Structural stability in synthetic rocks and metallic foams under reservoir conditions #720

Elsa M. de la Calleja*, Ignacio Figueroa y Roberto Zenit

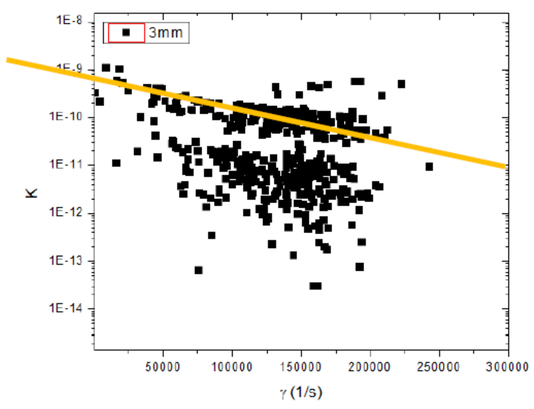
Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México *elsama79@gmail.com

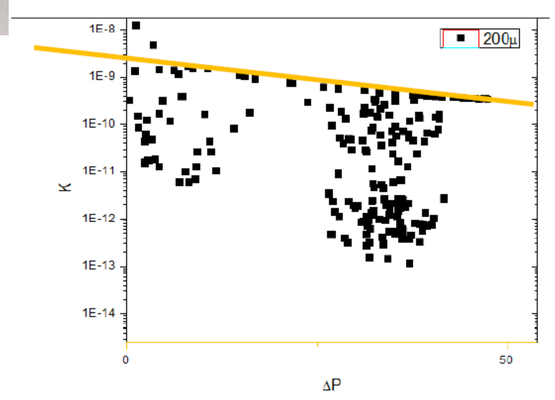
Abstract

In this poster, experimental results of structural stability of synthetic rocks and metal foams[1,2] subjected to reservoir conditions are presented. By controlling the injection of water and mineral oils on a confinement cell, the samples are subjected to conditions of high pressure (25KPSI) and high temperature (200°C). By means of micrography techniques the mechanical deformation of foam layers are characterized. The theoretical and experimental study of permeability and porosity in synthetic media has been studied at low pressures [3,4]. However, in this work we are interested in reproducing conditions close to those of exploration and perforation for geothermal and petro physics procedures. We compare the deformation suffered by metallic aluminum foams, with the behavior of synthetic porous rocks manufactured with glass spheres. Through the theoretical model of Ahmadi [5] we predict the permeability behavior in our samples. To do this we adjusted this theoretical model, taking into account the predictions of porosity and tortuosity proposed for the type of sphere used in our synthetic rocks and foams, as well as the constants of the Kozeny-Carman model [6,7]. The results of our case studies are shown and stability applications are established in studies for exploration and drilling of deposits.

Synthetic porous media [1]

Porous media were built with glass beads under different temperature ramps. The porosity is controlled by the size of the beads. The synthetic porous media were submitted to high pressure conditions up to 25KPSI on a high pressure chamber.





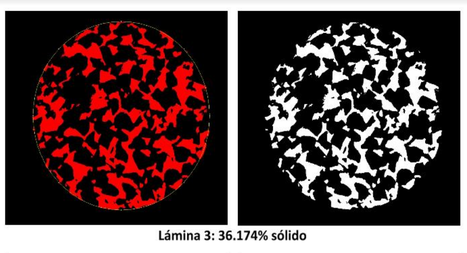
The Darcy's Law give the permeability of the synthetic rocs and the metallic foams by experimental measures using a high pressure chamber.

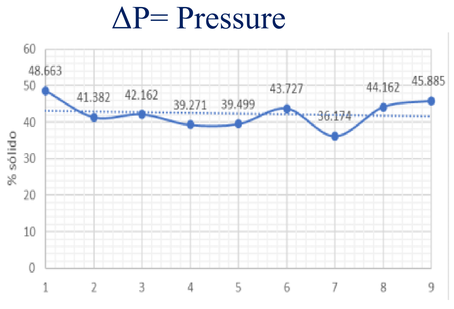
$$Q = \frac{\kappa A}{\mu}\frac{\Delta P}{L}$$

