Hydrol. Earth Syst. Sci. Discuss., 12, C113–C117, 2015
www.hydrol-earth-syst-sci-discuss.net/12/C113/2015/
© Author(s) 2015. This work is distributed under
the Creative Commons Attribute 3.0 License.

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Technical Note: The use of an interrupted-flow centrifugation method to characterise preferential flow in low permeability media" *by* R. A. Crane et al.

Anonymous Referee #2

Received and published: 10 February 2015

1 General comments

The manuscript proposes a novel method to characterise preferential flow in low permeability media with preferential flow paths. The method is given by a combination of an experimental and a modelling phase. The experimental phase consists in performing laboratory transport tests using the interrupted-flow centrifugation method. The modelling phase consists in fitting the experimental results with a dual domain model which is a variant of the dual porosity model considering also the molecular diffusion in the immobile domain. The method is applied to three samples of smectite clay dom-

inated samples, with diameter around 10 cm and height between 3 and 5 cm. The results show that the dual domain model fits very well the experimental data and that the model fitting efficiency is relatively insensitive to the model parameters. The conclusion is that the method proposed is a powerful method to characterise preferential flow in low permeability media.

I think that the subject is of interest to the scientific community: as stated by the authors, the hydraulic properties of aquitards are important, as the presence of preferential flow paths can compromise their integrity as barriers to the movement of groundwater contaminants. The method proposed in this paper has the objective of characterizing the dual porosity behaviour of such porous media.

The article is well structured, well written, concise and generally clear. The objectives are clearly stated both in the abstract and in the introduction, where a good list of references is given to introduce the subject.

Therefore, I recommend this manuscript for publication, after some minor revisions suggested in the following.

I have some doubts about the applicability of the method to practical situations. Specifically:

- I wonder at which scale this method can be applied. The samples diameter is around 10 cm and their height between 3 and 5 cm. Can the best fit parameters obtained at this scale be used to model transport at larger scale?
- Does the centrifugation affect the structure of the porous medium, i.e., the connectivity of the preferential flow paths?
- One of the conclusions of the paper is that the modelling enabled aspects of the physical properties of the two domains to be inferred. Moreover, the model fitting is shown to be relatively insensitive to the model parameters; can this fact weaken the former conclusion?

2 Specific comments

- Page 70, line 23: I suggest to modify the sentence in 'the possible dual porosity behaviour' or in 'low permeability porous media characterised by the presence of preferential flow path'. In fact, if the low permeability porous medium is homogeneous, then it does not show any dual porosity behaviour.
- Page 72, line 3: I think it should be specified somewhere in this section that three core samples were analysed, each one coming from a different depth.
- Page 72, lines 16-19: Is there a reason why the clay cores are taken larger than the core holder and then trimmed, instead of taking directly a clay core of the needed diameter? I think some more explanations would be useful here. Moreover, I think the sentence should be rephrased, as it seems that the subject of the verb 'inserted' is 'the outer 5 mm of the clay cores'.
- Page 74, line 20 (and following): I think it should be clearly distinguished between the different dual domain approaches in order to correctly situate the model introduced by the author in the existing literature. In particular, Coats and Smith (1964) and van Genuchten and Wierenga (1976) introduce a model of mobile/immobile type (which I would call dual porosity model). On the other hand, the model introduced by Gerke and van Genuchten (1993, 1993a) is not a mobile/immobile model, as water can flow in both domains (with different velocities) and so the solute can be transported by advection and by dispersion in both domains. This kind of models is more correctly called 'dual permeability model' (see, e.g., Baratelli et al 2014 for more references to the two different modeling approaches). The model introduced by the authors is closer to the dual-porosity mobile/immobile approach.
- Page 76, equations (5)-(7): I think the authors should clearly state how their model is 'novel' (Page 70, line 23) with respect to the model already existing

HESSD
12, C113–C117, 2015

in the literature. I guess the novelty is mainly related to the presence of the molecular diffusion term in the immobile domain; it would be interesting to add some explications to justify this choice.

- Page 76, lines 1-9: I think that the boundary conditions used are not very clear. In particular, the flow is not simulated and so the boundary conditions for flow (line 1) are not required. Moreover, it would be useful to explain more clearly the boundary conditions applied at the top and bottom of the columnn for both the mobile and immobile domain.
- Page 78, line 22-23: It would be interesting to explain the implications of this result.
- Page 79, line 3-4: Is the choice of using the same β as for parallel fracture geometry justified?

3 Technical corrections

- Page 72, line 7: Correct ASTM 2012 with ASTM (2012).
- Page 72, lines 11-12: I suggest to explicitly define the symbols EC and Eh, although I understand that it is a rather standard notation.
- Page 72, equation (2): It seems to me that the results has the unit of [1/T] and not of [L/T] as I would expect for the hydraulic conductivity.
- Page 72, equation (2): I think K should be substituted by K_v, as in the following the hydraulic conductivity is always indicated as K_v without being explicitly defined (see page 78, Table 1, ...).
- Page 76, line 2: exchange -> exchanged.

- Page 76, line 28: I think that ϕ should be corrected with ϕ_T.
- Page 78, line 19: I suggest to add a comma between '0.43' and 'this'.
- Page 82, line 21: afield -> a field.

4 References

Gerke H.H. and van Genuchten M.T. (1993a). A dual-porosity model for simulating the preferential movement of water and solutes in structured porous media. Water Resour. Res., 29:305–319.

van Genuchten M.T. and Wierenga P.J. (1976). Mass transfer studies in sorbing porous media I. Analytical solutions. Soil Sci. Soc. Am. J., 40(4):473–481.

Baratelli, F., Giudici, M., and G. Parravicini. 2014. Single- and dual-domain models of solute transport in alluvial sediments: the effects of heterogeneity structure and spatial scale. Transport in Porous Media, 105(2), 315-348.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 67, 2015.