Research article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

Dielectric study of Dry and Wet granite stones at Microwave frequency

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ABSTRACT:

The dielectric properties (ε', ε") of 30 granite samples collected from Rajasthan, Gujarat, Andhra Pradesh and Bangalore were studied in the range 200MHz - 20GHz at room temperature. The result have been presented in the form of variation of these parameters with frequency which show characteristics features. It is found that dielectric constant values of dry samples come in range of 1.7 to 6.5. The dielectric constant of moist sample increases due to absorption of water molecules. The increment is less due to closeness of inter granite molecules due to which it absorb less amount of water. The dielectric constant and loss of dry granite samples is found in good agreement with literature values.

KEY WORDS: Dielectric Properties, Moisture Content, Microwave

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INTRODUCTIONS

In the presence of microwaveregion the behavior of a dielectric material is fully different from that in presence of a direct current field. In microwavefield the material gets polarized and its degree of polarization depends upon permittivity and permeability of the material[1-2]. Granite is composed of orthoclase, and plagioclasefeldspar (Na or Ca), quartz(SiO_2), hornblende muscovite, or biotite mica (black or brown), and minor accessory minerals such as magnetite garnet and apatite. The composition particles are closed together which in turn depends upon grain size of granite stones. Due to this granite stones of different regions are characterized differently. Dielectric constant is one of the important parameter to study their characteristics[3].

Dielectric properties of granite depend considerably on moisture content in the granite and since there is large difference between dielectric constant of dry granite ($\approx$1.7-6.5) and water (80), addition to water content in granite increases its dielectric properties considerably and provide a tool to study water content in granite samples. Further the study of these parameter isalso helpfulto understand the behavior of induced polarization in granite.Several worker [4-9] reported dielectric properties of rocks and minerals. In present work we studied on dry and wet granite sample. Samples were collected from Rajasthan, Gujarat, Andhra Pradesh and Bangaloreand their dielectric properties with moisture content has been measured in the range 200MHz - 20GHz at room temperature.

EXPERIMENTAL DETAILS

Sample preparation for measurement s

The thirty granite samples were collected from various states of India. Dielectric measurement was carried out on dry and wet granite samples. Each sample was cut by a diamond wheel cutter and they were of dimensions (10mm*8mm*6mm) and were polished to get fine surface for proper probe contact. Dry samples were fully dried for measurement and wet granite samples were saturated with distilled water for seven days. Surface water on the sample was removed before measurements using soft tissue paper.

The samples were studied using Vector Network Analyzer (VNA) at Microwave Research Laboratory, Department of Physics, School of Sciences, Gujarat University, Ahmedabad, India. Samples are shown in figure: 1

Vector Network Analyzer (VNA) Set up

Anritsu Shockline Vector Network Analyzer (VNA) Model No.- MS46322A along with SPEAG DAK dielectric assessment kit as shown in the figure: 2 is used to measure the dielectric measurements like dielectric constant, dielectric loss, loss tangent, etc. for dry and moisture content granite samples over the frequency range of 200 MHz – 20 GHz at room temperature (300.15 K). DAK – 3.5 Probe having frequency range of 200 MHz – 20 GHz. Calibration has been done using two liquids (HPLC water and Methanol) to nullify the measurement error. Dry and moisture granite samples are gently brought into contact with the probe tip (figure: 3). Sweep is commanded to Anritsu Shockline VNA through DAK software and observations of dielectric constant, dielectric loss, loss tangent and electrical conductivity have been carried out by the software itself over the frequency range of 200 MHz to 20 GHz.

