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Prediction of porosity in mountain rocks

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Abstract: Porosity is one of the most important parameters when studying groundwater. The porosity parameter is used to estimate storage and travel times in aquifers and aquifers. Studies use seepage theory to determine the thickness and variation of rocks. The percentage of voids in a substance is called its porosity. To calculate porosity, it is needed to divide the volume of voids by the material's total volume to get the percentage.

Keywords: porosity, mountain rocks, displacement modulus, leakage theory, seepage theory.

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1. Introduction

Over the past few years, progress in predicting the elastic properties of porous materials over the entire porosity range has been closely related to the power law empirical relationship of Phani and Niyogi.

$$\mu = K_p \left(1 - \frac{P_{\mu 0}}{P_{\mu w}}\right)^f \quad (1)$$

where μ -is the effective displacement modulus of the material with porosity p , K_p -modulus of displacement of solid material, $P_{\mu w}$ - porosity where the effective displacement modulus becomes zero and f - is a parameter that depends on the atomic morphology of the porous material and the geometry of the pores [1]. These parameters are from Wagh et al. mentioned by [2]. A fit of experimental data to equation 1 is often obtained when $P_{\mu w} = 1$ [1, 3], and this fit does not accurately explain the data. In recent experimental work, either $P_{\mu w} \equiv 1$ is better used [4–6] or the linearized model ($f \equiv 1$) [7] by Lam et al., where $P_{\mu w}$ is assumed to be the initial dust porosity.

2. Methodological part

The empirical relationship shown in equation is the same as any collation theory equation for the behavior of shear modulus with displacement and porosity. In addition, the capability of the seepage model for the displacement modulus of porous materials will be demonstrated and the results discussed. The particles of porous materials are made of powders and their size and shape can vary significantly. Different pores can be achieved by changing technological parameters such as external pressure, temperature or time during powder solidification. Compaction begins just by touching the dust particles and progresses to low porosity with the formation and growth of pores between the particles. As a result of the subsequent closing of the pore channels, the process of pore elimination occurs. Usually three different porosity ranges can be defined, for example Danninger et al. [8] observed the following porosity ranges for sintered iron:

1. porosity $\leq 3\%$: fully isolated pores with almost spherical or elliptical shape
2. porosity $\geq 20\%$: complex-shaped fully interconnected pores
3. when the porosity is between 3% and 20%, both isolated and interconnected pores are present in varying amounts.

This indicates that dust coupling is a contact problem generally studied by seepage theory [9]. According to the seepage theory, there is a critical volume fraction, called n_c - seepage threshold, at which the solid phase forms a continuous network covering the entire system. The geometrical, physical and mechanical properties of the system at and above the leakage limit behave as follows.

$$\mu \propto (n - n_c)^f \quad n \geq n_c \quad (2)$$

Here, μ -is the special one under study, and n is the volume fraction of the solid body. Material and f is the theoretically predicted critical exponent for the object under study. The theory of seepage shows that the values of critical exponents are universal, that is, they do not depend on the structure and geometric properties of the system, but on the size of the problem. On the other hand, the value of the seepage threshold depends significantly on the structure. Experimental values of the seepage threshold in the three-dimensional (3D) structure were as high as 0.06% vol and 60% vol.

When porosity is used instead of powder volume fraction in Equation 2,

$$P_{\mu 0} = 1 - n,$$

$$P_{\mu 0} \leq P_{\mu w} \text{ for } \mu \propto (P_{\mu w} - P_{\mu 0})^f \quad P_{\mu 0} \leq P_{\mu w} \text{ for} \quad (3)$$

the formula is obtained. Thus, equation 3 must satisfy the con boundary. $E = E_0$; At $P_{\mu 0} = 0$, it can be expressed as follows:

$$\mu = K_p \left(1 - \frac{P_{\mu 0}}{P_{\mu w}}\right)^f \quad \text{for } P_{\mu 0} \leq P_{\mu w} \quad (4)$$

