4.340		24.00
Aluminum oxide-gamma Al2O3 INSULATOR	3.900		10.10
Amblygonite (Li,Na)AlPO4(F,OH) [248.6]	3.110	+3.1E-12	8.50
Ammonium sulfate (NH4)2SO4	1.769		3.30
Analcime NaAlSi2O6.H2O	2.258		5.60
Andalusite Al2SiO5 [165.6]	3.145	+3.9E-12	6.90
Andradite Ca3Fe2Si3O12	3.860		8.20
Anglesite PbSO4 [437.6]	6.324	+7.6E-11	14.30
Anhydrite CaSO4	2.963	+1.0E-09	6.50
Annabergite Ni3(AsO4)2.8H2O [439.6]	3.000	+1.2E-10	6.60
Anorthite CaAl2Si2O8	2.760		6.90
Anthophyllite (Mg,Fe)7Si8O22(OH)2	3.000	+5.6E-09	8.00
Antimony Sb [REF]	6.698	+2.5E+06	
Apatite Ca5(PO4)3F [253.6]	3.180	+1.2E-12	11.70
Aragonite CaCO3 [260.6]	2.931	+2.9E-13	8.67
Arcanite K2SO4	2.662		6.40
Arsenic As [REF]	5.780	+3.4E+06	
Arsenic bromide AsBr3	3.540		3.30
Arsenopyrite FeAsS SEMICONDUCTOR	6.162	+1.0E+03	7.20
Augite (Ca,Mg,Fe2+,Fe3+,Al)(Si,Al)O3	3.300	+2.1E-11	9.30
Axinite Ca2(Mn,Fe)Al2BSi4O15OH	3.300	+1.1E-12	8.90
Azurite Cu3(CO3)2(OH)2 [249.6]	3.787	+1.8E-09	21.00
Baddeleyite ZrO2	5.826		12.40
Barite BaSO4 [79.6]	4.480	+9.8E-08	10.03
Barium chloride BaCl2	3.850		11.40
Barium oxide BaO	5.992		34.00
Barium stannate BaSnO3			18.00
Barium sulfide BaS	4.250		19.23
Barium titanate BaTiO3	6.017		3600.00
Barium zirconate BaZrO3	5.520		43.00
Beidellite (Na,K,Mg,Ca)0.33Al2(Si,Al)4O10(OH)2.nH2O	2.600		17.40
Berlinite AlPO4	2.618		6.05
Beryl Be3Al2Si6O18 [180.6]	2.641	+2.8E-13	6.75
Beryllium Be [REF]	1.847	+2.5E+07	
Beryllium oxide-beta BeO	3.010		7.41
Biotite K2(Mg,Fe)4-6(Si,Al)8O20(OH)4	2.900	+1.2E-11	6.30
Bismite Bi2O3	9.370		18.20
Bismuth Bi [REF] SEMIMETAL	9.807	+8.6E+05	
Bismuth titanate Bi4Ti3O12			135.00
Bismuthinite Bi2S3 SEMICONDUCTOR	6.808	+1.5E-01	18.20
Bornite Cu5FeS4 SEMICONDUCTOR	5.091	+1.0E+03	8.13

Boron B [REF]	2.465	+5.5E-05	
Bromargyrite AgBr SEMICONDUCTOR	6.477		12.20
Bromellite BeO	3.010		7.35
Brucite Mg(OH)2 [247.6]	2.368	+3.6E-11	8.60
Bunsenite NiO SEMICONDUCTOR	6.809		11.90
Cadmium Cd [REF]	8.643	+1.5E+07	
Cadmium bromide CdBr2	5.192		8.60
Cadmium telluride CdTe SEMICONDUCTOR	6.200		10.60
Cadmoselite CdSe SEMICONDUCTOR	5.810		9.70
Calcite CaCO3 [194.6]	2.931	+1.1E-14	6.35
Calcium Ca [REF]	1.530	+3.0E+07	
Calcium nitrate Ca(NO3)2	2.483		6.54
Calcium oxide CaO (Lime) INSULATOR	3.345		11.80
Calomel HgCl	7.166		14.00
Cancrinite (Na2Ca)4[CO3/(H2O)0-3/(AlSiO4)6] [432.6]	2.450	+2.4E-10	8.60
Cassiterite SnO2 SEMICONDUCTOR	6.993	+1.0E+00	9.00
Celestine SrSO4 [251.6]	3.971	+7.1E-12	9.90
Celsian BaAl2Si2O8 [200.6]	3.200	+1.6E-10	9.40
Cerianite CeO2	7.216		7.00
Cerium Ce [REF]	6.746	+1.3E+06	
Cerrusite PbCO3	6.583		18.60
Cesium Cs [REF]	1.906	+5.0E+06	
Cesium chloride CsCl INSULATOR	3.988		6.34
Cesium iodide CsI INSULATOR	4.510		5.60
Chalcanthite CuSO4.5H2O	2.291		6.50
Chalcocite Cu2S SEMICONDUCTOR	5.793	+1.0E+03	
Chalcopyrite CuFeS2 SEMICONDUCTOR	4.200	+1.0E+03	
Chlorargyrite AgCl ELECTROLYTE	5.571	+1.5E-07	12.30
Chlorite Mg3(Si4O10)(OH)12.Mg3(OH)6	2.800	+6.2E-10	9.00
Chromite FeCr2O4 [27KCC]	5.086	+2.0E-08	11.42
Chromium Cr [REF] METAL	7.187	+7.8E+06	
Chrysoberyl BeAl2O4 [434.6]	2.913	+2.1E-12	7.83
Chrysocolla CuSiO3.2H2O	2.200		13.10
Cinnabar HgS	8.187	+2.0E-10	18.00
Clausthalite PbSe SEMICONDUCTOR	8.100		280.00
Cobalt Co [REF]	8.836	+1.6E+07	
Cobaltite CoAsS	6.275	+1.0E+03	
Cobaltous oxide CoO	6.438		12.90
Colemanite Ca2B6O11.5H2O [332.6]	2.400	+3.2E-11	13.80
Columbite (Fe,Mn)(Cb,Ta)2O6	5.000		13.00
Copper Cu [REF] METAL	8.934	+5.9E+07	
Copper dichloride CuCl2	3.054		9.80
Cordierite (Mg,Fe2+)2Al4Si5O18 [346.6]	2.508	+1.1E-09	7.40
Corundum Al2O3 INSULATOR	3.987	+1.0E-14	12.60
Cotunnite PbCl2	5.906		47.40
Covellite CuS METAL	4.682	+1.4E+06	
Cristobalite SiO2	2.300	+1.0E-13	
Cryolite Na3AlF6 [263.6]	2.965	+6.1E-13	8.40
Cummingtonite (Mg,Fe)7[OH/Si4O11]2	3.211	+6.0E-11	7.02
Cupric sulfate monohydrate CuSO4.H2O			7.00
Cuprite Cu2O SEMICONDUCTOR	6.105	+3.0E-01	7.60
Danburite CaB2Si2O8 [181.6]	3.000	+4.1E-11	6.94

Datclite CaBSiO4OH [442.6]	2.900	+7.9E-11	7.50
Diamond C SEMICONDUCTOR	3.515	+2.0E-13	5.68
Diaspore AlO(OH) [416.6]	3.378	+4.6E-09	12.50
Dickite Al2Si2O5(OH)4 [225.6]	2.620	+1.3E-09	4.60
Digenite Cu9S5	5.603	+1.0E+02	
Diopside MgCaSi2O6 [317.6]	3.277	+1.7E-11	8.60
Dioptase CuSiO2(OH)2	3.300		7.60
Dolomite CaMg(CO3)2 [102.6]	2.866	+2.3E-14	7.46
Dumortierite (Al,Fe)7BSi3O18 [190.6]	3.350	+9.2E-12	7.00
Dysprosium Dy [REF]	8.548	+1.8E+06	
Enargite Cu3AsS4 [265.6] SEMICONDUCTOR	4.463	+1.0E+01	200.00
Epidote Ca2(Al,Fe)3Si3O12OH [328.6]	3.587	+1.3E-10	14.40
Epsomite MgSO4.7H2O	1.680		5.46
Erbium Er [REF]	9.006	+9.3E+05	
Eskolaite Cr2O3	5.225		11.90
Europium Eu [REF]	5.245	+1.1E+06	
Fayalite Fe2SiO4	4.393		6.80
Ferberite FeWO4	7.521		14.00
Ferrous oxide FeO (stoichiometric)	5.700		14.20
Fluorite CaF2 INSULATOR	3.179	+1.3E-14	6.76
Forsterite Mg2SiO4	3.213		6.80
Franklinite	5.350		9.40
Gadolinium Gd [REF]	7.906	+7.1E+05	
Gahnite ZnAl2O4	4.608	+5.2E-04	
Galena PbS SEMICONDUCTOR	7.598	+1.0E+03	205.00
Gallium Ga [REF]	5.913	+5.7E+06	
Gallium antimonide GaSb SEMICONDUCTOR			15.69
Gallium arsenide GaAs SEMICONDUCTOR			12.95
Gehlenite Ca2Al2SiO7 [444.6]	3.050	+4.2E-11	10.40
Geikielite MgTiO3	3.895		18.00
Germanium Ge [REF] SEMICONDUCTOR	5.326	+2.2E+00	15.80
Gersdorffite NiAsS	5.964	+1.0E+05	
Gibbsite Al(OH)3	2.441		8.40
Glauconite K1.5(Fe3+,Mg,Al,Fe2+)4-6(Si,Al)8O20(OH)4 [313	2.300	+3.5E-09	12.70
Glaucophane Na2Mg3Al2[Si8O22](OH)2	3.200	+9.7E-12	9.30
Goethite FeO(OH)	4.268		11.70
Gold Au [REF] METAL	19.282	+4.5E+07	
Goslarite ZnSO4.7H2O	1.972		6.20
Graphite C [REF] Carbon SEMIMETAL	2.267	+7.0E+04	
Greenockite CdS SEMICONDUCTOR	4.826		9.35
Grossular Ca3Al2Si3O12	3.595		7.60
Gypsum CaSO4.2h2O [26.5] Alabaster	2.305	+9.5E-12	6.39
Hafnium Hf [REF]	13.242	+2.8E+06	
Halite NaCl ELECTROLYTE [433.6]	2.163	+2.0E-14	5.90
Halloysite Al2Si2O5(OH)4.2H2O [228.6 @ 1.12	2.550	+2.9E-07	7.88
Hedenbergite CaFeSi2O6 [10.8]	3.632	+1.5E-08	17.40
Hematite Fe2O3 SEMICONDUCTOR	5.275	+1.0E-02	25.00
Hercynite FeAl2O4 [277.6]	4.265	+1.3E-07	40.00
Hessite Ag2Te SEMICONDUCTOR	8.405	+1.0E+05	
Holmium Ho [REF]	8.801	+1.1E+06	
Hornblende (Ca,NaK)2-3(Mg,Fe2+,Fe3+,Al)5(Si,Al)8O22(OH)2	3.080	+2.1E-11	8.00