Figure 1- samples of granite stones

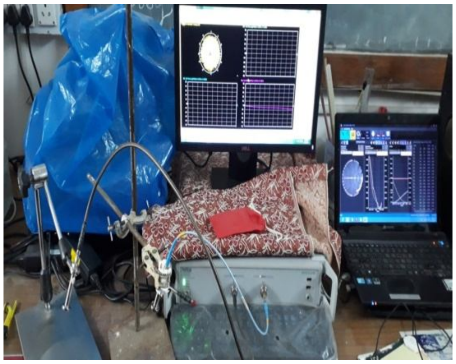

Figure 2- Experimental set up

Figure 3- Sample with probe contact

RESULTS AND DISCUSSION

The measured values of dielectric constant (ε') and dielectric loss (ε'') for thirty samples are given in table 1. It has been found that dielectric constant (ε') of dry granite samples varies 1.7 to 6.5 and for wet samples varies 4.5 to 8.0

The calculated values of dielectric constant and dielectric loss of dry and wet granite samples were plotted against frequencies. They are presented in figure: 4-9.These belongs to Jalore, Sirohi, Barmer (Rajasthan),Palanpur (Gujrat), Mahinoor (Bangalore), Hyderabad (Andra Pradesh) region of India. It can be seen from these plots that dielectric constant and dielectric loss increases with the water content in the granite and exhibit the same general shape, but have different curvature for different type of granite , this indicates that apart from water content in the granite, chemical composition and grain geometries also affect the dielectric constant (ε') of the granite. In these plots at low frequency dielectric constant of dry samples found larger whereas at high frequency region were found almost constant which is generaltendency of rocks materials. In rock materials the low frequency spread is believed to due to polarization associated with charge build up at grain boundaries. Similar response is found for wet samples. These results are in agreement with the earlier reported work [10-14].

The variation in loss tangent (tanδ= ε'/ ε'') with logf of dry and wet granite samples shown in figure 10-15.These plots show typical trends. The observed loss tangent Values of dry sample changes from 0.3 to 0.01 and for wet samples is 0.5 to 0.02. In all sample plots of dry and wet granite we observed at low frequencies (200MHz-less than 1GHz) loss tangent is higher and at high frequencies (1GHz-20GHz) it is low which is almost constant but there are typically some small peaks and dips are found[15-16]. Similar trends are found for wet samples.

TABLE No. 1 "Values of dielectric constant of granite samples at different frequency"

Sample No.	200MHz		1GHz		10GHz		20GHz	
	dry	wet	dry	wet	dry	wet	dry	wet
sample 1	4.5566	5.45473	4.17524	4.4038	3.7723	3.70882	3.8671	3.8819
sample 2	4.2372	5.72766	3.79717	4.7221	3.6061	3.96947	3.8326	4.0951
sample 3	4.2176	5.65505	3.81078	4.6471	3.6878	3.84651	3.7713	3.9329
sample 4	4.5978	5.64391	4.07487	4.49681	3.6425	3.71402	3.7525	3.8344
sample 5	3.9623	4.57267	2.83271	4.16101	2.2975	3.74763	2.2441	3.8657
sample 6	1.788	4.57267	2.44083	4.16101	2.1707	3.74763	2.2008	3.8657
sample 7	4.5861	5.6196	4.22305	4.46891	3.8058	3.72517	3.9486	3.7947
sample 8	4.6303	5.64735	4.15365	4.55199	3.714	3.73323	3.8558	3.6442
sample 9	5.1181	5.69292	4.40687	4.48035	3.6038	3.94262	3.6345	4.1629
sample 10	4.5775	4.89712	3.56119	3.96632	3.0623	3.40895	3.3757	3.6893
sample 11	3.4301	6.39148	2.82504	4.91868	2.5262	3.97035	2.6113	4.1156
sample 12	2.9768	5.09405	2.95162	4.37974	2.30611	3.85755	2.33387	3.9556
sample 13	3.0488	4.5731	3.8716	5.07644	3.4918	4.06607	0.2433	3.5944
sample 14	4.8801	6.94684	4.12637	5.5036	3.5896	4.47149	3.6426	4.6215
sample 15	4.9328	7.29686	4.17906	5.71031	3.6834	4.59159	3.8114	4.8531
sample 16	3.5615	6.75139	2.73044	5.40428	2.3103	4.42239	2.3859	4.6625
sample 17	5.8371	6.40903	4.58585	5.37999	3.7327	4.64055	3.9469	4.8345
sample 18	5.7886	6.31611	4.53331	5.37744	3.7597	4.66862	3.7913	4.7963
sample 19	5.0721	5.36264	3.54838	4.44594	2.8064	3.86001	2.8388	3.9825
sample 20	4.4554	7.18235	3.49215	5.66495	2.8644	4.61144	3.0234	4.6511
sample 21	5.1281	5.70722	4.21165	4.28181	3.6185	3.42539	3.7708	4.769
sample 22	5.5856	6.78352	4.59813	5.16357	3.9247	4.02803	4.0119	4.2903
sample 23	4.4928	5.84916	3.65304	4.4708	3.23	3.54747	3.3969	3.6257
sample 24	5.2778	5.31295	3.87972	4.3844	2.7988	3.78951	3.0285	4.0602
sample 25	5.1294	6.76265	4.21717	5.23332	3.6368	3.94461	3.7534	4.2365
sample 26	6.5788	8.00614	5.27511	6.31794	4.4705	5.11866	4.4654	5.2258
sample 27	5.3356	6.10025	4.3969	4.47385	3.753	3.58498	3.8276	3.5365
sample 28	5.4397	6.88588	4.39774	5.12989	3.7193	4.09471	3.8351	4.2722
sample 29	5.0713	6.23775	4.03144	4.78119	3.4414	3.8544	3.5152	4.022
sample 30	6.0557	6.51858	4.5455	5.45974	3.4783	4.73738	3.6312	4.7884