3. Results and discussion

The resulting equation (4) is the same as equation (1). Leakage theory predicts $f = 2.1$ for the displacement modulus in 3D [12]. This value is determined for a finite cluster or when all dimensions of the system tend to infinity. In a continuum, however, this universal behavior is often affected by the finite size of the system, thus yielding a characteristic rather than a critical one. This means that the characteristic index for all porous materials should be almost the same. On the other hand, the value of the filtration threshold depends on the size, shape, distribution and preparation method of the powder. Here, experimental data from different sources are combined in an attempt to obtain a wider range of porosity for the material under study, thus leading to unrealistic values of the pc compatibility parameters.

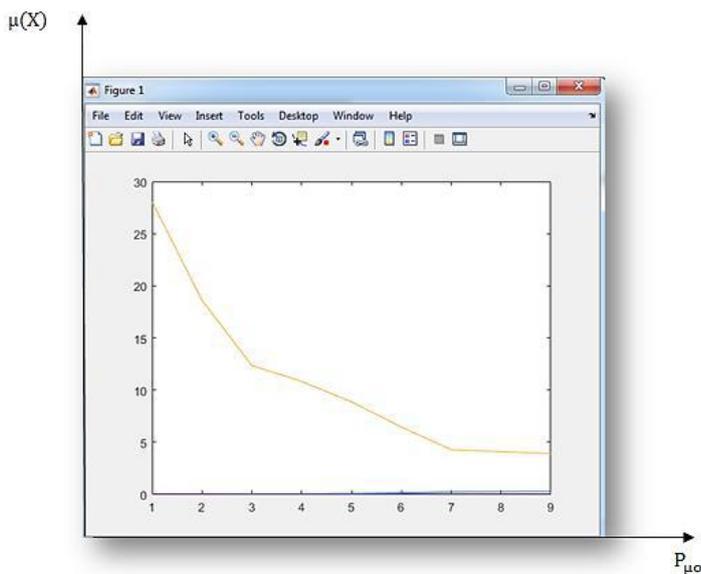
If we apply the obtained equation in determining the porosity of formation rocks in the case that the oil is full of product:

$$\mu(X) = K_p \left(\frac{P_{\mu W} - P_{\mu O}}{P_{\mu W}} \right)^2$$

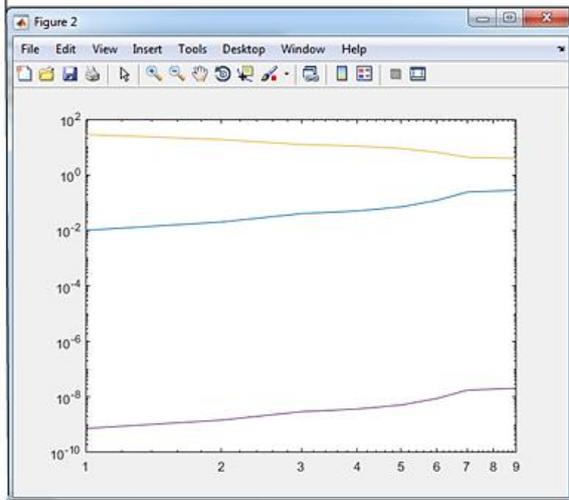
Data statistics are given in table 1:

Table 1.

