

Review of Thermal-Plume fiber Optic Tracking (T-POT) test for flow velocity measurement in groundwater boreholes

by

Tom Read, Victor F. Bense, Rebecca Hochreutener, Olivier Bour, Tanguy Le Borgne, Nicolas Lavenant, and John S. Selker

Synopsis

The manuscript describes a DTS cable-based method of estimating the speed with which a heat tracer pulse moves through a borehole. The experiment makes such determinations in a rock well pumped at different rates and finds a linear relationship between pumping rate and water velocity between two fracture sets. The quality of the relationship diminishes as water flows by the second fracture set.

General Comments

The application described in this article is, to the best of my knowledge, novel and timely. The method and results described in this article constitute worthy contributions to the growing use of DTS in hydrological work. On this basis the work is publishable. However, the manuscript may or may not be suitable for print as submitted, depending on the author's vision for it. The length, scope and detail provided in this paper is appropriate for a Correspondence or Note paper, but is less than expected for a full research article. For example, the article is entirely concerned with flow rates in a pumped borehole with virtually no discussion on how this relates to flow rates in the surrounding formation. Further, an estimate was given for the rate of water flow due to density differences between the ambient water and the heated water, but the details of the calculation were omitted as were any cited sources for making an estimate of this kind. This kind of calculation is not straightforward and deserves a higher measure of explanation in a full research paper.

The scope of the article is quite narrow and should be broadened a little to include discussion on how the estimated velocities could be used for practical advantage. Too little given on how this would work be useful in determining ambient flow in the formation, which is presumably an ultimate goal. From the limited information provided, it appears that density flow would be a large concern except where ambient flows were substantial. An expanded discussion of the limiting conditions would be a useful addition.

The total Q_s don't add up to match the pumping rate. The discussion was a bit vague on why, except noting that 1) some density flow is likely occurring, and 2) the effect of poorly resolved plumes above B3-1. Are those the only sources of error here?

The flow in the borehole this test is unquestionably turbulent. How will this relate to near laminar flow in fractures under conditions without pumping? Some discussion of the nature of flow (turbulent vs. laminar) in fractures should be alluded to? Will the linearity seen here be the rule? A little discussion on this would be appropriate since it could be an important aspect of the methods ultimate viability.

In summary, I recommend publication as a Note, with minor revisions. I recommend major revisions if this work is to be published as a full research article. Additional detailed comments follow, below.

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PageNo	Line No.	Comment
3	18	Some mention of density flow due to varying salt content should be made. In open water, such as the case of a borehole, the tiniest difference in fluid density (fourth or fifth decimal place) will result in very noticeable flow.
3	14	The discussion seems to be limited to the case where flow enters the borehole from a single fracture. If there are multiple fracture sets the 1D model won't work - at least not without special considerations. Since the paper goes on to discuss a multi-fracture system, this issue should be brought up at this point.
4	20	The DTS cable was continuous to a depth of 80 m yet the data are truncated at a depth of 68 m, where the heater was placed. Why? From the reader's point of view, background variability might be discerned from the lower section of the cable, which would help evaluate the sensitivity of measurements above 68 m depth.
5	19	The 'elongated' plumes in the shallowest locations in Figure 2 are not visually discernable at all. Also, the symbols in Figure 2 are not explained in the caption or legend. I think they identify the curve peaks. The one in (e) that is associated with line 8 is very peculiar - what is going on there?
5	15	More detail is needed to show how the sampling interval ends up being 1.1 m (and later 1.8 m). The moving average is fine, but what is the spacing of the individual points that are averaged, and on a continuous cable how are those points determined to be at the minimum point spacing?
6	16	More details on the Rayleigh number calculation is warranted since the value reported represents the lower limit of flow detection for the system.
6	6	Why should contributions from B3-2 and B3-2 be hard to resolve? Q_{tot} is constant and you can calculate Q at the bottom, $Q_{bottom}+Q_{middle}$, and $Q_{bottom}+Q_{middle}+Q_{top}=Q_{tot}$. Need more explanation.