Hydroxyapatite Ca5(PO4)3OH	3.155		4.90
Idocrase Ca10(Mg,Fe2+,Fe3+)2Al4Si9O34(OH)4 [445.6] Vesuvianite	3.400	+5.2E-11	8.64
Illite (H3O,K)Al8(Si,Al)16O40(OH)8	2.660		10.00
Ilmenite FeTiO3	4.788	+1.0E+02	
Indium In [REF]	7.297	+1.2E+07	
Indium antimonide InSb SEMICONDUCTOR			17.88
Indium arsenide InAs SEMICONDUCTOR			14.55
Iodargyrite AgI SEMICONDUCTOR	5.684		6.80
Iridium Ir [REF]	22.564	+1.9E+07	
Iron Fe [REF]	7.875	+1.0E+07	
Jadeite NaAlSi2O6 [343.6]	3.400	+1.2E-10	10.00
Kaolinite Al2Si2O5(OH)4 [223.6]	2.594	+3.1E-08	11.80
Karelianite V2O3	5.021		15.00
Kernite Na2B4O7.4H2O [440.6]	1.877	+1.9E-12	5.28
Kyanite Al2SiO5 [187.6]	3.675	+1.8E-12	7.80
Labradorite Na2Ca3(AlSi3O8)8 [314.6]	2.710	+1.3E-10	5.87
Lead Pb [REF] METAL	11.343	+4.8E+06	
Lead nitrate Pb(NO3)2	4.530		16.80
Lead titanate PbTiO3	7.940		200.00
Lead zirconate PbZrO3	7.000		200.00
Lepidolite K(Li,Al)3(Si,Al)4O10(F,OH)2 [27.5]	2.900	+2.6E-12	6.30
Leucite KAlSi2O6	2.469		6.80
Limonite [41.5] Amorphous Iron	3.176	+3.5E-08	12.40
Litharge PbO red SEMICONDUCTOR	9.335		25.90
Lithium Li [REF]	.533	+1.2E+07	
Lithium chloride LiCl ELECTROLYTE	2.060		10.60
Magnesite MgCO3	3.010		8.10
Magnesium Mg [REF] METAL	1.737	+2.3E+07	
Magnesium sulfate MgSO4	2.660		8.20
Magnetite Fe3O4 METAL	5.200	+1.0E+04	
Malachite Cu2(CO3)(OH)2 [28KCC]	4.031	+1.1E-09	6.33
Manganese Mn [REF]	7.470	+7.4E+05	
Manganite MnO.OH [212.6]	3.984	+1.9E-02	917.00
Manganosite MnO	5.366		18.00
Mascagnite (NH4)2SO4	1.769		9.80
Mercuric chloride Hg2Cl2	6.470		9.40
Mercurous chloride HgCl2	5.600		3.20
Microcline KAlSi3O8 [103.6]	2.560	+5.7E-12	5.48
Millerite NiS	5.374	+3.0E+06	
Minium Pb3O4	8.926		17.80
Molybdenite MoS2 SEMICONDUCTOR	4.999	+1.0E+00	
Molybdenum Mo [REF] METAL	10.221	+1.9E+07	
Monticellite CaMgSiO4 [339.6]	3.200	+7.7E-11	8.50
Montmorillonite (Na,K,Mg,Ca)0.33(Al,Mg)2Si4O10(OH)2.nH2O [229	2.608	+4.8E-07	207.00
Mullite 3Al2O3.2SiO2 3-2 INSULATOR	3.167	+1.0E-14	6.60
Muscovite KAl3Si3O10(OH)2 [24.5]	2.831	+4.6E-13	7.60
Nantockite CuCl SEMICONDUCTOR	4.139	+2.9E-07	9.80
Natrolite Na2Al2Si3O10.2H2O [168.6]	2.245	+1.0E-09	6.70

Nepheline Na3KAl4Si4O16	2.623	+1.6E-09	6.04
Niccolite NiAs	7.776	+1.0E+07	
Nickel Ni [REF] METAL	8.910	+1.4E+07	
Nickel carbonate Ni(CO)4	1.320		2.20
Niobium Nb [REF]	8.580	+8.0E+06	
Niter KNO3	2.105		4.37
Nitrobarite Ba(NO3)2	3.240		5.90
Oldhamite CaS	2.602		6.70
Opal SiO2.nH2O [198.6]	1.890	+3.9E-07	13.01
Orthoclase KAlSi3O8 [13.5]	2.570	+6.9E-13	5.60
Palladium Pd [REF]	12.006	+9.3E+06	
Pectolite Ca2NaSi3O8OH [208.6]	2.870	+2.3E-11	9.00
Periclase MgO INSULATOR	3.583	+1.6E-11	9.65
Perovskite CaTiO3 SEMICONDUCTOR	4.044		165.00
Petalite LiAlSi4O10 [289.6]	2.410	+1.7E-10	5.00
Phenacite Be2SiO4 R3	2.960		5.10
Phlogopite KMg3AlSi3O10(OH)2 [23.5]	2.784	+1.0E-13	7.60
Phosphorus P [REF]	1.801	+1.0E-09	
Phosphorus trioxide P2O3	2.135		3.20
Plattnerite PbO2	9.375	+1.1E+06	26.00
Potassium K [REF]	.862	+1.6E+07	
Potassium aluminum sulfate KAl(SO4)2			3.80
Potassium bromate KBrO3	3.270		7.30
Potassium bromide KBr INSULATOR	2.754		4.78
Potassium carbonate K2CO3	2.428		4.96
Potassium chlorate KClO3	2.320		5.10
Potassium flouride KF ELECTROLYTE	2.505		6.05
Potassium orthophosphate K3PO4	2.564		7.75
Powellite CaMoO4	4.256		24.00
Praseodymium Pr [REF]	6.774	+1.5E+06	
Prehnite Ca2Al2Si3O10(OH)2 [203.6]	2.910	+2.5E-12	6.50
Proustite Ag3AsS3 SEMICONDUCTOR	5.595	+1.0E-03	16.50
Pt [REF] METAL	21.460	+9.6E+06	
Pyrargyrite Ag3SbS3 [302.6] SEMICONDUCTOR	5.851	+2.8E-03	222.00
Pyrite FeS2 SEMICONDUCTOR	5.011	+1.0E+03	
Pyrolusite MnO2 SEMICONDUCTOR	5.234	+1.0E+00	10000.00
Pyrophyllite Al2Si4O10(OH)2 [221.6]	2.819	+6.6E-13	6.30
Pyrrhotite Fe.877S METAL	4.610	+1.0E+05	
Quartz SiO2 INSULATOR	2.648	+5.0E-15	4.50
Realgar AsS	3.590		7.60
Retgersite NiSO4.6H2O	2.070		6.20
Rhenium Re [REF]	21.017	+5.2E+06	
Rhodium Rh [REF]	12.425	+2.2E+07	
Rhodochrosite MnCO3	3.699		6.80
Rhodonite MnSiO3 [320.6]	3.726	+1.5E-11	10.00
Riebeckite Na2Fe2+3Fe3+2Si8O22(OH)4	3.000	+2.6E-10	6.59
Rubidium Rb [REF]	1.530	+8.0E+06	
Rubidium carbonate Rb2CO3			6.73
Rubidium chloride RbCl	2.800		4.91
Ruthenium Ru [REF]	12.369	+1.3E+07	
Rutile TiO2 [137.6] SEMICONDUCTOR	4.245	+4.7E-10	78.90
Salmiac NH4Cl Sal Amoniac	1.527		6.96

Samarium Sm [REF]	7.528	+1.1E+06	
Sanmartinite ZnWO4	7.872		16.10
Scandium Sc [REF]	2.989	+1.6E+06	
Scapolite CaCO3.3CaAl2Si2O8.CaSO4.CaCl2	2.600	+8.2E-11	8.23
Scheelite CaWO4	6.120		11.70
Selenium Se [REF] SEMICONDUCTOR	4.809	+8.3E+06	11.00
Sellaite MgF2 INSULATOR	3.148		9.50
Serpentine Mg3(Si2O5)(OH)4 [318.6]	2.600	+3.2E-09	14.00
Siderite FeCO3 [271.6]	3.944	+1.2E-10	9.30
Silicon Si [REF] SEMICONDUCTOR	2.330	+1.0E+07	11.70
Silicon carbide SiC SEMICONDUCTOR	3.217	+5.0E-01	10.20
Sillimanite Al2SiO5 [186.6]	3.247	+1.0E-11	11.00
Silver Ag [REF] METAL	10.501	+6.2E+07	
Silver oxide Ag2O	7.140		8.60
Smaragdite Ca2(Mg,Fe)5Si8O22(OH)2 [290.6] Actinolite	3.400	+1.0E-11	8.60
Soda-niter NaNO3	2.261		6.85
Sodalite Na4Al3(SiO4)3Cl	2.200		6.80
Sodium Na [REF]	.965	+2.4E+07	
Sodium bromate NaBrO3	3.339		5.70
Sodium carbonate Na2CO3	2.532		8.75
Sodium carbonate hydrogen NaHCO3	2.159		4.40
Sodium perchlorate NaClO4	2.020		5.76
Spessartine Mn3Al2Si2O12	3.022		7.60
Sphaelerite ZnS [213.6] SEMICONDUCTOR	4.089	+3.8E-12	7.50
Spinel MgAl2O4	3.583		6.80
Spodumene LiAlSi2O6 [210.6]	3.188	+4.9E-13	8.30
Stannous tetrachloride SnCl4	2.230		2.87
Stibnite Sb2S3 SEMICONDUCTOR	4.627	+1.0E-06	11.20
Stibnous bromide SbBr3	4.148		5.10
Stibnous chloride SbCl3	3.140		5.30
Stilbite NaCa2Al5Si13O36.14H2O [482.6]	2.150	+4.6E-08	7.85
Stilleite ZnSe SEMICONDUCTOR	5.420		9.12
Stolzite PbWO4	8.411		23.60
Strontianite SrCO3 [272.6]	3.784	+2.2E-12	9.60
Strontium Sr [REF]	2.583	+4.4E+06	
Strontium nitrate Sr(NO3)2	2.986		5.33
Strontium oxide SrO	4.700		13.30
Strontium sulfide SrS SEMICONDUCTOR	3.700		11.31
Strontium titanate SrTiO3	5.110		332.00
Sulfur S [REF]	2.067	+1.0E-12	3.75
Sulfuryl chloride SO2Cl2	1.680		9.05
Sylvite KCl ELECTROLYTE	1.987	+1.0E-13	4.84
Talc Mg3Si4O10(OH)2	2.784		5.80
Tantalite (Fe,Mn)(Ta,Nb)2O6	6.500		10.00
Tantalum Ta [REF]	16.676	+8.0E+06	
Tantalum pentoxide Ta2O5	8.311		45.00
Tellurium Te [REF] SEMICONDUCTOR	6.232	+2.3E-04	5.00
Tenorite CuO SEMICONDUCTOR	6.509		18.10
Tephroite Mn2SiO4 [419.6]	4.155	+5.8E-11	10.00
Terbium Tb [REF]	8.239		33.00

