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Interactive comment on "Fracturing of ductile anisotropic multilayers: influence of material strength" *by* E. Gomez-Rivas et al.

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GENERAL COMMENTS

This contributions presents analogue experiment of multilayer deformation. The authors utilises layered elastoviscoplastic composite materials, which are subjected to bulk pure shear deformation. They report a transition from non-localised (distributed) to localized deformation, discuss the role of mechanical anisotropy and the resulting fracture patterns. In general, the paper in a pretty good form, with only few typos. The analog experiments seem relatively well designed and calibrated. The model results are described into detail and are quite instructive. However I found that some results/statements are quite confusing and that some aspects of the model description are missing. Therefore I provide some comments, questions and suggestions that the

authors can address prior to final publication.

Best regards, Thibault Duretz

SPECIFIC COMMENTS

1) p. 424. You mention the density of the paper flakes. Are they neutrally buoyant?

2) p. 424. Stress and viscosities are important quantities. Do you refer to bulk normal stress (probed along the pistons) and bulk normal viscosity? For plasticines with paper flakes, was the compression direction normal to the statistical orientation of the flakes?

3) Another important parameter is the volumetric fraction of flakes. What is the approximate value of this volumetric fraction of flakes in the presented experiments?

4) Table 1 and 2 contains rheological data (power law parameters and estimated shear moduli). Since the models deals with plasticity and crack formation. It would be nice to list the complete list of parameters (moduli for volumetric deformation, tensile strength, cohesion. . .).

5) p. 427 You mention a 'degree of anisotropy'. This should be important to interpret the results of the experiments. Can you introduce this measurement and give estimations for the different experiments? Is this anisotropy estimation valid for models characterized by intrinsic and composite anisotropy?

6) p. 427 - 5 In the model scaling section, you mention dynamic scaling but I don't find information about the gravity. Are the models scaled with regard to the gravity stress ? Please add information about this and give the complete scaling including flow stress/gravity stress ratios. This is also why the density needs to be mentioned in the parameter table.

7) The values of schist viscosity are calculated for temperatures ranging between 500-700 C, it seems a warm for the middle crust (see table 3 and p. 427-15). Characteristic viscosities of order 10ˆ18 or 10ˆ19 Pa.s for the middle crust is extremely and would be

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likely results in purely viscous deformation and not brittle structures. Maybe the author could use more representative crustal viscosity values for the scaling.

8) p 428-20 - The notion of 'void' is introduced here. What does it actually mean? I seems that these cracks are not related to bubbles since the plasticine receives a special treatment to avoid bubbles. What are the voids filled with? Are these voids corresponding to the cracks themselves?

9) More generally is the process of void/crack collapse relevant for natural rocks since cracks are generally filled with minerals and therefore not willing to collapse ?

10) p. 430-20 The sentence about length scales and strain localisation is unclear. Do you mean that the shear zones do not cut across the entire model?

11) p. 432-20 If I understand well, strain localisation did not occur in plasticines containing randomly-oriented flakes nor in those containing aligned flakes ('. . .samples did not fracture during uniaxial compression', p. 426). Heterogeneities (randomly oriented or aligned flakes) did not produce stress perturbations that were large enough to trigger yielding. Strain localisation only occurred in multilayer cases (composite anisotropy), is that right? If yes, then it is not consistent with the sentence l. 24.

12) p. 433-10 The statements about tectonic underpressure are vague and qualitative - or not well formulated. In Mancktelow (2008), underpressure is shown within an already formed and filled neck (non void) subjected to extension (suction effect, see fig 6). I am not sure there is a statement that underpressure is the reason for forming the crack. I would suggest to either rewrite or remove this part of the discussion.

I would rather discuss the role of stress variations around hetegeneities. In general, stress variations (and hence pressure varaitions) occurs in the vicinity of material interfaces and heterogeneities. Stress variations are indeed proportional to rheological contrasts and geometries. In the presented models, stress variations due to flakes did not promote localisation in non-layered experiments. In the layered case, stress varia-

tions due to mechanical layering are sufficient to trigger the development of structures (i.e. pinch and swells) within the timeframe of the experiments.

13) Strain localisation in viscoplastic multilayers (hence in the absence of any elastic effects) was documented in the numerical models of Schmalholz & Maeder (2012). The experimental conditions are fairly similar to those of the present study, I would suggest the authors to discuss these results.

14) p. 437-25 the fractures are considered as 'easy slip'. Does it mean that, within the duration of an experiment, once a layers breaks (losing cohesion), it cannot heal (by bonding the same way you assemble the multilayer)?

15) From figure 8 (type A) it appears that all the layers do not have the same thickness. Does this affect the model results?

Reference: S. M. Schmalholz, X. Maeder, Pinch-and-swell structure and shear zones in viscoplastic layers, Journal of Structural Geology 37 (2012) 75-88 # TECHNICAL CORRECTIONS 1) In the assembled pdf, all mathematical symbols appear as squares (minus signs, multiplications, tilde).

2) p. 425-16 It is written 'both authors' but three authors are co-signing this contribution.

3) p. 429-10 - 'plasticine' instead of 'plascitine'.

4) p. 429-25 the symbol 'n' has two meanings, one for stress exponent (p. 426), one for fracture counts. Please use different symbols.

5) p. 435-12 'mixed-mode' instead of 'mixed-more'

6) In general figure 8 contains a lot of detailed annotations, it is however not easy to distinguish all the subtleties. For example, I do no see much at the tip of the arrow #1. It could be useful if the authors would select some key features and provide enlarged images of them.

7) Figures 3, 4 and 6 have slightly 'heavy' axis label annotations (e.g. stress (\sigma)

[Pa] (x10ˆ5) on figure 6). In general, I would rather write the mathematical symbol and its corresponding unit, I guess it's just a matter of taste. Also, units are missing for quantities stated in figure 4 (strain rate, effective viscosity).

Interactive comment on Solid Earth Discuss., 7, 419, 2015.