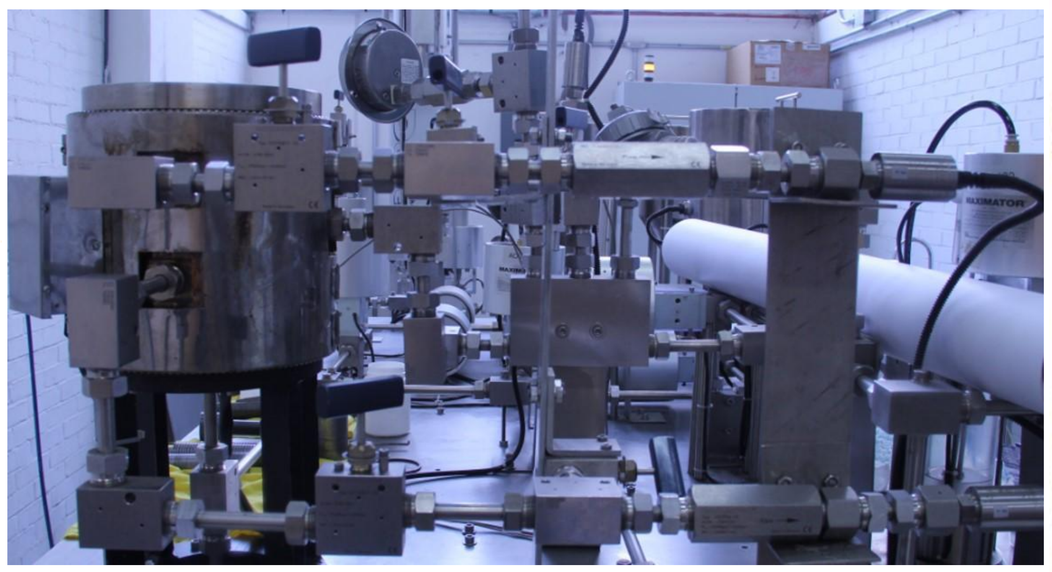
Q= flux,
A= area, L=lenght
μ= viscocity,
ΔP= Pressure

$$k = \frac{\Phi^3}{36 C_f \tau^2 (1-\Phi)^2} d_p^2,$$

The Carman-Kozeny model describe the permeability as a function of porosity.
Φ=porosity,
Cf= Carman-Kozeny factor,
τ=tortuosity

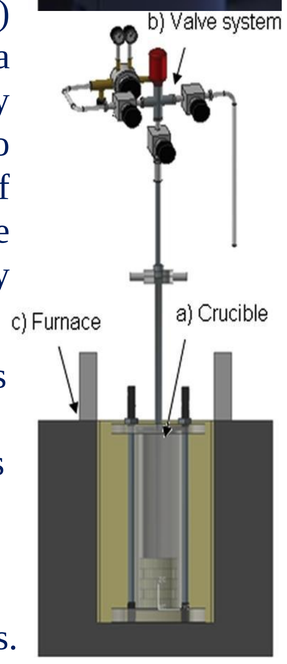






Experimental procedure to manufacture Metallic Foams [8]

The open-cell foams are manufactured by infiltration process, using a replication casting device in controlled conditions. The replication device, shown on the left side, consists of three parts: a cylindrical container made of stainless steel, a valve system and an electric furnace. Cylindrical pre-forms were produced by using amorphous NaCl particles, sieved and separated in two average sizes: (A) 0.7-1mm, and (B) 2-2.38mm. NaCl particles and Aluminum were deposited in the cylinder, subsequently sealed an connected with the valve system. Melting was carried out at 750 °C under a low (Ar) gas pressure of 0.1 MPa for 1 h while infiltration was at 0.4 MPa for 10 min. When the formed Al–NaCl composite was completely solidified, this was extracted from the container and machined to obtain cylindrical samples of 38 mm of diameter and 50 mm of height. The NaCl particles were completely dissolved in H_2O. The porosity was characterized by image processing and calculated by means of the relative density ρ_{Rel}.



Conclusion [1]. The synthetic rocks manufactured with glass beads and metals allow controlling the porosity and hence the permeability. The high pressure chamber apply reservoir conditions to the samples and based on experimental procedures is possible to obtain petrophysical characterizations in laboratory. There area many applications in energy sector, develop of novel materials, biomedical innovations and structural stability of extraction process.

References

[1] de la Calleja, Zenit, R. Permeability in synthetic porous media under reservoir conditions (To be submitted)

[2] G.A. Lara-Rodriguez, I.A. Figueroa, M.A. Suarez, O. Novelo-Peralta, I. Alfonso, R. Goodall. A replication-casting device for manufacturing open-cell Mg foams. Journal of Materials Processing Technology 243 (2017) 16–22 .

[3] D. Hernandez-Diaz, O. Chavez, A. Beltran, A. Garcia, B. Mena, and R. Zenit. Experimental study of the effect of wettability on the relative permeability for air-water flow through porous media (2017) .

[4] Beltran, A., Chavez, O., Zaldivar, J., Godinez, F., Garcia, A. and Zenit, R., A new model for the computation of the formation factor of core rocks, Journal of Structural Geology, 97, 189-198, 2017.

[5] Mohammad Mehdi Ahmadi, Soheil Mohammadi, and Ali Nemati Hayati. Analytical derivation of tortuosity and permeability of monosized spheres: A volume averaging approach. Phys. Rev. E 83, 026312 (2011).

[6] M. Kaviany, Principles of Heat Transfer in Porous Media (Springer, New York, 1995).

[7] B. M. Yu and J. H. Li. A geometry model for tortuosity of flow path in porous media. Chin. Phys. Lett. 21, 1569–1571 (2004).

[8] J. O. Osorio-Hernández, M. A. Suárez, R. Goodall, G. A. Lara-Rodríguez, I. Alfonso and I. A. Figueroa. (2014). Manufacturing of open-cell Mg foams by replication process and mechanical properties. Materials and Design, 64, 136-141.