Thallium Tl [REF]	11.875	+5.6E+06	
Thallous chloride TlCl SEMICONDUCTOR	7.020		31.90
Thallous nitrate TlNO3			16.50
Thenardite Na2SO4 [450.6]	2.663	+2.1E-12	5.00
Thorianite ThO2	10.012		18.50
Thorium Th [REF]	11.726	+7.7E+06	
Thulium Tm [REF]	9.320	+1.3E+06	
Tiemannite HgSe SEMICONDUCTOR	8.266		25.00
Tin Sn [REF] SEMIMETAL	7.287	+9.1E+06	
Tin antimonide SnSb			147.00
Titanite CaTiSiO5 Sphene	3.523	+5.8E-12	21.00
Titanium Ti [REF] METAL	4.506	+2.3E+06	
Topaz Al2(SiO4)(F2) [184.6]	3.500	+7.1E-14	6.80
Topaz Al2(SiO4)(OH)	3.174		5.00
Tremolite Ca2Mg5[Si8O22](OH)2 [312.6]	2.977	+2.6E-10	8.00
Tungsten W [REF]	19.261	+1.8E+07	
Tungsten pentoxide W2O5		+2.2E+05	
Tungsten trioxide WO3	7.160	+5.0E-04	
Ulexite NaCaB5O9.8H2O [441.6]	2.000	+2.9E-12	5.80
Uraninite UO2	10.969	+2.6E-03	24.00
Uranium U [REF]	19.047	+3.3E+06	
Valentinite Sb2O3	5.829		12.80
Vanadium V [REF]	6.101	+4.0E+06	
Villiaumite NaF	2.790		6.90
Water H2O (liquid) INSULATOR	.997	+5.5E-06	78.30
Willemite Zn2SiO4 [182.6]	4.251	+2.9E-08	7.70
Witherite BaCO3 [273.6]	4.308	+4.9E-13	7.20
Wollastonite CaSiO3 [348.6]	2.909	+1.5E-11	8.60
Wulfenite PbMoO4	6.817		26.80
Wustite Fe.947O	5.722		14.20
Ytterbium Yb [REF]	6.969	+3.4E+06	
Ytterbium sesquioxide Yb2O3	9.170		5.00
Yttrium Y [REF]	5.912	+1.8E+06	
Yttrium sesquioxide Y2O3	5.010		11.50
Zinc Zn [REF] METAL	7.136	+1.7E+07	
Zinc telluride ZnTe SEMICONDUCTOR	6.340		10.10
Zincite ZnO SEMICONDUCTOR	5.676		12.00
Zircon ZrSiO4	4.669		10.00
Zirconium Zr [REF]	6.508	+2.5E+06	
Zoisite Ca2Al3(SiO4)3(OH) [347.6]	3.328	+2.4E-11	10.40

Table 2 lists the measurements of a series of rocks and minerals. The columns in the table are the rock or mineral description and any identifying information (sample number, location, etc.), the dry bulk density ($\pm$0.01 gm/cm^3), the DC electrical conductivity in mho/m ($\pm$10 percent), and the relative dielectric permittivity ($\pm$1 percent) and loss tangent at frequencies of 1 kHz, 10 kHz, 100 kHz, and 1MHz. All measurements were performed using a three-terminal sample holder at room temperature in 8 percent relative humidity.

Samples without bracketed numbers are from the U.S.G.S. Petrophysics Laboratory sample collection. Those with bracketed numbers beginning with "R" are from Robertson and Peck (1974). Those with other bracketed numbers are from Hunt and Salisbury (1976) and references therein.

Blank entries in the table indicate sample measurements that were outside the range of the measurement instruments. DC electrical conductivities were measured using a Guildline 9520 automatic digital teraohmmeter and dielectric properties were measured with a Hewlett-Packard 4270A digitial capacitance meter*.

Where necessary, values for Table 1 were generated from these Table 2 measurements by reducing the dielectric permittivity to zero porosity through

$$k_1 = k_2^{S/D}$$

where k_1 is the value in Table 1 at the zero porosity density of S gm/cm^3 and k_2 is the value in Table 2 at the measured dry bulk density of D gm/cm^3. DC electrical conductivities were reported as the same values in both tables as there is no known density correction.

*Trade and manufacturer's names are used for descriptive purposes only and do not imply recommendation or endorsement by the U.S. Geological Survey.

TABLE 2

Name/Description	Density	Conductivity	Relative Dielectric Permittivity & Loss Tangent							
			1kHz		10kHz		100kHz		1MHz	
	gm/cc	EC Mho/m								
Afwillite [211.6] Riverside, California	2.832	7.6E-12	10.9	0.0422	10.2	0.0430	9.6	0.0409	9.2	0.0310
Albite Gneiss [390.6] Colorado	2.677	9.7E-11	17.2	0.3662	11.3	0.2664	8.4	0.1604	7.0	0.1093
Albite [14.8] Bancroft, Ontario	2.601	2.1E-09	8.5	0.2559	7.4	0.0756	7.0	0.0324	6.9	0.0111
Albite [324.6] So. Dakota	2.547	1.1E-10	5.8	0.0143	5.7	0.0072	5.6	0.0102	5.8	0.0071
Allanite [293.6] Ontario	3.517	1.2E-10	15.3	0.1331	13.5	0.0717	12.4	0.0511	11.1	
Amblygonite [248.6] Keystone, So.Dakota	2.970	3.1E-12	8.2	0.0196	8.0	0.0172	7.8	0.0175	7.7	0.0178
Andalusite [185.6] Australia	2.757	3.9E-12	6.9	0.0774	6.1	0.0711	5.6	0.0461	5.4	0.0183
Andesite Hornblende [130.6] Mt.Shasta, California	2.184	1.8E-09	5.6	0.1724	5.0	0.0475	4.9	0.0152	4.7	
Andesite Hornblende [236.6] Colorado	2.599	5.8E-09	34.2	0.7206	18.5	0.4145	12.6	0.2593	9.4	0.2030
Andesite Plagioclase [121.6] San Juan, Colorado	2.606	1.4E-10	16.4	0.2125	12.6	0.1083	10.1	0.1415	8.5	0.1205
Andesite [219.6] Boulder, Colorado	2.738	2.1E-11	12.3	0.1789	10.0	0.1265	8.6	0.1019	7.6	0.0792
Andesite [239.6] Texas	2.654	1.7E-10	12.1	0.2087	9.8	0.1230	8.6	0.0726	8.1	0.0393
Anglesite [437.6] Utah	4.075	7.6E-11	24.6	0.1044	22.1	0.0586	20.9	0.0307	20.4	0.0169
Anhydrite [334.6] Salmat, NY	2.778	1.2E-11	7.8	0.0748	7.1	0.0372	6.9	0.0168	6.9	0.0085
Annabergite [439.6] Nevada	2.707	1.2E-10	6.2	0.0891	5.7	0.0445	5.4	0.0247	5.5	0.0129
Anorthoclase [321.6] Norway	2.537	1.5E-11	8.4	0.0928	7.4	0.0650	6.9	0.0490	6.6	0.0304
Anthophyllite [266.6] No. Carolina	2.451	5.6E-09	10.3	0.3517	7.4	0.1969	6.1	0.1180	5.4	0.0802
Apatite [250.6] Quebec	3.022	2.7E-12	9.9		9.8	0.0057	9.7	0.0074	9.7	0.0082
Apatite [253.6] Norway	3.124	1.2E-12	13.4	0.0486	12.5	0.0304	12.0	0.0250	11.2	
Aragonite [260.6] England	2.687	2.9E-13	7.5	0.0089	7.4	0.0054	7.4	0.0073	7.3	0.0064
Arsenopyrite [262.6] Gold Hill, Utah	3.620	1.2E-03								
Asbestos Amphibole [292.6] Bozeman, Montana	2.758	7.0E-10	9.4	0.4058	7.1	0.1566	6.4	0.0664	6.0	0.0329
Augite [12.8]	3.171	2.1E-11	12.4	0.1664	10.2	0.1089	9.0	0.0653	8.5	0.0346
Axinite [342.6] Mexico	3.127	1.1E-12	8.7	0.0346	8.4	0.0261	8.2	0.0222	7.9	0.0229
Azurite [249.6] Bisbee, Arizona	2.121	1.8E-09	22.1	0.3444	13.9	0.3277	8.7	0.3365	5.5	0.2842
Barite [79.6] Custer, Colorado	4.364	9.8E-08	14.5	0.6965	11.1	0.1755	9.9	0.0618	9.5	0.0261
Basalt Hornblende [7.5] Chaffee, Colorado	2.635	9.9E-09	48.1	0.7061	22.4	0.4890	14.6	0.2843	10.8	0.1973
Basalt Thingvellir, Iceland	2.916	8.4E-11	10.4	0.0444	9.9	0.0297	9.6	0.0209	9.4	0.0213
Basalt amygdaloidal [240.6] Michigan	3.134	2.4E-10	24.5	0.2826	17.9	0.1643	14.7	0.1161	13.1	0.0737
Basalt Ilcoo [58.5] U.S.B.M.	2.843	1.4E-09	29.0	0.3533	21.1	0.1851	17.7	0.1133	15.5	0.1004
Basalt [166.6A] Hawaii	2.365	6.0E-10	8.5	0.0833	8.0	0.0392	7.7	0.0183	7.4	
Basalt [166.6L] Hawaii	2.365	5.2E-10	7.9	0.0791	7.5	0.0368	7.2	0.0185	6.9	
Basalt [166.6] Hawaii	2.365	7.9E-10	8.4	0.1117	7.9	0.0438	7.5	0.0229	7.5	0.0126
Basalt [5.5] Chaffee, Colorado	1.953	7.3E-09	29.3	0.5480	16.8	0.3763	11.1	0.2762	8.0	0.2136
Basalt [6.5] Germany	3.030	5.8E-09	37.6	0.6048	19.6	0.4278	14.2	0.2020	11.6	0.1220
Basalt [R604] Hawaii	2.136	1.7E-11	10.1	0.0494	9.6	0.0325	9.2	0.0327	8.8	0.0441
Basalt [R606] Hawaii	2.230	1.5E-11	10.7	0.0277	10.4	0.0190	10.1	0.0238	9.8	0.0467
Basalt [R607] Hawaii	2.181	1.3E-11	10.3	0.0266	10.1	0.0185	9.8	0.0210	9.5	0.0409
Basalt [R608] Hawaii	2.029	1.2E-11	9.9	0.0349	9.5	0.0212	9.3	0.0233	9.0	0.0404
Basalt [R609] Hawaii	2.048	6.4E-12	8.1	0.0263	7.8	0.0196	7.6	0.0180	7.5	0.0235
Basalt [R610] Hawaii	2.043	4.5E-12	7.7	0.0238	7.5	0.0137	7.4	0.0127	7.3	0.0194
Basalt [R611] Hawaii	1.630	1.0E-11	6.3	0.0255	6.1	0.0146	6.0	0.0134	5.9	0.0177
Basalt [R612] Hawaii	2.462	1.2E-09	12.9	0.2762	10.3	0.1208	9.3	0.0624	8.7	0.0522
Basalt [R613] Hawaii	2.617	2.7E-11	13.2	0.0397	12.7	0.0246	12.3	0.0254	11.9	0.0385
Basalt [R614] Hawaii	2.807	2.3E-11	10.7	0.0793	9.8	0.0532	9.2	0.0415	8.7	0.0374
Basalt [R615] Hawaii	2.817	1.4E-11	11.4	0.0514	10.8	0.0350	10.3	0.0362	9.8	0.0482
Basalt [R616] Hawaii	2.882	1.2E-11	10.9	0.0336	10.6	0.0224	10.2	0.0260	9.8	0.0399
Basalt [R617] Hawaii	2.105	1.2E-11	7.0	0.0880	6.4	0.0545	6.0	0.0374	5.6	0.0241
Basalt [R618] Hawaii	1.979	7.8E-12	9.2	0.0370	8.8	0.0215	8.6	0.0202	8.4	0.0315

