Review of:
Title: Bench scale laboratory tests to analyze non linear flow in fractured media
Author(s): C. Cherubini, C.I. Giasi, N. Pastore
Journal: HESS

Reviewer: Noelle Odling, School of Earth and Environment, University of Leeds.

I read the article with interest although this is rather outside my own area of expertise. The article concerns non-linear flow in fractures. Since in hydrogeology we largely assume linear (Darcian) flow in our calculations of hydraulic parameters, this is of interest to the wider hydrogeological community. Since this rather outside my area of expertise, I cannot vouch for the equations used or the accuracy of the mathematical development. Overall I judge the article to be of good quality, relevant to HESS, and that it makes a substantial contribution and would recommend acceptance after some revision.

In general I found the article quite hard to follow and I think that the paper would be improved with clarification on several points. I have the following specific comments:

1) Fracture apertures of up to 3 mm are reported. What is generating these apertures? Since these were created by hitting the slab, I would expect that much smaller apertures would result if the pieces were fitted together as closely as possible. Please explain how these apertures were generated.

2) Fractal dimensions are reported in Table 2 which were estimated using the box counting method. I assume that the box counting method was applied to the fracture pattern, although this is not stated and this should be clarified. The box counting methods gives results which are scale dependent (i.e. dependent on the number of fractures in the system) unless a large part of the fracture network with a large number of fractures is analysed. Since the experiment contains only 5 fractures, this effect will be present. In addition, these fractal dimensions are not mentioned again in the paper and do not seem to contribute, so I would recommend that they be dropped from the paper.

3) The letter A is used several times in equations as A_1, A_2 and A (equation 12,13 and 14) which is rather confusing. Also you seem to use A_1 to mean both cross-sectional area of the flow cell and storage of the upstream tank (page 5584). Can different letters be use to avoid confusion?

4) Flow through the fracture system is modelled using a finite element model. The modelling is steady state whereas the experiments (if I have understood the procedures correctly) are transient, so how can you compare the results? It is not clear how parameters a_f and b_f are incorporated into the modelling at present. How was the fracture roughness incorporated? The detail of roughness included will depend on the size of the finite elements so this should be given. Do the modelling results depend on the discretization of the fractures?

5) Figure 8 shows a clear division of the experiments into two groups with steep and shallow slopes but this is not discussed in the text. In the text you say that steep slopes of this graph correspond to more linear flow behaviour, so I guess that the

shallow slopes are those with non-linear flow effects. What is causing the difference between these two sets of experiments and why is there such a clear separation between them?

6) The Forchheimer equation has been used to analyse the experiment results, but two other equations (equations 1 and 3) are also give in the introduction. Their fit to the experimental data is not tested. Some justification of this should be made in the paper.

7) It would be interesting to have some discussion about the implications of the findings. What is dependence on fluid velocity here? The head difference across the model is not very large (around 1m) and it would seem that head gradients of this sort are larger than you would expect under natural conditions but could certainly occur during pumping. What implications does the presence of non-linear flow have for determination of hydraulic parameters from pump test results which assume Darcian flow, for instance?

The article is generally clearly written and diagrams are clear. However, there is a tendency to write paragraphs consisting on one sentence and it would improve the paper to gather sentences together into coherent paragraphs.

The English needs improving in some places. Below is a list of corrections suggested:

Page 5576, lines 7-8: … in a laboratory increase our understanding of …

Page 5576, line 9: …fractures which generates a substantial deviation …

Page 5576, line 19: delete 'Successively'

Page 5577, line 11: …valid at low flow regimes…

Page 5577, line 17: Replace 'As far as' with 'In'

Page 5577, line 23: …non-laminar flow regimes…

Page 5578, line 3: … incompressible…

Page 5579, line 28: …vice versa…

Page 5580, line 10: In the literature different laws are reported …

Page 5581, line 22: delete 'respectively'

Page 5582, line 5: In the same way, the effective fracture transmissivity for a discontinuity can be defined….

Page 5582, line 13: … of the flow regime…

Page 5582, line 15: as a first exploratory step…

Page 5582, line 24: replace 'reported' by 'returned'

Page 5585, line 10: …parameters…

Page 5585, line 14: …in-out port configuration. …

Page 5585, line 15: …observes are…

Page 5586, line 8: … of the port holes…

Page 5586, line 10: delete 'manner'

Page 5586, line 15: …figuration of ports…

Page 5586, line 25: …aperture with respect…

Page 5588, line 15: … assuming the cubic law is valid:…

Page 5589, line 1 …(1999) found…

Page 5589, line 4: replace 'individuated' with 'found'

Page 5589, line 6: replace 'planform' with 'area'??

Page 5589, line 21: …has been proved to…

Page 5590, line 1: …assuming the cubic law is valid…