

Dielectric Constant and Emissivity of Rock Samples at Microwave Frequencies

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ABSTRACT: The dielectric constants are measured for five igneous rock samples at three microwave frequencies by using waveguide cell method. The values of emissivity of rock samples are estimated with the use of respective dielectric constant. The estimations of emissivity are made with incidence angles from 0^0 to 80^0 for vertical polarization. The result shows that the emissivity of rock depends on microwave frequencies in x-band region and angle of incidence. Also the change in emissivity for vertical polarization occurs at higher angles of incidence and at change over angle the emissivity reaches to unity.

KEYWORDS: Change over angle, Dielectric constant, emissivity, igneous rocks, microwave frequency, vertical polarization.

I. INTRODUCTION

The study of earth's surface is important for remote sensing applications. The electrical properties like dielectric constant and emissivity of the objects on the earth surface like minerals and rocks are fundamental significance in microwave remote sensing. Emission of electromagnetic energy from an object depends on its dielectric constant, surface roughness, chemical composition, physical temperature, frequency of polarization and angle of incidence [1]. This property of emission of electromagnetic energy is called emissivity.

In microwave frequency region, the dielectric constant and hence emissivity of dry rocks is independent of frequency [2]. The dielectric constant and hardness increases with increasing density of the rock samples, and also dielectric constant observed to be decreased with increasing frequency [3]. In microwave frequency region, the reflection coefficient decreases with increasing frequency and water content of rock samples [4]. Because of absorption of minute amount of moisture from atmosphere, the dielectric constant and emissivity become frequency dependent. The study of emission characteristics of igneous rock samples in microwave region under atmospheric conditions have remained the subject of investigation. In this paper dielectric constant and emissivity for vertical polarization are measured for five igneous rock samples at three microwave frequencies in X- band region.

II. RELATED WORK

A. Measurement of Dielectric Constant

The dielectric constant of five igneous rock samples are Rhyolite, Granite, Tholeiite Basalt, Dolerite Dyke and Ferro Basalt have been measured at three different microwave frequencies in X- band region. The X-band microwave test bench shown in Fig.1 was used to measure dielectric constant of rock samples. Rock samples were shaped according to the dimensions of rectangular waveguide i.e. with 2.286 cm x 1.016 cm. The waveguide cell method was used to measure dielectric constant.

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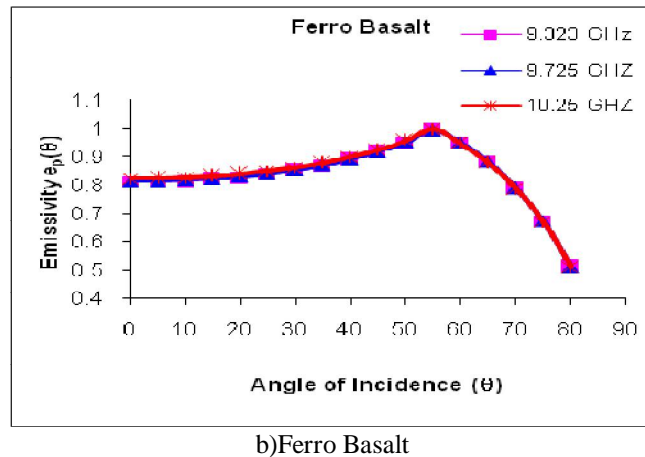
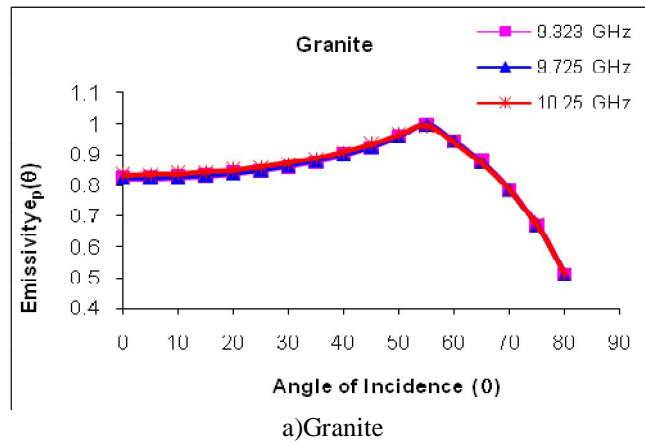
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III. EXPERIMENTAL RESULTS