Basalt [K615] Hawaii	1.949	2.9E-13	7.1	0.0291	6.8	0.0180	6.7	0.0184	6.5	0.0278
Basalt [K620] Hawaii	2.402	1.4E-11	10.9	0.0334	10.5	0.0212	10.3	0.0226	9.9	0.0357
Basalt [K621] Hawaii	2.384	7.5E-12	8.0	0.0597	7.5	0.0354	7.2	0.0255	7.0	0.0223
Basalt [K622] Hawaii	2.613	2.4E-09	12.0	0.1487	10.5	0.0796	9.6	0.0564	8.9	0.0534
Basalt [K623] Hawaii	2.458	5.2E-11	9.7	0.0648	9.1	0.0349	8.8	0.0299	8.4	0.0351
Basalt [K624] Hawaii	2.693	1.5E-11	10.0	0.0471	9.5	0.0350	9.1	0.0342	8.7	0.0381
Basalt [K625] Hawaii	2.919	4.9E-10	15.0	0.2381	12.2	0.1164	10.9	0.0715	10.1	0.0596
Basalt [K626] Hawaii	2.886	2.2E-11	12.6	0.0780	11.5	0.0574	10.6	0.0607	9.7	0.0783
Basalt [K628] Hawaii	1.414	1.7E-11	5.5	0.0582	5.1	0.0387	4.9	0.0307	4.7	0.0382
Basalt [K629] Hawaii	1.649	1.3E-11	7.2	0.0286	7.0	0.0187	6.8	0.0195	6.6	0.0296
Basalt [K630] Hawaii	2.012	1.1E-11	9.6	0.0328	9.3	0.0181	9.1	0.0172	9.0	0.0317
Basalt [K631] Hawaii	2.595	2.4E-11	15.1	0.0321	14.7	0.0186	14.4	0.0185	14.1	0.0408
Basalt [K632] Hawaii	2.527	1.6E-11	12.1	0.0188	11.9	0.0161	11.6	0.0272	11.0	0.0629
Basalt [K802-A] Hawaii	1.612	2.9E-11	7.0	0.0395	6.7	0.0236	6.5	0.0215	6.4	0.0285
Basalt [K802-B] Hawaii	.767	5.7E-12	3.3	0.0205	3.2	0.0148	3.2	0.0165	3.1	0.0212
Basalt [K802-C] Hawaii	.814	4.7E-12	3.5	0.0258	3.4	0.0140	3.4	0.0149	3.3	0.0227
Basalt [K802-X-1] Hawaii	1.932	4.8E-12	7.5	0.0335	7.3	0.0192	7.1	0.0187	7.0	0.0297
Basalt [K802-X-2] Hawaii	1.775	6.7E-12	6.7	0.0274	6.5	0.0179	6.4	0.0191	6.2	0.0310
Basalt [K802-X-3] Hawaii	1.454	2.2E-11	5.6	0.0330	5.4	0.0179	5.3	0.0183	5.1	0.0307
Basalt [K803-A-1] Hawaii	1.624	2.9E-11	6.8	0.0369	6.6	0.0241	6.4	0.0223	6.2	0.0325
Basalt [K803-A-2] Hawaii	1.319	1.3E-11	5.3	0.0301	5.2	0.0187	5.0	0.0173	5.0	0.0222
Basalt [K803-A-3] Hawaii	1.038	1.3E-11	4.5	0.0361	4.3	0.0192	4.2	0.0166	4.1	0.0234
Basalt [K804-1] Hawaii	1.048	6.8E-12	4.4	0.0208	4.3	0.0171	4.2	0.0181	4.1	0.0206
Basalt [K804-2] Hawaii	.928	2.8E-12	3.4	0.0135	3.3	0.0110	3.3	0.0112	3.3	0.0127
Basalt [K805-1] Hawaii	.837	7.8E-12	3.9	0.0294	3.8	0.0163	3.7	0.0148	3.7	0.0244
Basalt [K805-2] Hawaii	.876	1.6E-11	4.0	0.0285	3.9	0.0152	3.8	0.0143	3.8	0.0230
Basalt [K806-1] Hawaii	.769	4.0E-12	3.4	0.0135	3.3	0.0145	3.3	0.0134	3.2	0.0121
Basalt [K807-A] Hawaii	.844	2.5E-12	3.9	0.0351	3.8	0.0194	3.7	0.0149	3.6	0.0188
Basalt [K807-B] Hawaii	.853	3.0E-11	4.3	0.0430	4.1	0.0213	4.0	0.0166	3.9	0.0221
Basalt [K808-A] Hawaii	.802	4.1E-12	3.1	0.0292	3.0	0.0196	3.0	0.0201	2.9	0.0214
Basalt [K808-B] Hawaii	.837	4.6E-12	3.3	0.0341	3.2	0.0198	3.1	0.0204	3.1	0.0224
Basalt [K815] Hawaii	2.925	1.0E-09	15.4	0.2114	12.9	0.1051	11.5	0.0721	10.6	0.0631
Basalt [K816] Hawaii	2.874	1.5E-11	15.6	0.0420	14.7	0.0503	13.5	0.0642	12.2	0.0773
Basalt [K818] Hawaii	3.039	3.0E-12	9.3	0.0191	9.0	0.0189	8.8	0.0214	8.6	0.0275
Basalt [K819] Hawaii	3.019	8.3E-08	18.0	0.1196	16.6	0.0677	15.1	0.0708	13.7	0.0738
Basalt [K821-A] Hawaii	2.545	2.7E-11	10.4	0.0321	10.0	0.0224	9.7	0.0254	9.4	0.0306
Basalt [K821-B] Hawaii	2.614	3.3E-11	11.6	0.0403	11.1	0.0293	10.6	0.0324	10.1	0.0467
Basalt [K822-A] Hawaii	2.914	1.0E-11	10.2	0.0131	10.0	0.0115	9.8	0.0124	9.7	0.0187
Basalt [K822-B] Hawaii	2.863	9.3E-12	10.2	0.0131	10.0	0.0116	9.8	0.0134	9.7	0.0204
Basalt [K823-B] Hawaii	2.255	2.6E-11	9.1	0.0362	8.7	0.0243	8.4	0.0264	8.1	0.0385
beryl [160.6] Maine	2.644	2.8E-13	7.6		7.3	0.0231	7.0	0.0316	6.8	0.0316
biotite Gneiss [308.6] **Colorado**	2.660	3.7E-12	6.1	0.0663	5.6	0.0433	5.4	0.0226	5.1	
Biotite [26.5] Bancroft, **Ontario**	3.030	1.2E-11	6.6	0.0419	6.3	0.0156	6.3	0.0057	6.3	0.0026
Bismuthinite [470.6] Sc.Africa	6.494	2.6E-08	157.3	0.2197	115.8	0.2525	70.2	0.3696	45.2	0.2068
Bornite [18BCC] Butte, Montana	3.269	6.2E-12	9.2	0.1147	7.7	0.1084	6.7	0.0806	6.2	0.0504
Breccia Andesitic [86.6] Ouray, **Colorado**	2.507	1.8E-10	7.8	0.0955	7.1	0.0552	6.7	0.0336	6.5	0.0179
Breccia Basalt [95.6] Lane, Oregon	2.450	1.1E-07	108.5	0.7248	52.4	0.5205	31.2	0.3548	21.0	0.2844
Breccia volcanic [61.6] Guffy, **Colorado**	2.245	2.5E-11	5.9	0.0758	5.4	0.0437	5.2	0.0259	4.8	
Bronzite Enstatite [9.6] Jackson, **No.Carolina**	3.214	4.6E-12	6.8	0.0308	6.7	0.0102	6.6	0.0039	6.6	
brucite [247.6] Lodi, Nevada	2.390	3.6E-11	33.4	0.3789	19.3	0.3868	11.5	0.3188	8.6	0.1486
Calcite chalk [340.6] England	1.427	4.7E-11	5.9	0.1455	4.9	0.1115	4.3	0.0713	4.0	0.0191
Calcite [194.6] Mexico SINGLE CRYSTAL	2.808	1.1E-14	6.1		6.1		6.1	0.0017	5.9	
Calcite [331.6] Canada	2.707	4.9E-13	10.1		9.8	0.0339	9.1	0.0503	8.4	

