

## ***Interactive comment on “Estimate of ULF electromagnetic noise caused by a fluid flow during seismic or volcano activity” by V. V. Surkov and V. A. Pilipenko***

**V. V. Surkov and V. A. Pilipenko**

pilipenk@augzburg.edu

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In our paper the main concern is on the comparison between electrokinetic and MHD effects upon pore fluid flow. We believe that this point is very important for adequate interpretation of seismo-electromagnetic data and understanding of the role played by both effects. Additionally, we have revised the estimate by Kopytenko and Nikitina (2004a,b) of the geomagnetic perturbations due to magma motion. We have demonstrated that the effect of rock conductivity results in a significant decrease of the above estimate.

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We agree that the references in the introductory part are not complete, and appreciate additional references to the basic principles of the electrokinetic effect, suggested by the Reviewer. Though, their consideration is beyond the scope of our paper, we are ready to revise the m/s accordingly.

However, we wonder why the Reviewer did not pay attention to the new results in the paper, and had not discussed whether they are correct or not.

Here are point-by-point replies to the reviewer comments.

The reviewer wrote: “Please cite the fundamental literature on the subject (e.g., Pride, 1994 and many others.)” We shall add references to the paper by Pride (Pride, S. (1994), Governing equations for the coupled electromagnetics and acoustics of porous media, *Phys. Rev. B*, 50, No. 21, 15678-15696.) as well as the paper by Mahardika et al. (Mahardika, H., A. Revil, and A. Jardani (2012), Waveform joint inversion of seismograms and electrograms for moment tensor characterization of fracking events, *Geophysics*, 77(5), ID23-ID39, doi: 10.1190/GEO2012-0019.1)

The reviewer wrote: “Eq. 5 cannot be found in de Groot and Mazur which is a general textbook on cross-coupling phenomena. But it does not deal with electrokinetic effects.” Indeed, the book by de Groot and Mazur contains the electrokinetic effect (page 438), but only in the form of Onsager reciprocal relations. We shall cancel the corresponding reference before Eq. (5).

The reviewer wrote: “Volume averaging theory implies that the formation factor and therefore a tortuosity factor should be generally present in Eq. 5.” This is beyond the scope of our present paper which focuses on the simple estimates and comparison between the electrokinetic and MHD effects.

The reviewer wrote: “A lot of the math can be found in Kopytenko and Nikitina.” In our paper we have shown (see Eq. (15)) that the approach of Kopytenko and Nikitina (2004a,b) is incorrect and it gives overestimated electromagnetic effect caused by

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magma motion, because they had not account for the rock conductivity. On page 16 of our paper we clearly indicated: “In contrast to (Kopytenko and Nikitina, 2004a, b), we have found that the rock conductivity reduces this estimate essentially.”

The reviewer wrote: “The authors forgot to make the connection with the generation of the cracks (where is the statistics on crack formation and therefore electromagnetic noise?).” The micro-cracking is just another possible mechanism of the electromagnetic noise generation, and it has not been considered in the paper. We have to repeat that this effect is beyond the scope of the present paper since the crack generation triggers many physical mechanisms which are capable of producing the electromagnetic noise. A more complete treatise on the effect of random crack generation and distribution are found in our previous papers (e.g., Surkov, V. V., and M. Hayakawa (2006), ULF geomagnetic perturbations due to seismic noise produced by rock fracture and crack formation treated as a stochastic process, *Physics and Chemistry of the Earth*, Vol. 31, Issues 4–9, 273–280.)

The reviewer wrote: “Therefore I don’t think this paper can be consider as new enough to warrant publication.” Considering this remark, we note that the reviewer has not paid attention to the following new points: (1) We have studied the Hall current/magnetic force which are usually ignored in the papers on electrokinetic effect (for example, see fundamental equations (9) and (38) for current density in porous media (Pride, 1994)). (2) We have added new terms into Onsager reciprocal relations and compared the electrokinetic and MHD effects due to conducting fluid motion. (3) We have obtained a new estimate for geomagnetic perturbations caused by magma motion along volcano vent that specified the estimate by Kopytenko and Nikitina (2004a,b).

Finally, the Reviewer did not find any errors or wrong conclusions in our paper.

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