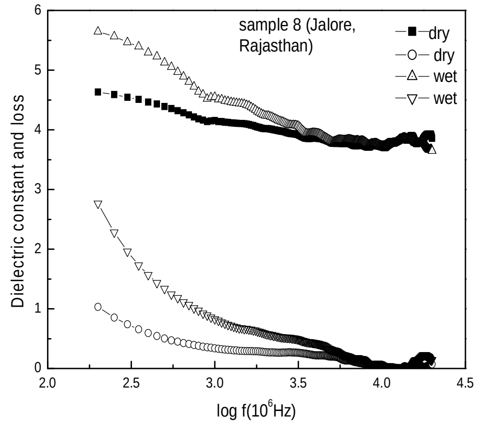

Figure4- variation in dielectric constant (ε') and loss (ε'')of dry and wet granite of Rajasthan with frequency

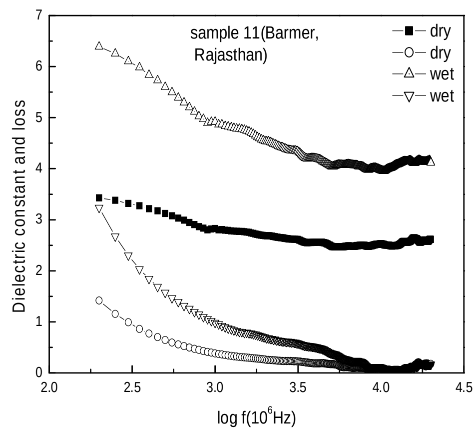

Figure 5-variation in dielectric constant (ε') and loss (ε'') of dry and wet granite of Rajasthan with frequency

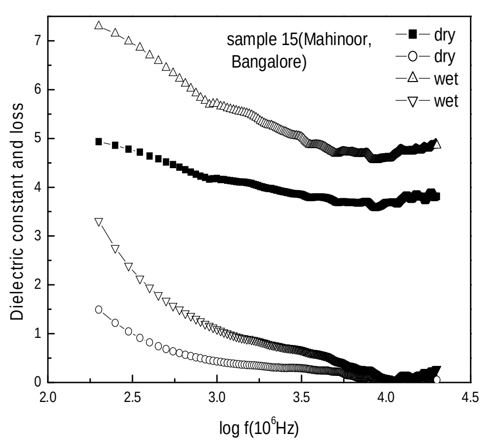

Figure 6-variation in dielectric constant (ε') and loss (ε'') of dry and wet granite of Bangalore with frequency