A. Variation of Emissivity with Angle of Incidence for Vertical Polarization at Three Frequencies.

The studies of emission characteristics of dry and wet soils have been carried by Calla and Sharma [6] and Calla et al. [7]. They studied the emissivity of dry and wet soils from different regions of India at different frequencies and different angles of incidence. Fig. 2 (a-e) shows the variation of emissivity (vertical polarization) for five igneous rock samples with angle of incidence at three frequencies. It is observed that there is a same trend in the variation of emissivity with angle of incidence at all frequencies and for all rock samples.

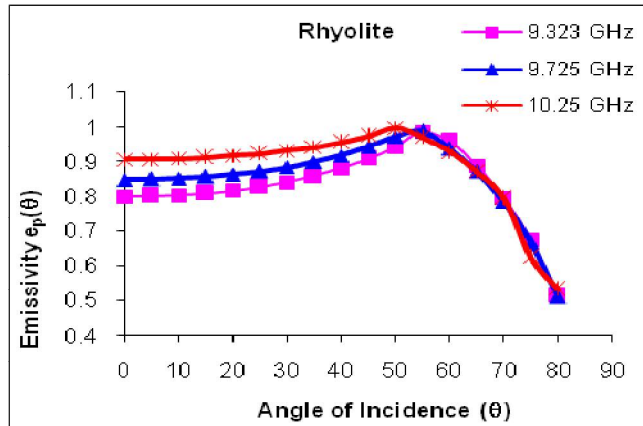


In fig (a-b), Granite and Ferro Basalt rock samples the values of emissivity at 9.32 GHz, 9.75 GHz and 10.25 GHz have negligible difference.

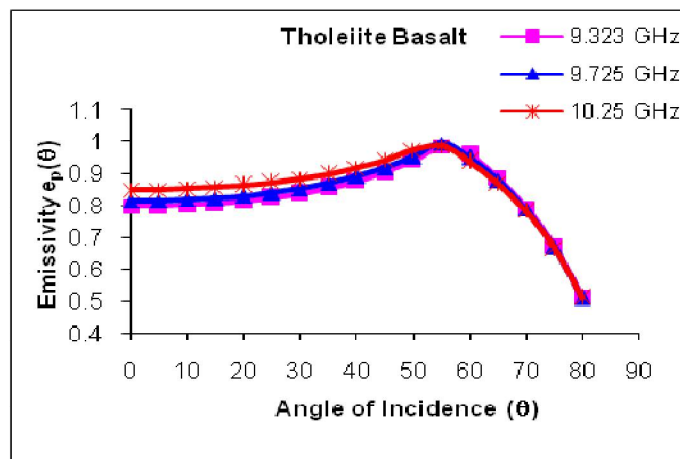
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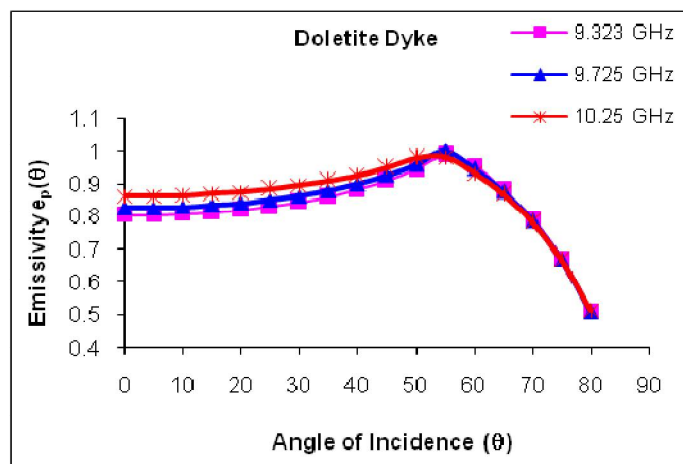
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c)Rhyolite