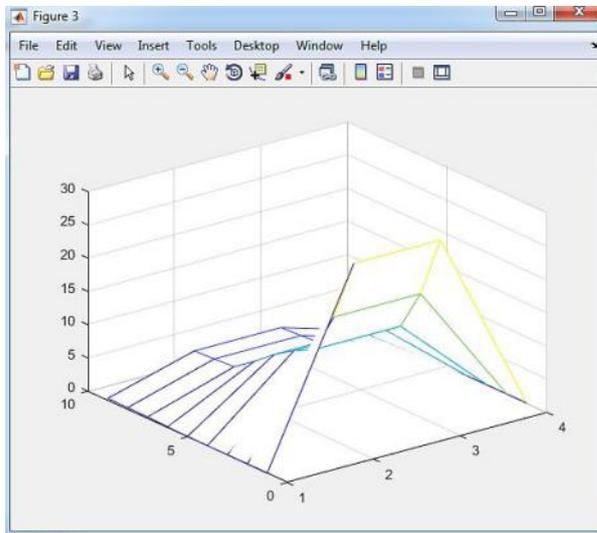
Kp	P μ Dry	P μ Water	P μ Oil
0.01	28.00215609	28.06902632	28.06138849
0.02	18.56439005	18.62162559	18.61655848
0.04	12.30750149	12.35400671	12.35064508
0.05	10.78207279	10.82522932	10.82228368
0.07	8.831781873	8.870116177	8.86770254
0.12	6.415595781	6.446916571	6.445162308
0.24	4.253301857	4.277029962	4.275866145
0.26	4.056133838	4.07908848	4.077978524
0.28	3.88174283	3.903999858	3.902937545



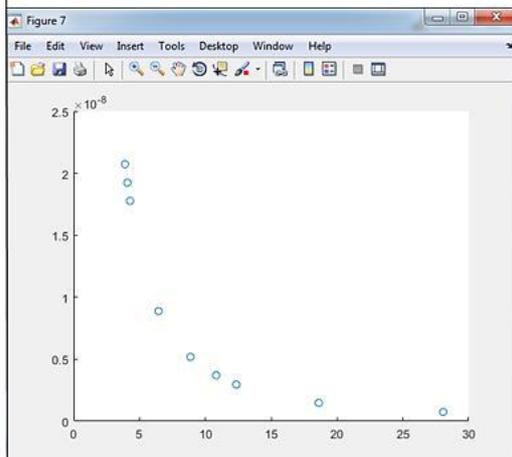
$\mu(X)$



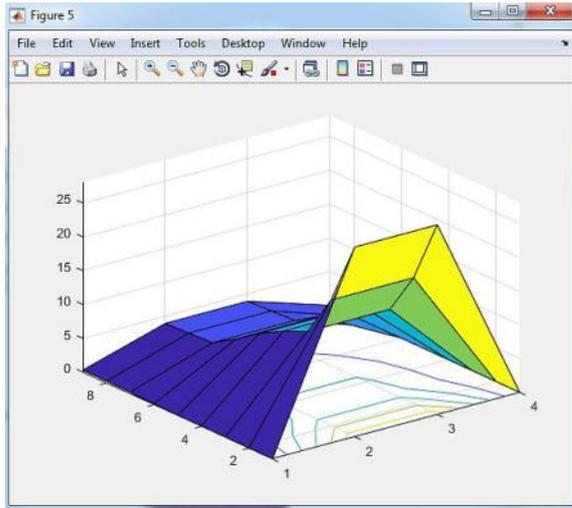
$P_{\mu\sigma}$



$\mu(X)$



$P_{\mu\sigma}$



Kp	PW	PO	EX
0,01	28,06902632	28,06138849	7,4043e-10
0,02	18,62162559	18,61655848	1,4809e-09
0,04	12,35400671	12,35064508	2,9617e-09
0,05	10,82522932	10,82228368	3,7022e-09
0,07	8,870116177	8,86770254	5,1830e-09
0,12	6,446916571	6,445162308	8,8852e-09
0,24	4,277029962	4,275866145	1,7770e-08
0,26	4,07908848	4,077978524	1,9251e-08
0,28	3,903999858	3,902937545	2,0732e-08

```

KP(1-(PO/PW)) EX=KP*(1-(PO/PW))^2;
>> KP = 0.01;
>> PO = 28.06138849;
PW = 28.06902632;
>> EX=KP*(1-(PO/PW))^2;
>> plot(PO,PW)
>> EX=KP*(1-(PO/PW))^2;

```

3. Conclusion

1. Fuzzy set theory in predicting rock porosity has 4 times more accuracy than classical methods.
2. The values of the porosity of the displacement modulus in dry, water and oil environments were determined by the theory of fuzzy sets.

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