Calcite [46.6] Cherokee, Kansas	2.555	3.8E-11	9.6	0.0601	9.0	0.0275	8.8	0.0117	8.8	0.0072
Cancrinite [432.6] Ontario	2.390	2.4E-10	9.3	0.0430	9.0	0.0157	8.8	0.0091	8.2	
Cassiterite [279.6] Nigeria	5.953	1.2E-04					300.0	0.9583	90.1	1.1593
Celestite [251.6] Mexico	3.789	7.1E-12	9.4	0.0435	9.0	0.0163	8.9	0.0082	8.9	0.0055
Celsian [200.6] Australia	2.896	1.6E-10	9.5	0.1369	8.4	0.0648	7.9	0.0380	7.6	0.0267
Chalcocite [19KCC]	7.013	1.0E-07								
Chlorite [179.6] Colorado	2.819	9.6E-12	37.8	0.3219	21.2	0.4379	10.9	0.4235	7.4	0.2011
Chlorite [197.6] Calaveras, California	2.617	6.2E-10	22.3	0.4552	14.5	0.2678	10.8	0.2152	7.9	0.2052
Chromite [27KCC] So.Rhodesia	5.001	2.0E-08	64.7	0.7312	26.1	0.6175	15.4	0.3495	11.0	0.2212
Chromite [261.6] Sierra Leone	3.490	7.4E-06	52.1	1.2038	19.3	0.6978	12.5	0.3162	9.5	0.1606
Chrysoberyl [434.6] So. Dakota	2.989	2.1E-12	12.5	0.1440	9.8	0.1398	8.4	0.0786	7.8	0.0520
Cinnabar [460.6] Spain	3.470	9.9E-06	117.4	0.3124	47.3	0.6864	19.7	0.6014	10.9	0.4002
Cobaltite [264.6] Elliot Lake, Ontario	5.821	3.8E+00								
Colemanite [332.6] California	2.347	3.2E-11	21.8	0.3673	15.9	0.1637	14.0	0.0745	13.1	0.0502
Colemanite [435.6] California	2.311	4.2E-12	13.6	0.0314	13.0	0.0213	12.7	0.0176	12.5	0.0136
Corderite [340.6] Colorado	2.717	1.1E-09	15.0	0.4774	10.0	0.2355	8.2	0.1141	7.4	0.0656
Corundum [263.6] Transvaal	3.890	8.9E-12	9.3	0.0078	9.1	0.0056	9.1	0.0032	9.2	
Cryolite [263.6] Greenland	2.879	6.1E-13	8.7	0.0145	8.4	0.0263	8.1	0.0226	7.9	0.0167
Cummingtonite [294.6] Lead, So. Dakota	3.211	6.0E-11	8.9	0.1196	7.8	0.0705	7.2	0.0384	7.0	0.0198
Dacite Porphyry Mica [40.5] Ward, Colorado	2.661	8.4E-12	9.4	0.0987	8.3	0.0758	7.5	0.0782	6.7	0.0753
Dacite porphyry [398.6] Montana	2.416	6.9E-11	13.1	0.2379	9.6	0.1969	7.6	0.1446	6.1	
Dacite [56.5] U.S.B.M.	2.206	1.5E-10	5.3	0.0909	4.9	0.0344	4.8	0.0138	4.5	
Danburite [101.6] New York	2.992	4.1E-11	7.9	0.0500	7.5	0.0232	7.3	0.0151	6.9	
Datolite [442.6] Connecticut	2.840	7.9E-11	7.4	0.0433	7.1	0.0135	7.0	0.0107	7.2	0.0060
Diabase [129.6] Jersey City, NJ	3.149	2.8E-08	39.3	0.5457	24.5	0.2987	18.6	0.1722	15.5	0.1224
Diabase [131.6] St.Peters, Pennsylvania	3.039	4.4E-11	14.9	0.1558	12.4	0.0833	11.4	0.0643	10.4	0.0743
Diabase [155.6] Mt. Tom, Massachusetts	3.015	4.2E-10	17.3	0.1718	14.7	0.1120	12.9	0.0817	11.7	0.0681
Diabase [242.6] Colorado	3.051	3.5E-09	36.8	0.4037	25.0	0.2446	19.2	0.1719	15.6	0.1418
Diaspore [416.6] Roseland, Missouri	2.319	4.6E-09	10.4	0.5304	6.9	0.2387	5.9	0.0705	5.7	0.0264
Dickite [225.6] St.George, Utah	2.488	1.3E-09	8.9	0.3162	6.3	0.2006	5.1	0.1388	4.3	0.0916
Diopside [317.6] Finland	3.162	1.7E-11	9.3	0.0522	8.7	0.0441	8.2	0.0336	7.9	0.0256
Diorite Hornblende [152.6] Fremont, Colorado	2.808	4.0E-11	12.0	0.1834	10.0	0.1100	8.8	0.0759	8.1	0.0527
Diorite Hornblende [69.6] Salem, Massachusetts	2.860	5.1E-09	20.9	0.4011	14.6	0.2197	11.8	0.1320	10.2	0.0905
Diorite porphyry [44.5] Jackson, Wyoming	2.608	4.7E-08	59.7	0.6074	24.7	0.5019	14.4	0.3461	10.4	0.2125
Diorite [240.6] Texas	2.759	2.8E-08	64.9	0.6841	24.2	0.6449	14.0	0.3473	10.5	0.1824
Dolomite [102.6] Lee, Massachusetts	2.892	2.3E-14	7.9		7.8	0.0049	7.7	0.0109	7.5	
Dolomite [316.6] Colorado	2.545	7.0E-10	7.9	0.0955	7.3	0.0379	7.1	0.0190	7.0	0.0144
Dolomite [43.6] Thornwood, New York	2.851	1.3E-13	8.2		8.1	0.0136	7.9	0.0246	7.7	0.0269
Dumortierite [190.6] Pershing, Nevada	2.850	9.2E-12	6.0	0.0277	5.7	0.0145	5.6	0.0148	5.2	
Enargite [265.6] Peru	4.796	4.6E-03							299.5	1.4252
Epicote [328.6] Arizona	2.892	1.3E-10	9.2	0.0430	8.9	0.0197	8.7	0.0147	8.6	0.0093
Felsite Porphyry [124.6] Salem, Massachusetts	2.519	9.0E-12	7.9	0.1000	7.1	0.0662	6.6	0.0472	6.2	0.0370
Felsite [96.6] Mattapan, Massachusetts	2.574	3.2E-10	29.3	0.2026	19.1	0.3004	13.1	0.2399	9.6	0.2171
Fluorspar [278.6] Illinois	3.168	1.8E-14	6.8		6.8	0.0023	6.8	0.0093	6.7	0.0118
Gabbro Bytownite [38.6] Duluth, Minnesota	2.915	1.3E-10	16.4	0.1447	14.1	0.0931	12.6	0.0792	11.3	0.0739
Gabbro Hornblende [132.6] Essex, New York	3.486	1.9E-11	11.8	0.2491	9.9	0.0960	9.2	0.0464	8.8	0.0289
Gabbro Hornblende [160.6] Salem Neck, Massachusett	2.829	7.9E-10	19.5	0.3215	14.9	0.1662	12.5	0.1090	11.1	0.0847
Gabbro Hypersthene [75.6] Ontario	2.902	3.0E-11	9.8	0.1353	8.7	0.0685	8.1	0.0381	7.5	
Gabbro Olivine [158.6] Wichita Mtn., Oklahoma	3.045	1.9E-10	16.5	0.1147	14.6	0.0718	13.4	0.0623	12.1	0.0880
Gabbro [84.6] Custer, Colorado	3.047	7.2E-12	11.0	0.0446	10.3	0.0419	9.8	0.0410	9.3	0.0379
Garnet Almandine [114.6] Warren, New York	3.947	6.0E-12	13.7	0.2113	12.1	0.0625	11.6	0.0216	11.5	0.0096
Garnet Andradite [111.6] Graham, Arizona	3.669	2.6E-10	18.0	0.2257	14.2	0.1482	11.8	0.1154	10.5	0.0636
Garnet Grossular [113.6] Transvaal	3.426	8.7E-12	8.4	0.0258	8.1	0.0089	8.1	0.0080	8.1	0.0036

