

Interactive comment on “Hydraulic properties at the North Sea island Borkum derived from joint inversion of magnetic resonance and electrical resistivity soundings” by T. Günther and M. Müller-Petke

Anonymous Referee #1

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Revision of Paper:

Hydraulic properties at the North Sea island Borkum derived from joint inversion of magnetic resonance and electrical resistivity soundings

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General comment: from my point of view the paper seems to be addressed to specialists is the mathematical apparatus concerning the geophysical data inversion, providing too many details irrelevant for other kind of readers (Nevertheless, these details may

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be insufficient for the ones willing to take advantage of the new inversion approach proposed by the authors, as is becoming usual in our nowadays scientific publications system). In contrast it is a little short in providing the necessary information about some geophysical aspects, with the result that this interesting experiment may result in poor help for other people working in the hydrogeophysical methods.

Specific comments: (Authors text between quotation marks)

Page 3, line 28-29: “For calculation of surface NMR responses a resistivity model is needed that determines the magnetic fields in the subsurface”. This paragraph is confusing. I think rocks resistivity has nothing to see with rocks magnetic susceptibility. The resistivity matrix or filter for MRS inversion is needed to calculate the electromagnetic field (either the excitation one or the one due to precession of magnetic moments of hydrogen protons), not the magnetic field, which can be understood as a natural magnetic field.

Page 4, line 4-5: “However, the instruments do often not deliver reliable phases”. May be a short explanation of this sentence is needed; otherwise it is useless. One of the parameters provided by MRS measurements is the change of phase between the excitation electrical current and the one induced by the water signal, which depends on the layers resistivity and then could be used to acquire the geoelectrical model of the underground.

Page 4, line 16: “There are a few papers dealing with retrieving hydraulic conductivity K from free induction decay (T_2^*) measurements in the field scale.” Almost all the published papers dealing with this questions make also (or principally) used of longitudinal time T_1^*

Page 9: as deduced from Figure 1 you have used a reference coil (presumably connected by means of a diode box to the Tx-Rx coil) at a certain distance. It should be interesting providing some details about this question.

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Page 11, line 1-2: "For joint inversion we chose a 5-layer model to account for the dry sand, the two aquifers, the aquitard and the conductive clay/salt-water zone where we do not expect an NMR signal." May be you should explain why you do not expect a signal from this layer.

Page 11-12: The determination of longitudinal and transversal relaxation times of the NMR signal is a corner stone of the MRS methodology, and the communication of all the experiences acquired is welcome by the MRS community. So it is important to know if all your comments about the influence of magnetic impurities on relaxation time are supported by magnetic susceptibility measurements of these rocks, or they are just speculative (and may lead to confusion). On page 11 line 24 you say: "From borehole logs we observed an increased susceptibility in the second aquifer.but cannot be proved without samples." What kind of logs are you talking about? You mean that you do not have measured susceptibility on rock samples?. Can you provide with susceptibility values?. Why you did not measured T1?.

Page 15, line 7: you refer to a large amount of stacks in your MRS measurements. On table 2, for SKD sounding you have used 32 stacks. This is really a very low number of stacks in the general MRS world wide experience. It would be very interesting if you add some figures showing some field results: $e(t)$, $E_0(q)$, noise (q), phase (q), etc.

Technical corrections:

Page 5, line 6: write $u = Kw$ instead of $u = K f$

Page 5, line 12: I suggest changing "(calculation of B fields and.." for (calculation of magnetic field intensity B and. . .

Page 9, line 1: "MRS soundings" is a redundancy. Say MRS or MR soundings instead.

Page 9, line 7. mind sounding PO5 is not labelled at Figure 1.

Page 9, line 12: "Magnetic field was about $49.3 \mu T$." Geomagnetic field was about 49300 nT. (I suggest using nT, more usual within the geophysical world).

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Page 9, line 17: .."with small instrument dead times". Please, quantify "small".

Page 9, line 19: pulse moment is usually expressed in A ms. I think it is better to be consistent in the use of units. If you are talking about a pulse length of 40 ms (and not of 0.040 s), why not to say 7000 Ams?

Page 10, line 1: please, quantify "a very good noise level".

Page 10, line 16: say "resistivity inversion models.." instead of "resistivity inversion.."

Page 10, line 19: I do not understand what you mean by surrounding in the sentence "It is followed by a silt-sand-clay layer surrounding the Holocene base".

Page 10, line 21: ". . .sand and clay at about 50 m." of depth?

Page 12, line 21 About the title "3.3 Soundings OD33: hydraulic calibration". You say nothing about calibration in this paragraph.

Page 15, line 14: "However, the latter. . ." The latter what? Please, modify this sentence.

Page 17, line 1-3: may be there is something wrong in the figures. Transmissivity should be $9.86 \times 10^{-4} \text{ m}^2/\text{s}$, and calibration factor becomes 1.01×10^{-6} (for porosity in %/100 and time in ms). Could you add some references for this value "well in the literature ranges"?

Page 18, line 25 number of unknowns

Page 19, line 1: "(iii) Noise Cancellation techniques improved the data quality of MRS significantly." Please, provide some information about the noise cancellation techniques you have used.

Page 19, line 2: "The data presented have very good S/N ratio". Please, give some figures of S/N.

Figure 1: - Indicate units and system of coordinates - VES, borehole and HEM marks are not visible - MRS PO5 is not labelled. - For decay time you should use ms for

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consistency with other figures and Table 3

Figure 2: depth number in the lithological column are not visible Figure 3, 4, 5 and 6: -
add units for porosity (%) - T2* is in s, and not in ms

Table 1: add units to water content [%]

Table 2: could you add a column with the Signal/Noise, and other one with the maximum E0 values?

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