

Broadband Dielectric Characterization of Bentonite for Hydromechanical Monitoring

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Abstract. We report a method relying on a dielectric spectroscopy laboratory experimental set-up and on a suitable electromagnetic model for the broadband characterization of compacted partly saturated bentonite under controlled boundary conditions. This work is a step in the development of a non destructive method with a view to the monitoring of the hydromechanical properties of clay materials such as bentonites used in civil engineering works such as nuclear waste repository closures.

Keywords. Dielectric spectroscopy, bentonite, hydromechanical

1. Introduction

Civil engineering works like radioactive waste repositories will implement clay materials like bentonite so as to provide with closures featuring very low permeability to radionuclide. Since such features are a function of the hydromechanical properties of the materials, it is necessary to develop non destructive instrumentation methods for monitoring them. Therefore, electromagnetic reflectometry approaches can be envisaged since they are sensitive to the dielectric permittivity of the materials which is dependent on their hydro-mechanical features. Due to the dispersion of clay materials over frequencies ranging from several MHz to several GHz, broadband dielectric reflectometry measurements are worth envisaging [1] rather than time domain reflectometry methods [2]. Prior to design non invasive reflectometry devices for in situ applications, it is necessary to characterize the dielectric permittivity of bentonite, which has been little investigated yet. Therefore, we propose a dielectric spectroscopy laboratory experimental set-up combined with a suitable electromagnetic model and we report broadband characterization results of bentonite samples.

2. Bentonite dielectric permittivity characterization

The laboratory method proposed to characterize the dielectric permittivity of bentonite samples relies on the measurement of the scattering parameters S_{ij} ($i, j \in \{1, 2\}$) of a two ports coaxial transmission line holding a sample, by means of a vector network

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analyzer (VNA) operating on the 1 MHz – 6 GHz frequency range (Figure 1). Provided an electromagnetic model applying to the experimental set-up [3], the dielectric permittivity of compacted bentonite samples featuring different hydromechanical properties (S_w water saturation, W water content and ρ_d dry density) were determined from measurements, as illustrated by 3 examples in Figure 2.

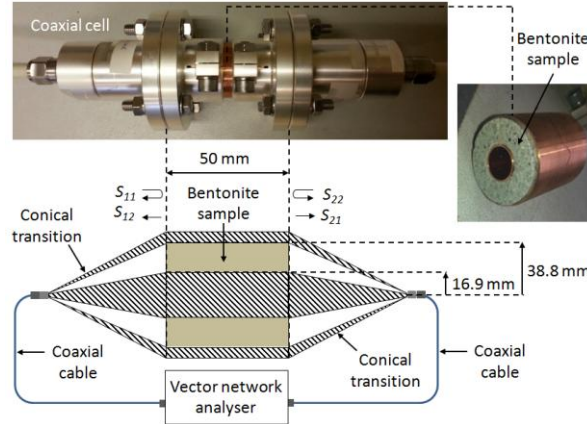


Figure 1. Broadband dielectric characterization experimental set-up.

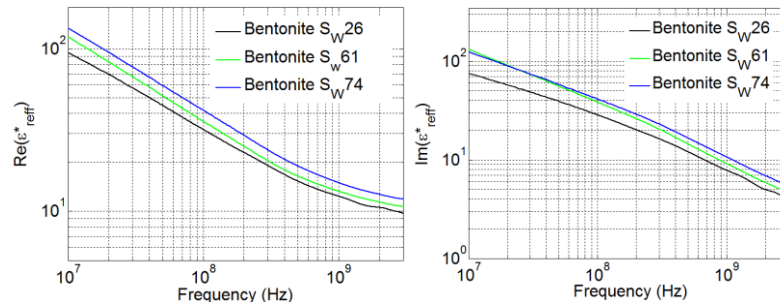


Figure 2. Complex effective dielectric permittivity ϵ_{eff}^* of bentonite samples featuring a S_w of 25.80 %, 60.61 % and 73.59, a W of 8.65 %, 10.8 % and 13.05 % and a ρ_d of 1.55, 1.77 and 1.72 respectively.

3. Conclusions

The dielectric permittivity of bentonites characterized for various hydromechanical features will next be used in finite elements simulations in order to design an open ended coaxial reflectometry probe adapted to non destructive hydromechanical characterization of bentonites used in civil engineering works.

References

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