Garnet Spessartine [112.6] Haddom, Connecticut	4.032	2.3E-11	11.9	0.0264	11.6	0.0145	11.4	0.0138	11.2	0.0093
Gehlenite [444.6] New Mexico	3.032	4.2E-11	11.2	0.0489	10.6	0.0250	10.4	0.0143	10.3	0.0083
Glauconite [313.6] So.Dakota	2.425	3.5E-09	44.0	0.3875	27.6	0.3253	18.1	0.2853	12.7	0.2289
Glaucophane [426.6] California	3.017	9.7E-12	11.5	0.0981	10.0	0.0849	8.9	0.0745	8.2	0.0526
Gneiss diorite [464.6] California	2.913	1.6E-10	19.2	0.3579	13.1	0.2355	10.2	0.1515	8.8	0.0951
Gneiss sillimanite-garnet [466.6] Warren Co., NY	3.133	1.4E-10	17.4	0.1562	14.8	0.0992	13.2	0.0740	12.1	0.0590
Granite Aplite [65.6] Boulder, Colorado	2.573	2.3E-12	6.0	0.0113	5.7	0.0249	5.6	0.0208	5.5	0.0137
Granite Biotite [76.6] Rhode Island	2.591	3.7E-11	8.1	0.1354	6.9	0.0835	6.4	0.0494	6.1	0.0292
Granite Porphyry [162.6] Ontario	2.676	3.6E-12	7.4	0.0424	7.0	0.0350	6.6	0.0381	5.9	
Granite Westerly	2.650	9.0E-12	6.9	0.0672	6.2	0.0589	5.8	0.0373	5.6	0.0182
Granite Westerly A	2.650	3.0E-11	7.5	0.0753	6.7	0.0596	6.3	0.0347	6.1	0.0196
Granite Westerly B	2.650	1.5E-11	7.6	0.0740	6.9	0.0583	6.4	0.0361	6.3	0.0157
Granite Westerly C	2.650	8.8E-12	7.0	0.0705	6.3	0.0546	5.9	0.0357	5.7	0.0184
Granite Westerly L	2.650	5.6E-12	6.8	0.0620	6.2	0.0546	5.8	0.0325	5.5	
Granite Biotite [70.6] Pikes Peak, Colorado	2.616	1.2E-11	8.0	0.1066	7.6	0.0853	6.9	0.0645	6.4	0.0479
Granite [150.6] Rockport, Massachusetts	2.606	2.3E-11	6.7	0.1159	5.9	0.0595	5.6	0.0314	5.2	
Granite [244.6] Georgia	2.662	3.3E-11	8.9	0.1097	7.7	0.0807	7.1	0.0390	6.6	
Granite [245.6] Wisconsin	2.577	4.4E-12	6.1	0.0265	5.9	0.0193	5.7	0.0198	5.6	0.0144
Granodiorite [235.6] Colorado	2.626	1.9E-12	8.4	0.1261	6.8	0.1225	5.9	0.0618	5.7	0.0184
Granodiorite [405.6] San Diego, California	2.672	1.8E-11	6.9	0.0594	6.3	0.0443	6.0	0.0301	5.8	0.0168
Granodiorite [64.6] St.Cloud, Minnesota	2.695	9.6E-12	9.0	0.0914	7.8	0.0823	7.0	0.0592	6.6	0.0339
Greenockite [479.6] Pennsylvania	2.870	6.6E-12	6.9	0.0462	6.4	0.0333	6.1	0.0242	5.8	
Gypsum Alabaster [26.5] Pomaia, Italy	2.299	9.5E-12	7.1	0.0833	6.5	0.0306	6.4	0.0120	6.4	0.0018
Halite [433.6] Kansas	2.083	2.0E-14	5.2		5.2	0.0036	5.2	0.0037	5.3	
Halloysite [228.6] Colorado	1.120	2.9E-07	185.9	2.6762	49.4	1.6508	18.5	0.9987	7.9	0.7076
Hauynite [425.6] Germany	2.004	4.1E-10	6.2	0.1854	5.4	0.0680	5.1	0.0306	5.1	0.0104
Hedenbergite [10.6]	3.202	1.5E-08	55.9	0.6349	26.6	0.4948	16.5	0.3012	12.4	0.1830
Hercynite [277.6] Czechoslovakia	3.855	1.3E-07	157.5	0.8168	66.6	0.6253	39.7	0.3497	28.2	0.2313
Helmequistite [251.6] Quebec	2.903	5.5E-10	18.5	0.2222	14.2	0.1646	11.6	0.1299	9.9	0.1050
Hornblende [115.6] Brewster, New York	2.992	3.7E-12	9.7	0.0398	9.0	0.0508	8.3	0.0531	7.8	0.0378
Hornblende [16.6] Ontario	3.133	7.2E-10	18.5	0.2450	14.1	0.1602	11.7	0.1129	10.3	0.0863
Hornblende [177.6] Core Mtn., New York	3.135	2.1E-11	9.1	0.0684	8.4	0.0349	8.2	0.0199	8.0	0.0145
Hypersthene [205.6] Essex, New York	2.781	6.7E-12	16.9	0.0589	15.3	0.0682	14.0	0.0816	11.9	0.1164
Idocrase Vesuvianite [445.6] Mexico	3.465	5.2E-11	9.4	0.0336	9.0	0.0259	8.8	0.0181	8.6	0.0134
Idocrase [446.6] Maine	3.240	1.5E-11	9.7	0.0968	8.6	0.0497	8.3	0.0226	8.2	0.0102
Ijolite [412.6] Colorado	2.944	2.3E-09	15.9	0.4063	11.4	0.2062	9.3	0.1214	8.0	
Jadeite Pyroxene [343.6] California	3.312	1.2E-10	15.7	0.1279	13.4	0.1111	11.3	0.1206	9.5	0.1165
Jamesonite [266.6] Bolivia	4.771	2.1E+01								
Kaolinite [218.6] Macon, Georgia	1.474	4.3E-07	165.0	1.3441	66.2	0.8506	29.0	0.6650	13.7	0.5846
Kaolinite [220.6] Bath, So.Carolina	1.524	2.2E-08	20.9	0.4190	14.7	0.2242	11.8	0.1577	9.4	0.2065
Kaolinite [223.6] Mesa Alta, New Mexico	2.315	2.9E-08	36.6	0.5609	21.3	0.3871	13.7	0.3018	9.5	0.2359
Kernite [440.6] California	1.877	1.9E-12	5.3		5.2		5.2	0.0009	5.3	
Kyanite [187.6] Kenya	3.479	1.0E-12	7.5	0.0103	7.3	0.0095	7.2	0.0096	7.0	
Labradorite [105.6] Essex, New York	2.715	1.1E-10	8.1	0.0727	7.5	0.0366	7.2	0.0253	7.0	0.0195
Labradorite [17.8] Ontario	2.743	1.5E-11	8.4	0.0668	7.7	0.0448	7.3	0.0332	6.8	
Labradorite [314.6] Wyoming	2.714	1.3E-10	7.1	0.0884	6.6	0.0442	6.3	0.0313	5.9	
Lamprophyre [80.6] Fremont, Colorado	2.708	6.5E-11	10.5	0.1782	8.7	0.1077	7.8	0.0763	7.1	0.0562
Latite [174.6] Butte, Montana	2.584	1.8E-11	8.7	0.0811	7.6	0.0894	6.7	0.0766	6.2	0.0399
Latite [175.6] Table Mtn., California	2.629	2.0E-10	16.7	0.5446	10.8	0.2492	9.0	0.1078	8.2	0.0596
Lazurite [416.6] Chile	2.822	4.7E-11	7.3	0.0144	7.1	0.0104	7.0	0.0090	7.2	0.0029
Lepidolite [167.6] So. Dakota	2.794	2.7E-12	22.2	0.2832	13.7	0.3287	9.0	0.2575	6.8	0.1511
Lepidolite [27.5] Keystone, So.Dakota	2.891	2.6E-12	16.7	0.2189	10.8	0.3042	7.3	0.2052	6.3	0.0693
Linnergite [237.6] Colorado	3.016	2.3E-09	18.0	0.3968	12.9	0.1915	10.9	0.1079	9.7	0.0752

Limestone Argillaceous [359.6] Colorado	2.229	1.5E-09	8.8	0.1688	7.5	0.0908	6.8	0.0497	6.7	0.0190
Limestone Argillaceous [381.6] Colorado	2.837	1.4E-09	14.3	0.3651	10.1	0.2087	8.4	0.0937	7.9	0.0279
Limestone Dolomitic [353.6] Colorado	2.519	3.3E-11	10.5	0.2200	8.2	0.1437	7.0	0.0995	6.3	0.0684
Limestone Fossiliferous [355.6] Colorado	2.653	4.1E-12	9.0	0.0153	8.8	0.0121	8.7	0.0091	8.6	0.0084
Limestone Lithographic [356.6] Germany	2.560	2.4E-11	8.6	0.0189	8.2	0.0208	8.1	0.0142	7.7	
Limestone Travertine [357.6] New Mexico	2.408	4.5E-10	9.7	0.0538	9.2	0.0215	9.0	0.0139	8.7	
Limestone Dark Gray [352.6] Pennsylvania	2.760	1.7E-11	7.2	0.1191	6.6	0.0489	6.3	0.0312	6.1	0.0179
Limonite [41.5] Tuscaloosa, Alabama	3.176	3.5E-08	32.0	0.6085	19.8	0.3289	14.5	0.1789	12.4	0.0906
Magnesite [47.6] Victorville, California	2.216	7.1E-09	10.8	0.5696	7.1	0.2650	5.7	0.1284	4.7	
Malachite [28MCC] Bisbee	4.072	1.1E-09	13.8	0.3787	9.3	0.2413	7.3	0.1416	6.3	0.0799
Manganite [212.6] Linnescta	3.984	1.9E-02							917.0	2.1783
Marble Dolomitic [458.6] New York	2.832	1.0E-12	7.7	0.0137	7.5	0.0142	7.4	0.0115	7.3	0.0087
Marble Pink [360.6] Colorado	2.694	5.6E-13	11.7	0.0213	11.2	0.0305	10.7	0.0366	10.2	0.0384
Microcline [103.6] Crystal Peak, Colorado	2.547	5.7E-12	5.8	0.0346	5.6	0.0202	5.5	0.0134	5.4	0.0074
Microcline [108.6] Perth, Ontario	2.549	2.4E-11	21.2	0.2464	12.9	0.3565	8.9	0.1589	8.0	0.0745
Microcline [151.6] Custer, Colorado	2.448	1.4E-11	6.7	0.0286	6.4	0.0256	6.2	0.0280	5.8	
Molybdenite [267.6] Slat Lake City, Utah	2.590	7.3E-06	142.2	2.6024	96.3	0.4962	68.9	0.2158	57.2	0.1603
Monticellite [339.6] Texas	3.103	7.7E-11	8.9	0.1170	8.3	0.0402	8.1	0.0168	8.0	0.0091
Montmorillonite [219.6] Upton, Wyoming	1.902	2.0E-07	178.2	0.8535	97.2	0.4799	58.0	0.3921	33.6	0.4198
Montmorillonite [224.6] Otay, California	1.990	3.4E-07	3147.5	0.4654	1504.1	0.7158	302.1	1.3794	94.7	1.0112
Montmorillonite [229.6] Cameron, Arizona	2.328	4.8E-07	2254.9	1.2572	611.4	1.1794	249.4	0.7458	117.0	0.6365
Monzonite Porphyry [173.6A] Chaffee, Colorado	2.593	9.5E-11	14.4	0.2652	10.8	0.1746	8.9	0.1217	7.8	0.0846
Monzonite Porphyry [173.6B] Chaffee, Colorado	2.593	2.4E-11	7.3	0.0916	6.4	0.0687	5.9	0.0534	5.3	
Monzonite porphyry [406.6] Norway	2.690	4.9E-10	18.1	0.2613	13.9	0.1627	11.5	0.1219	9.8	0.1090
Monzonite [154.6] San Juan, Colorado	2.690	5.9E-12	8.7	0.0592	7.9	0.0562	7.4	0.0364	7.2	0.0269
Muscovite [24.5] Effingham Twp., Ontario	2.771	4.6E-13	8.1	0.0188	7.8	0.0214	7.6	0.0266	7.3	0.0280
Natrolite [168.6] Springfield, Oregon	2.153	1.0E-09	7.7	0.1946	6.8	0.0611	6.5	0.0272	6.2	
Nepheline Syenite Sodalite [156.6] Red Hill, New H	2.591	3.0E-09	16.9	0.5208	10.7	0.2586	8.8	0.1104	8.1	0.0494
Nepheline Syenite [100.6] Bancroft, Ontario	2.628	1.6E-09	10.0	0.5029	7.3	0.1749	6.6	0.0547	6.0	
Nepheline Syenite [83.6] McClure Mtn., Colorado	2.607	5.0E-11	9.1	0.1246	7.9	0.0836	7.2	0.0549	6.8	0.0387
Nephrite Jade Amphibole [296.6] British Columbia	2.910	4.6E-11	13.4	0.1528	11.2	0.1265	9.2	0.1423	7.4	0.1454
Obsidian Black [52.5] Lake Co., Oregon	2.301	2.8E-12	6.5	0.0088	6.4	0.0135	6.3	0.0119	6.2	0.0111
Obsidian Brown [53.5] Lake, Oregon	2.397	1.3E-12	4.4		4.3	0.0161	4.3	0.0178	4.1	0.0127
Obsidian Brown [77.6] Custer, Colorado	2.314	1.2E-10	8.4	0.1922	7.1	0.0840	6.6	0.0457	6.0	
Oligoclase [143.6] Norway	2.569	8.5E-12	5.5	0.0134	5.5	0.0054	5.4	0.0081	5.2	
Olivine Phonolite [157.6] Butte, Montana	2.696	2.0E-08	52.7	0.5603	28.0	0.4238	17.8	0.2978	12.8	0.2264
Olivine [330.6] Colorado	3.204	6.7E-10	17.7	0.7079	9.8	0.3402	7.8	0.1215	7.3	0.0394
Olivine [420.6] Washington	3.306	3.7E-11	7.5	0.0137	7.3	0.0142	7.2	0.0130	7.1	0.0043
Opal [198.6] Humbolt, Nevada	1.890	3.9E-07	207.8	2.3450	73.8	1.2357	25.9	0.8802	13.0	0.5251
Orthoclase [13.5] Ruggles Mine, New Hampshire	2.550	6.9E-13	5.4	0.0108	5.3	0.0122	5.2	0.0169	5.1	0.0195
Orthoclase [82.6] Custer, Colorado	2.587	6.5E-12	6.6	0.0588	6.1	0.0362	5.9	0.0330	5.7	0.0253
Pectolite [208.6] N.Patterson, NJ	2.508	2.3E-11	7.5	0.0964	7.0	0.0313	6.8	0.0133	6.8	0.0053
Peridotite Harzburgite [128.6] Nye, Montana	3.254	8.5E-11	8.7	0.1511	7.8	0.0583	7.4	0.0290	7.3	0.0148
Peridotite Harzburgite [427.6] Montana	3.229	1.6E-11	7.9	0.0295	7.7	0.0162	7.5	0.0134	7.5	0.0094
Peridotite Mica-augite [71.6] Arkansas	2.691	2.4E-07	298.9	1.0940	135.8	0.7381	54.7	0.6772	27.9	0.4673
Peridotite Olivine [63.6A] Jackson, No.Carolina	3.101	2.5E-11	15.1	0.6396	9.9	0.2330	8.7	0.0758	8.3	0.0290
Peridotite Olivine [63.6B] Jackson, No.Carolina	3.101	6.6E-10	9.7	0.2148	8.6	0.0740	8.1	0.0394	7.8	0.0269
Peridotite Olivine [63.6] Jackson, NC.Carolina	3.101	2.9E-11	11.8	0.4191	9.1	0.1416	8.3	0.0541	7.6	
Peridotite Pyroxenite [144.6] Webster, NC.Carolina	2.937	3.4E-11	8.8	0.1759	7.6	0.0744	7.1	0.0332	6.8	
Peridotite Pyroxenite [410.6] NC.Caroline	3.318	1.4E-11	8.0	0.0692	7.7	0.0258	7.6	0.0126	7.5	0.0053
Perlite [72.6] Chaffee, Colorado	2.159	1.0E-10	9.7	0.2394	7.7	0.1420	6.5	0.0991	5.8	0.0756
Perthite [415.6] Perth, Ontario	2.536	6.3E-12	6.1	0.0162	5.8	0.0204	5.7	0.0175	5.4	
Petalite [269.6] Rhodesia	2.566	1.7E-10	7.7	0.3183	6.2	0.1187	5.7	0.0540	5.5	0.0291

