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Interactive comment on "Stress Characterization and Temporal Evolution of Borehole Failure at the Rittershoffen Geothermal Project" *by* Jérôme Azzola et al.

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This paper addresses the important issue of evaluating a regional stress field from images of two different failure processes (borehole breakouts and so called drilling Induced fractures) observed in deep boreholes with different orientations, as well as from results from various water injection tests. The methodology is applied at the Rittershoffen site, located 6km east from the Soultz site, where the stress field is quite well known. This is an important contribution for the understanding of stress field in deep rock masses and the quality of images as well as that of their analysis justify completely its publication. But before publication of the paper, some errors must be corrected and

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the discussion of results must be revised. Here after my main comments. 1. The GRT-2 borehole is inclined 37° to the vertical so that the axial and tangential stress components at the borehole wall are not principal stresses. Authors must write down the equations they are considering, including the role of pore pressure, and that of thermal stresses. Indeed the principal directions, at the wellbore wall, of stresses resulting from the far field stresses are not the same as those of the thermal stresses resulting from the cooling of the rock. This issue is completely ignored and the paper cannot be published before this is properly dealt with. I encourage authors to look at paper by Wileveau et al. that provides good illustrations of en echelon breakouts observed in inclined wells. (Wileveau Y , F.H. Cornet, J. Desroches and P. Blumling, 2007 ; Complete in situ stress determination in an argillite sedimentary formation; Physics and Chemistry of the Earth (vol. 32, pp 866-878) 2. For their analysis of the width of borehole breakouts, authors refer to three different failure criteria, including the Hoek and Brown criterion. For the parameters to be considered in these criteria, they refer to laboratory work quoted by Rummel, 1991 and by Valley and Evans, 2006. They should also look at the publication by Villeneuve et al. (Villeneuve M.C., M.J. Heap, A.R.L. Kushnir, T. Qin, P. Baud, G. Zhou, and T. Xu, 2018; Estimating in situ rock mass strength and elastic modulus of granite from the Soultz-sous-forêts geothermal reservoir (France); Geothermal Energy, 6(11), https://doi.org/10.1186/s40517-018-0096-1), which address precisely this issue. 3. In their table 3 the density value for the granite is said to be 2570 kg/m3, yet in equation (6) the vertical stress is assumed to be equal to 0.024 z-0.83. These differences should be discussed. In addition, given the vertical stress magnitude is taken into consideration in the three dimensional failure criteria, authors should show how they determine uncertainties on the vertical stress component evaluation. 4. Similarly, equations used for the evaluation of the minimum principal stress magnitude is not described and this should be corrected. Evaluation of associated uncertainty should be discussed. 5. Table 2 indicates values for the Poisson's ratio but no reference is made to Young's moduli nor to thermal expansion coefficients used in equation 8. How are the various parameters measured? How valid

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are those measurements for in-situ properties ? This should be better discussed. 6. In equation (2) the stress component τoct implies the three principal stress components. This should also apply to the mean stress, as opposed to equation written on line 179. 7. In their discussion of results, authors argue that some of the results obtained for the magnitude of the maximum principal stress magnitude do not satisfy the Coulomb stability condition for the rock mass. Interestingly, Cornet (2016) has argued that the large scale fluid injections conducted at Soultz have generated large scale failure zones that are changing in orientation with depth, a feature consistent with the Hoek and Brown criterion but not with a Coulomb criterion. This issue should be discussed more carefully (Cornet, F.H., 2016. Seismic and aseismic motions generated by fluid injections; Geomech. Ener. Env., 5, pp 42-54).

caption of figure 12 has been exchanged with that of fig 13

Because of these many issues, I recommend publication of this paper only after they have been answered, with particular attention to the issue raised on principal stress directions close to inclined boreholes.

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