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Interactive comment on "A Multi-phasic Approach for Estimating the Biot Coefficient for Grimsel Granite" *by* Patrick Selvadurai et al.

Anonymous Referee #2

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General comments

The measurement of the poroelastic properties of low permeability rocks is not an easy task due to saturation issues and pore pressure artifacts. This paper presents a mixed approach for estimating Biot's coefficient based on direct measurements of the bulk modulus of the porous skeleton and estimations of the bulk modulus of the solid matrix from the sample mineral content and the bulk moduli of the constitutive minerals. The paper is interesting and well-written. The authors first summarize the measures of the elastic constants of Grimsel granite available in the literature and discuss their consistency. The transversely isotropic measurements are used to compute an equivalent isotropic skeletal bulk modulus. The multiphasic approach used to assess the bulk modulus of the solid matrix (Ks) is then detailed and upper and lower bounds are

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Discussion paper

computed. The obtained bounds are then used to compute upper and lower limits for Grimsel Granite Biot's coefficient. The consistency of the obtained variation ranges is finally discussed and a set of realistic estimates is provided.

Specific comments

Measurement of Biot's coefficient

Additional information on the test system and the followed loading path associated to the "conventional" measurement of Ks considered by the authors would make it easier to follow the reasoning. Is this an unjacketed test? If not, the flow through the cylindrical sample would be linked to its length or half-length according to the applied hydraulic conditions at the sample ends and not to its diameter. Is the sample initially saturated at a given small confining pressure and then both the confining pressure and the pore pressure are simultaneously increased at the same rate? Or is the sample saturated at a higher confining pressure which is then kept constant as the pore pressure is gradually increased? The later approach would allow the checking of the pore pressure equilibrium at each pore pressure increment (see for example Bemer E., Longuemare P., Vincké O., 2004, Poroelastic parameters of Meuse/Haute Marne argillites: Effect of loading and saturation states, Applied Clay Science, 26, 359-356).

Transversely isotropic material

Equations (1) correspond to the behavior of a transversely isotropic dry porous skeleton. The description of the poromechanical behavior of this porous medium would require the introduction of two different Biot's coefficients (Coussy O., 2004, Poromechanics, John Wiley and Sons, USA). Equations (1) are used to define a bulk modulus for the transversely isotropic porous skeleton through Equation (4). The computed "TI" bulk modulus is then used to compute an isotropic Biot's coefficient through the expression α=1-(Kd/Ks). The transversely isotropic nature of Grimsel granite is thus not fully considered here. This point should be rapidly discussed in the paper.

Measurement of the elastic properties of Grimsel granite

As a general comment on the literature data on the elastic properties of Grimsel granite, the issue of the saturation state of the tested samples should be more thoroughly discussed. The considered elastic properties should be representative of the skeleton behavior (drained or "dry" properties). The skeletal bulk modulus values deduced from measurements performed on "wet" samples could notably be overestimated. The applied confining level would also be a key parameter as the presence of cracks could lead to underestimated skeletal bulk moduli at low confining pressures. The saturation state issue is all the more pregnant for dynamic measurements as dispersion effects could be high for cracked samples and lead to overestimated skeletal bulk moduli.

Multiphasic approach for computing Ks

The void fraction is said to be neglected in the calculations. As the aim of the computation is to derive the bulk modulus of the solid material, the only relevant void fraction should correspond to occluded porosity. It should be clearly specified in the text. Anyway as it is neglected, it should be removed from Equation (7).

Technical corrections

Lines 27-29: Terzaghi's effective stress corresponds to a Biot's coefficient tending towards unity and thus to a case where the bulk modulus of the solid material is small and not large in comparison to the skeletal bulk modulus. Please correct the misprint.

Figure 1: (b) the legend and details of the figure are too small.

Line 81: One extra bracket

Figure 2: Please specify the sample size and its orientation. White lines oriented at 45° seem to be visible on the sample lateral surface.

Line 136: The maximum and minimum values associated to the medium-grained granite are missing in the text.

Line 185: There is a misprint in the unity of Poisson's ratio estimates.

Line 234: Only the Hashin-Shtrikman reference is given in the text, while the keywords include Hashin-Rosen estimates. "Shtrikman" is misprinted line 237.

Equations (13) and (14): The lower (L) estimates are higher than the upper (U) estimates?

Line 242: "skeletal" is misprinted.

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