d)Tholeiite Basalt



e)Dolerite Dyke

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In fig (c-e), observed that for Rhyolite, Tholeiite Basalt and Dolerite Dyke rock samples, for all frequencies, upto change over angle there is significant difference between the values of emissivity. Beyond this the emissivity at all frequencies will try to close with each other and at last at it reaches to about 0.5 at 80°.

B. Variation of Emissivity with Frequency at different angles of incidences

Fig.3 shows variation of emissivity with respect to frequency at three angles of incidence 0°, 45°, 80°, for all rock samples under study.

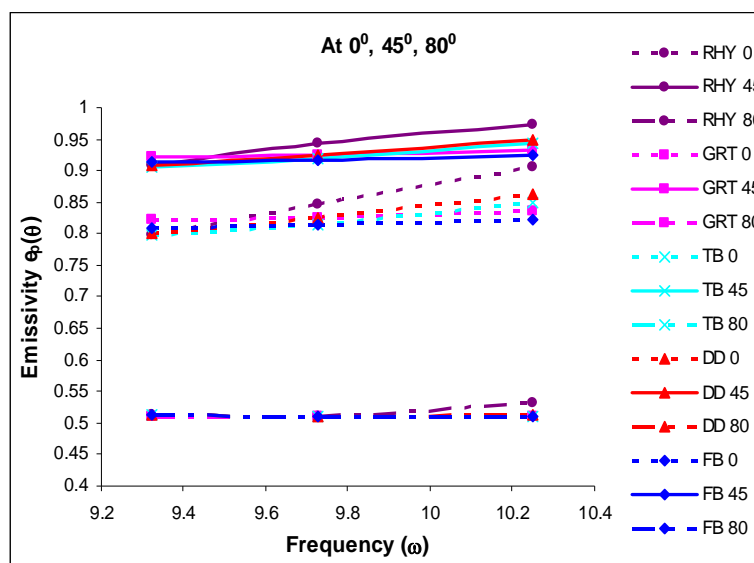


Fig. 3 Variation of emissivity with frequency

Following inferences can be made from this graph

- For 0°, for all rock samples emissivity increases with increase in frequency.
- For 45°, nature of the curves for respective rock samples is same as that for 0° but relative change in the value of emissivity is very small as compared to that for 0°.
- For 80°, from 9.32 GHz to 9.8 GHz the values of emissivity of all samples almost remain constant and coincide with each other. Beyond 9.8 GHz, the values of emissivity of all samples except Rhyolite will get coincide. For Rhyolite there is increase in the rate of emissivity with increase in frequency.
- This means that as we go from 0° to 80° the difference in the values of emissivity for all rock samples will go on decreasing.
- For Rhyolite, the rate of increase in the value of emissivity with frequency is more as compared to other rock samples

IV. CONCLUSIONS

From the results and discussion we have concluded the following points.

- At a given frequency the trend of variation of emissivity with angle of incidence in vertical polarization, for all rock samples under study, is almost the same.
- The value of emissivity for vertical polarization, at all frequencies, initially increases with angle of incidence and then after a change over angle, it starts decreasing. This change over angle lies between 50° to 60°.
- In vertical polarization the change in emissivity occurs at higher angle of incidence and hence it is suitable to study emissivity behavior at these angles.

Such study of emissivity of igneous rocks under ambient atmospheric conditions forms the basis for detecting and mapping areas containing potential deposits of sources of igneous rock using remote sensing

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techniques. It also provides information for designing of passive microwave sensors in microwave remote sensing.

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