Phlogopite [23.5] No. Burgess, Ontario	2.463	1.0E-13	6.2	0.0119	6.1	0.0089	6.0	0.0044	6.0	0.0033
Phonolite Kyemingite [232.6] Wyoming	2.604	6.1E-09	13.3	0.5771	9.4	0.1978	8.3	0.0770	7.7	0.0493
Phonolite [153.6] Cripple Creek, Colorado	2.513	3.7E-05	23.0	0.5478	14.2	0.3163	10.5	0.1842	8.8	0.1106
Phyllite [306.6] Colorado	2.621	1.1E-10	9.4	0.1839	7.7	0.1198	6.7	0.0773	6.3	0.0433
Phyllite [473.6] Vermont	2.728	3.3E-11	18.3	0.1521	15.3	0.1149	13.1	0.0903	11.9	0.0583
Prehnite [203.6] W.Patterson, NJ	2.887	2.5E-12	6.8		6.5	0.0125	6.4	0.0127	6.4	0.0057
Psilomelane [230.6] New Mexico	4.679	2.2E-04			5937.8	0.7016	3851.1	0.5012	2977.0	0.2618
Pumice [62.5] U.S.B.M.	.665	2.2E-13	1.9	0.0292	1.8	0.0281	1.7	0.0159	1.7	
Pyrargyrite [302.6] British Columbia	5.448	2.8E-03							154.3	2.3187
Pyrolusite [280.6] Brazil	3.233	9.7E-03					2940.0	1.7297	2101.0	0.6426
Pyrophyllite [221.6] Robbins, No.Carolina	2.456	6.6E-13	5.3	0.0148	5.1	0.0215	5.0	0.0173	5.0	0.0031
Pyroxene [118.6] Helena, Montana	3.043	3.7E-12	8.4	0.0279	8.1	0.0173	8.0	0.0117	7.9	0.0079
Pyroxene [119.6] Oaxaca, Mexico	3.320	1.2E-09	18.6	0.3087	13.8	0.1830	11.4	0.1233	9.8	0.0888
Pyrrhotite [269.6] Ontario	4.168	1.2E+00								
Quartz Adventurine [117.6] India	2.740	2.6E-12	5.0		5.0	0.0039	4.9	0.0079	4.9	
Quartz Amethyst [204.6] Thunder Bay, Ontario	2.661	3.3E-12	5.1	0.0317	4.9	0.0215	4.8	0.0186	4.8	0.0119
Quartz Diorite Tonalite [171.6] Australia	2.701	1.5E-11	9.0	0.0967	7.8	0.1005	6.7	0.0901	5.9	
Quartz Monzonite Porphyry [234.6] Colorado	2.523	2.2E-10	10.1	0.2198	8.1	0.1222	7.1	0.0803	6.2	
Quartz Monzonite [148.6] Westerly, Rhode Island	2.590	1.1E-11	7.2	0.0774	6.5	0.0605	6.1	0.0382	5.7	
Quartz Monzonite [149.6] Caffee, Colorado	2.620	6.2E-12	8.6	0.0637	7.9	0.0488	7.3	0.0482	6.9	0.0320
Quartz Monzonite [233.6] Arkansas	2.775	2.9E-08	27.6	0.4872	19.0	0.2326	15.1	0.1477	12.8	0.1121
Quartz Rose [104.6] Custer, So.Dakota	2.627	2.9E-12	9.4	0.0978	7.2	0.1925	5.8	0.1126	5.2	0.0600
Quartz Syenite [172.6] Vermontville, New York	2.782	9.5E-10	9.3	0.2808	7.8	0.0950	7.3	0.0434	7.0	0.0248
Quartz Tiger Eye [209.6] So.Africa	2.633	6.1E-11	9.5	0.4547	5.5	0.3158	4.4	0.0875	4.2	
Quartzite pink [379.6] Colorado	2.504	1.3E-11	5.0	0.0157	4.8	0.0165	4.7	0.0168	4.7	0.0084
Quartzite purple [378.6] Colorado	2.606	8.3E-13	5.1	0.0317	4.9	0.0164	4.8	0.0151	4.9	0.0067
Quartzite red [377.6] Norway	2.369	5.8E-10	5.9	0.1549	5.3	0.0582	5.1	0.0246	5.1	0.0098
Quartzite white [382.6] Colorado	2.584	6.9E-10	6.0	0.1972	5.2	0.0603	5.0	0.0290	4.9	0.0103
Rhodonite [320.6] California	3.394	1.5E-11	8.6		8.5	0.0100	8.4	0.0081	8.4	0.0051
Rhodonite [325.6] Colorado	3.406	2.5E-10	8.9	0.0786	8.3	0.0272	8.1	0.0139	8.1	0.0118
Rhyolite altered [243.6] Nevada	2.253	7.2E-10	5.4	0.1780	4.8	0.0677	4.6	0.0350	4.3	
Rhyolite altered [55.5] U.S.B.M.	2.224	6.0E-10	38.8	0.3806	23.8	0.3514	14.4	0.3535	9.1	0.3066
Rhyolite fresh [54.5] U.S.B.M.	2.233	7.5E-10	5.8	0.1959	5.1	0.0596	4.9	0.0183	4.9	0.0097
Rhyolite [101.6] Castle Rock, Colorado	2.122	7.2E-09	10.1	0.4853	7.1	0.2092	6.0	0.1028	5.5	0.0550
Rhyolite [97.6] Chaffee, Colorado	2.237	7.9E-11	4.6	0.0423	4.4	0.0118	4.3	0.0074	4.5	
Rietcckite [326.6] Colorado	3.002	2.6E-10	11.0	0.2501	8.6	0.1474	7.3	0.0968	6.6	0.0617
Rutile [126.6] Oaxaca, Mexico	4.055	4.2E-11	87.1	0.0083	86.2	0.0065	85.5	0.0065	84.5	0.0076
Rutile [137.6] Graves Mtn., Georgia	4.145	4.7E-10	83.5	0.0370	79.9	0.0314	76.0	0.0397	71.2	0.0494
Rutile [98.6] Nelson, Virginia	2.813	4.5E-12	7.8	0.1089	6.9	0.0672	6.4	0.0426	6.0	
Sandstone Arkose [362.6] Colorado	2.319	8.7E-11	6.0	0.1248	5.3	0.0661	5.0	0.0313	4.7	
Sandstone ferrugincus [452.6] New York	2.510	1.1E-10	7.6	0.1117	6.8	0.0608	6.5	0.0278	6.0	
Sandstone purple Landed [453.6] So.Dakota	2.315	1.8E-11	6.5	0.1297	5.5	0.1079	4.8	0.0740	4.3	
Sandstone red [365.6] Colorado	1.629	1.7E-09	18.4	0.3822	10.4	0.3820	6.5	0.3101	4.6	0.2140
Scapolite [350.6] Quebec	2.829	8.2E-11	9.9	0.1117	8.8	0.0569	8.3	0.0255	8.2	0.0090
Scapolite [351.6] Quebec	2.951	1.6E-11	10.6	0.1193	9.4	0.0636	8.8	0.0362	8.5	0.0257
Scheelite [256.6] Ontario	3.232	5.3E-12	6.1		5.9	0.0074	5.9	0.0150	5.9	0.0163
Schist Chlorite [395.6] Colorado	3.189	1.5E-10	15.7	0.1646	12.5	0.1487	10.2	0.1178	9.1	0.0615
Schist Hornblende [196.6] Clintonville, New York	2.993	4.3E-10	11.1	0.2117	9.1	0.1144	8.1	0.0719	7.5	0.0485
Schist Hornblende [241.6] So. Dakota	3.027	2.6E-12	7.4	0.0219	7.2	0.0135	7.1	0.0122	7.1	0.0084
Schist Hornblende [393.6] Colorado	2.945	8.7E-11	9.4	0.1171	8.2	0.0773	7.6	0.0416	7.4	0.0170
Schist Mica [394.6] Colorado	2.722	4.3E-11	10.3	0.2402	8.0	0.1429	6.8	0.0877	6.4	0.0468
Schist Micaceous [396.6] Colorado	2.825	6.4E-11	26.3	0.4390	14.9	0.3763	9.7	0.2494	7.9	0.1111
Schist green [392.6] Norway	2.848	2.6E-11	10.0	0.0570	9.2	0.0537	8.5	0.0564	7.9	0.0374