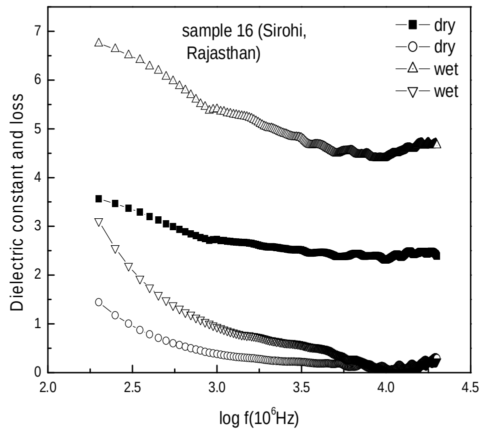

Figure 7-variation in dielectric constant (ε') and loss (ε'') of dry and wet granite of Rajasthan with frequency

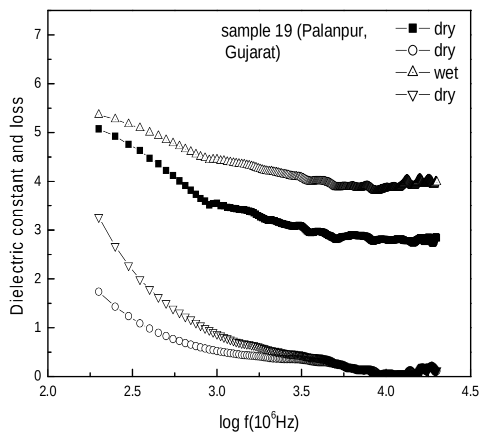

Figure8-variation in dielectric constant (ε') and loss (ε'') of dry and wet granite of Gujarat with frequency

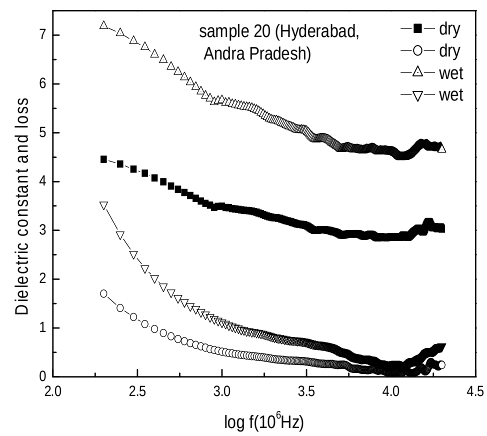

Figure 9-variation in dielectric constant (ε') and loss (ε'') of dry and wet granite of Andra with frequency

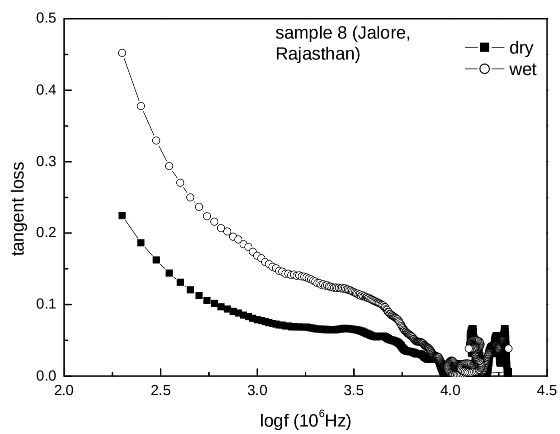

Figure 10- variation in tangent loss (tan δ) of dry and wet granite of Rajasthan with frequency

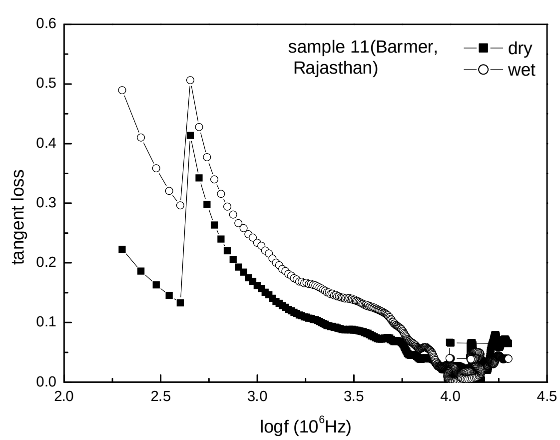

Figure 11-variation in tangent loss (tan δ) of dry and wet granite of Rajasthan with frequency

