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Pore fabric anisotropy: Testing the equivalent pore concept using magnetic ferrofluid and synthetic voids of known geometry

S. Jones (1), **P. Benson** (1,2) and P. Meredith (1)

(1) University College London, Department of Earth Sciences, London, WC1E 6BT United Kingdom, (2) Lassonde Institute, University of Toronto, 170 College Street, Toronto, M5S 3E3, Canada

We present results from an experimental and theoretical study of pore fabric anisotropy using the method of anisotropy of magnetic susceptibility (AMS) and synthetic pore spaces of known geometry. AMS has traditionally been used to measure the magnetic anisotropy of a dry rock matrix. However, in this work, we use the technique to directly determine the anisotropy of the void space. We provide the voids with an artificial magnetic susceptibility by saturating them with magnetic ferrofluid. AMS measurements are then made in the normal manner, and interpreted using the theoretical equivalent pore concept (EPC) proposed by Hrouda et al. (2000). This theory attempts to relate the magnetic measurements of lineation, foliation and bulk anisotropy to the physical anisotropy of the real pore fabric, expressed via the principal anisotropy length ratios of the cavity. To achieve this, an average physical pore space shape and alignment is modeled that will produce the same magnetic properties as those measured on the real sample. In order to test the theory, we prepared a range of synthetic samples with known pore geometries from cylindrical polycarbonate blanks 25mm in diameter by 22mm long. Firstly, a set of "special fabrics" were machined axially into the sample blanks: (a) a set of 19 equally spaced holes, 2mm in diameter by 12mm long, representing a needle-like fabric (b); a row of 5 holes, 3.3mm in diameter by 16mm long, representing a planar-type fabric; and (c) a tier of four disks, 18mm in diameter by 1.4mm thick, representing a crack-like fabric. The total bulk susceptibility of each "special fabric" was approximately the same. Secondly, a set of seven samples were machined with quasi-ellipsoidal voids with axial to radial axis ratios of: 0.75, 0.83, 0.92, 1.0, 1.1, 1.2, and 1.3. All of the special-fabric samples

showed high magnetic anisotropy, with a maximum foliation of 1.41 and lineation of 1.29. The results are as expected intuitively, with the needle-like sample exhibiting a highly prolate fabric and the crack-type sample exhibiting a highly oblate fabric. For the quasi-ellipsoids, the foliation decreases and the lineation increases as the axial to radial axis ratio increases from 0.75 to 1.3; i.e. as we move from an oblate to a prolate void. The measured magnetic foliations and lineations are then used to estimate the pore fabric via the EPC, for direct comparison with the known geometry. We find that the EPC method underestimates the anisotropy of the void space, especially for low ferrofluid concentration. As we increase the concentration this discrepancy decreases, but does not disappear even for the highest concentration (undiluted ferrofluid with an intrinsic susceptibility of 3.34). We propose a phenomelogical ‘correction-factor’ based upon the ferrofluid concentration with which to account for this effect.