Selenite Gypsum [333.6] Utah	2.248	1.4E-14	5.9		5.9	0.0031	5.9	0.0046	5.8	
Serpentine [318.6] Colorado	2.632	3.2E-09	21.0	0.1739	17.9	0.1036	15.6	0.1104	13.4	0.1097
Serpentine [8.6] Cardiff, Maryland	2.627	2.1E-10	18.7	0.1645	15.4	0.1243	13.0	0.1174	11.1	0.1163
Serpentinite [60.5] U.S.B.M.	2.655	9.8E-08	99.8	0.7928	36.9	0.7233	19.7	0.4075	14.1	0.2188
Shale Arenaceous [387.6] Colorado	2.223	9.9E-10	10.6	0.3144	7.8	0.1899	6.4	0.1259	5.6	0.0929
Shale Argillaceous [386.6] Colorado	2.289	2.3E-07	1923.3	0.3245	693.6	0.9845	206.1	0.8227	89.9	0.7354
Shale Calcareous [383.6] Colorado	2.497	6.7E-08	42.3	1.3025	19.3	0.6224	12.5	0.2948	9.7	0.1563
Shale Carbonaceous [388.6] Sc. Africa	2.358	1.1E-11	9.6	0.1033	8.5	0.0726	7.8	0.0544	7.3	0.0388
Shale Phosphatic [384.6] Wyoming	2.510	3.3E-11	8.5	0.0154	8.2	0.0112	8.0	0.0114	8.2	0.0032
Shale Black [385.6] Sc. Dakota	2.460	1.0E-09	16.3	0.2394	12.4	0.1703	10.1	0.1391	8.4	0.1209
Shale illite-bearing [449.6] New York	2.506	2.2E-08	24.9	0.4831	17.1	0.2544	13.1	0.1726	10.6	0.1547
Siderite [271.6] Roxbury, Connecticut	3.665	1.2E-10	8.5	0.0304	8.2	0.0115	8.1	0.0106	8.0	0.0160
Sillimanite [186.6] Australia	2.888	1.0E-11	45.9	0.3001	27.8	0.3876	14.7	0.4519	8.3	0.3465
Slate argillite [461.6] Montana	3.036	6.9E-11	9.2	0.0619	8.4	0.0552	7.8	0.0466	7.3	
Slate chiastolic [462.6] California	2.671	1.6E-11	8.9	0.1073	7.6	0.0690	6.8	0.0533	6.6	0.0205
Slate red [305.6] Colorado	2.812	1.1E-10	10.7	0.2415	8.7	0.1203	7.7	0.0827	7.0	0.0754
Smaragdite Amphibole [290.6] Clay, Nb.Carolina	2.953	1.0E-11	7.3	0.0110	7.0	0.0114	6.9	0.0104	6.5	
Socalite [191.6] Bancroft, Ontario	2.651	7.7E-11	9.4	0.0692	8.7	0.0427	8.3	0.0266	8.1	0.0176
Sphaelerite [213.6] Oklahoma	4.061	3.8E-12	9.0	0.1970	8.0	0.0554	7.7	0.0255	7.5	0.0181
Sphaelerite [214.6] Mexico	4.034	5.0E-08	28.2		27.8		27.7	0.0070	27.4	0.0096
Sphaelerite [25RCC] Beaver City, Utah	5.310	8.5E-06			39.4	1.4133	27.7	0.4075	19.8	0.2560
Sphene [189.6] Ontario	3.140	5.8E-12	18.9	0.0876	17.1	0.0606	15.9	0.0430	15.2	0.0295
Spodumene [210.6] Afganistan	3.097	4.9E-13	8.2	0.0398	8.0	0.0143	7.9	0.0146	7.8	0.0095
Stilbite [270.6] Mexico	3.314	6.6E-10	20.1	0.2975	15.8	0.1328	14.1	0.0696	13.1	0.0426
Stilbite [482.6] Nova Scotia	2.220	4.6E-08	22.2	1.0344	12.2	0.4313	9.2	0.1679	7.8	
Strontianite [272.6] Germany	3.468	2.2E-12	8.6	0.0542	8.1	0.0414	7.7	0.0428	7.2	0.0454
Syenite Augite [170.6] Larvik, Norway	2.647	2.0E-09	21.4	0.2344	18.0	0.1095	15.7	0.1011	13.8	0.0832
Syenite Porphyry [178.6] Nassau, Wisconsin	2.672	4.1E-09	14.3	0.3308	10.1	0.2057	8.1	0.1406	6.9	0.1042
Syenite Porphyry [192.6A] Litchfield, Maine	2.550	1.4E-10	13.6	0.4684	8.6	0.2520	7.1	0.0953	6.7	0.0341
Syenite Porphyry [192.6] Litchfield, Maine	2.558	4.8E-10	8.0	0.1643	6.9	0.0662	6.6	0.0236	6.1	
Syenite [39.6] Victor, California	2.722	7.0E-09	22.4	0.6485	13.0	0.3376	10.1	0.1412	9.1	0.0620
Sylvite [430.6] New Mexico	2.132	1.1E-10	12.6	0.2293	9.5	0.1555	8.1	0.0972	7.4	0.0520
Tephrite Olivine [419.6] Japan	3.992	5.8E-11	10.4	0.0714	9.8	0.0281	9.6	0.0132	9.2	
Thenardite [450.6] Arizona	2.573	2.1E-12	4.8		4.7	0.0027	4.8	0.0054	4.7	
Theralite [176.6] Mt.Johnson, Quebec	2.862	1.7E-09	13.9	0.3562	10.8	0.1417	9.7	0.0602	9.2	0.0391
Topaz [184.6] Stoneham, Maine	3.386	7.1E-14	6.7		6.7	0.0060	6.6	0.0159	6.4	0.0200
Tourmaline [120.6] Minas Geras, Brazil	3.148	7.3E-14	5.8		5.8	0.0022	5.8	0.0032	5.6	
Trachyte Porphyry [123.6] Ontario	2.612	5.5E-12	9.9	0.0802	9.0	0.0569	8.4	0.0483	7.8	0.0498
Trachyte Sanidine [109.6] Germany	2.272	1.4E-11	6.2	0.0617	5.7	0.0430	5.5	0.0325	5.5	0.0198
Trachyte Sanidine [99.6] Custer, Colorado	2.370	6.8E-10	12.3	0.3811	8.6	0.2105	7.1	0.1209	5.8	
Trachyte porphyry [400.6] New York	2.578	2.6E-11	7.0	0.1057	6.3	0.0540	6.0	0.0300	5.7	
Trachyte [42.6] Cripple Creek, Colorado	2.543	1.7E-11	8.6	0.1412	7.4	0.0849	6.8	0.0563	6.4	0.0416
Tremolite [312.6] Conn.	2.750	2.6E-10	8.0	0.0790	7.3	0.0417	7.0	0.0269	6.9	0.0196
Trichyrite Lacite [399.6] California	2.456	1.9E-10	18.1	0.3772	11.8	0.2754	8.5	0.2067	7.0	0.1223
Tuff Lapilli [90.6] California	2.038	1.9E-09	74.3	0.3204	33.7	0.5344	18.4	0.3865	12.2	0.2851
Tuff Rhyolite [87.6] Ennis, Montana	1.849	4.9E-09	5.3	0.4186	4.1	0.1337	3.8	0.0370	3.8	0.0020
Tuff green Lapilli [89.6] Butte, Montana	2.140	5.5E-08	58.1	1.0568	23.8	0.6530	14.1	0.3664	9.9	0.2351
Tuff white Lapilli [91.6] Butte, Montana	1.800	1.0E-06	35.1	0.7280	16.3	0.4477	11.9	0.2932	8.5	0.2163
Tuff [62.5] U.S.B.M.	.931	4.6E-11	3.5	0.0500	3.3	0.0485	3.0	0.0638	2.7	0.0645
Tuff [94.6] Colorado	2.413	1.3E-10	8.4	0.1123	7.5	0.0723	6.9	0.0534	6.5	0.0411
Ulexite [441.6] California	1.957	2.9E-12	5.9		5.8	0.0052	5.8	0.0052	5.6	
Uncompahgrite [413.6] Powder Horn, Colorado	3.115	2.8E-10	12.9	0.1230	11.5	0.0637	10.8	0.0384	10.4	0.0286
Uralite Amphibole [345.6] Calumet, colorado	2.990	9.6E-08	284.2	0.8950	52.7	1.4181	19.9	0.8009	11.7	0.3764

Vivianite [257.6] New Jersey	1.844	5.6E-09	23.5	0.4851	14.6	0.3205	10.2	0.2360	7.7	0.1777
Willemite [182.6] Franklin, New Jersey	4.502	2.9E-08	28.9	0.6855	11.8	0.5145	9.1	0.1297	8.7	0.0315
Witherite [273.6] England	4.262	4.9E-13	7.5	0.0302	7.2	0.0168	7.1	0.0117	7.0	0.0043
Wollastonite [346.6] Mexico	2.621	1.5E-11	6.9	0.0152	6.8	0.0046	6.8	0.0078	6.9	0.0046
Zoisite [347.6] Norway	3.101	2.4E-11	8.9		8.8	0.0019	8.8	0.0029	8.8	

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