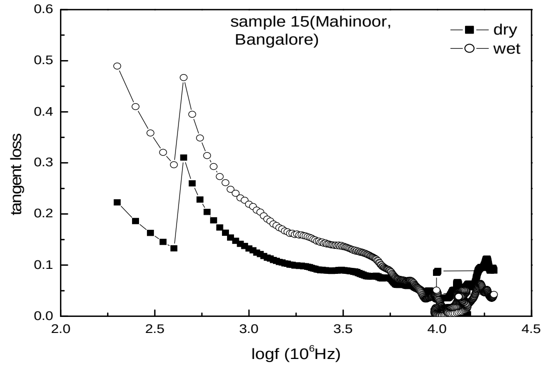

Figure 12-variation in tangent loss (tan δ) of dry and wet granite of Bangalore with frequency

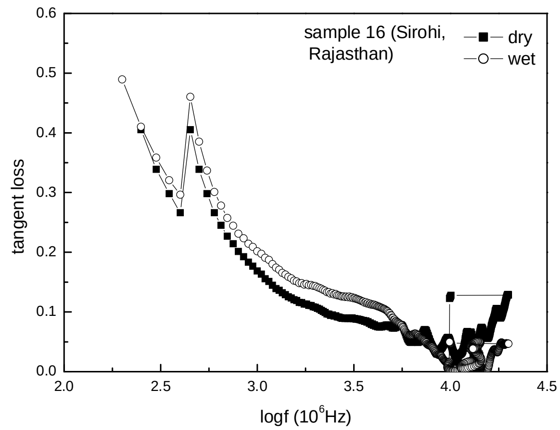

Figure 13-variation in tangent loss (tan δ) of dry and wet granite of Rajasthan with frequency

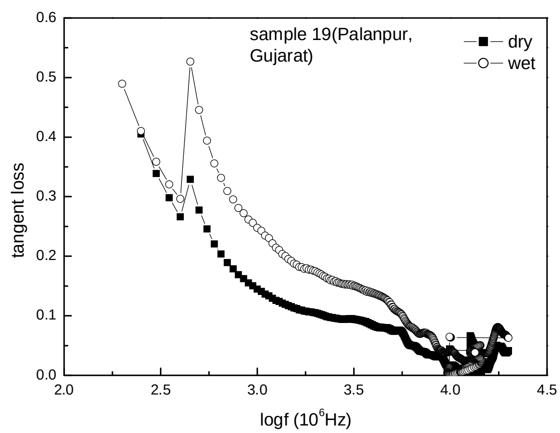

Figure 14-variation in tangent loss (tan δ) of dry and wet granite of Gujarat with frequency

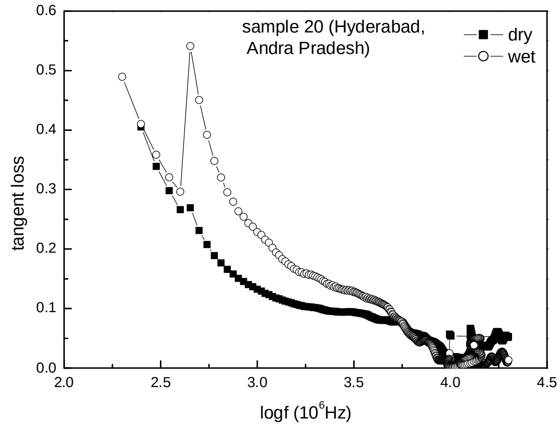

Figure 15-variation in tangent loss (tan δ) of dry and wet granite of Andra with frequency

ACKNOWLEDGEMENT

The authors are greatful to Prof (Dr.) P. N. Gajjar, Head Department of Physics, Gujarat University, Ahmedabad, for providing laboratory facilities. We are also thankful to Prof (Dr.) S.K. Sharma, Head Department of Physics, and Prof. (Dr.) R. J. Sengwa, Jai Narain Vyas University, Jodhpur for constant encouragement.

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