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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Pre-earthquake magnetic pulses" *by* J. Scoville et al.

J. Scoville et al.

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Dear Dr. Masci,

Thank you for your comment. First, note that the data presented in the paper by Dahlgren, et al.[1] does not actually support its conclusion that "no electric current was generated in fluid-saturated samples during several cycles of stress loading." In fact, the "stress-stimulated currents" in fluid-saturated samples were much larger than those reported for dry samples. Figures 4b and 5b, attached, clearly show changes in electrical currents over the course of stress-loading cycles. It is unclear how or why the authors of this paper arrived at a conclusion that directly contradicts their experimental results, or how such an obvious contradiction could have been overlooked during the review process.

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Moreover, the data presented by Dahlgren, et al. are incorrectly plotted as “currents” whereas the graph captions state they are “stress-stimulated currents” or “SSC”. This quantity, not the same as a physical electrical current, was apparently contrived for the purposes of this paper. Also note that its repeated reference to Freund (2002) is incorrect - the experimental setup does not appear there.

Dahlgren, et al. define “SSC” not as a current, but as a difference of currents. In the SSC, “baseline” levels of currents were subtracted from the data, so, in reality, the values plotted are not absolute currents, but rather offsets from a baseline value. Without information about the baseline currents, the SSC is meaningless. Ostensibly, this definition was introduced to take into account the effect of electrochemical (galvanic) potentials. However, it is more likely that these potentials actually result from the large pre-loading force that was applied to the samples before the baseline level was recorded. Referring to (and drawing conclusions from) the SSC values as if they were currents is not only misleading – it is not physically valid. The situation is somewhat reminiscent of a merchant zeroing the value of a scale while leaning on it.

There are many reasons that the experiments described by Dahlgren, et al. are not analogous to conditions deep in the crust. Liquid water can’t exist deep in the crust where temperatures exceed 400C. At these temperatures and pressures, water exists not as a liquid but as a supercritical fluid with very different physical and chemical properties. Also, the measurements involving fluid-saturated samples were actually of a circuit containing both a rock and a resistor, the latter having been introduced due to difficulties with an ammeter.

Furthermore, the presence of free water deep in the crust isn’t a fully established fact. It is one of several hypotheses that have been proposed to explain anomalous regions of high conductivity for which there is no generally accepted explanation. Alternative explanations include partial melting, intergranular carbon films, and – notably - peroxy defects[2]. Silicates that incorporate water into their structures form peroxy defects by a redox mechanism. In this way, our paper already describes one mechanism by which

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deep crustal water could lead to the generation of charge carriers and magnetic pulses.

In terms of more shallow liquid water between the source of a pulse and its observer, attenuation of magnetic fields through a conductive crust are considered in the study by Bortnik et al. referenced in our manuscript. In an attempt to keep the number of free parameters in our model to a minimum, we have not considered attenuation, reflection/refraction, surface geometry, etc. related to the propagation of electromagnetic pulses through the crust and the air/ground interface. A future study may consider these factors.

All this being said, the simplest response to your query, perhaps, is that at depths of more than a few kilometers the pore spaces of rocks are closed by the overload pressure. Without a connected pore space, no contiguous voids exist within the rocks for water or other fluids to fill.

Best regards,

John Scoville

References:

1. Dahlgren, P. R., M. J. S. Johnston, V. C. Vanderbilt, and R. N. Nakaba (2014), Comparison of the stress-stimulated current of dry and fluid saturated gabbro samples, *Bulletin of the Seismological Society of America*, 104, 2662-2672.

2. Freund, F. (2003), On the electrical conductivity structure of the stable continental crust, *Journal of Geodynamics*, 35, 353-388.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 7367, 2014.

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Interactive Comment

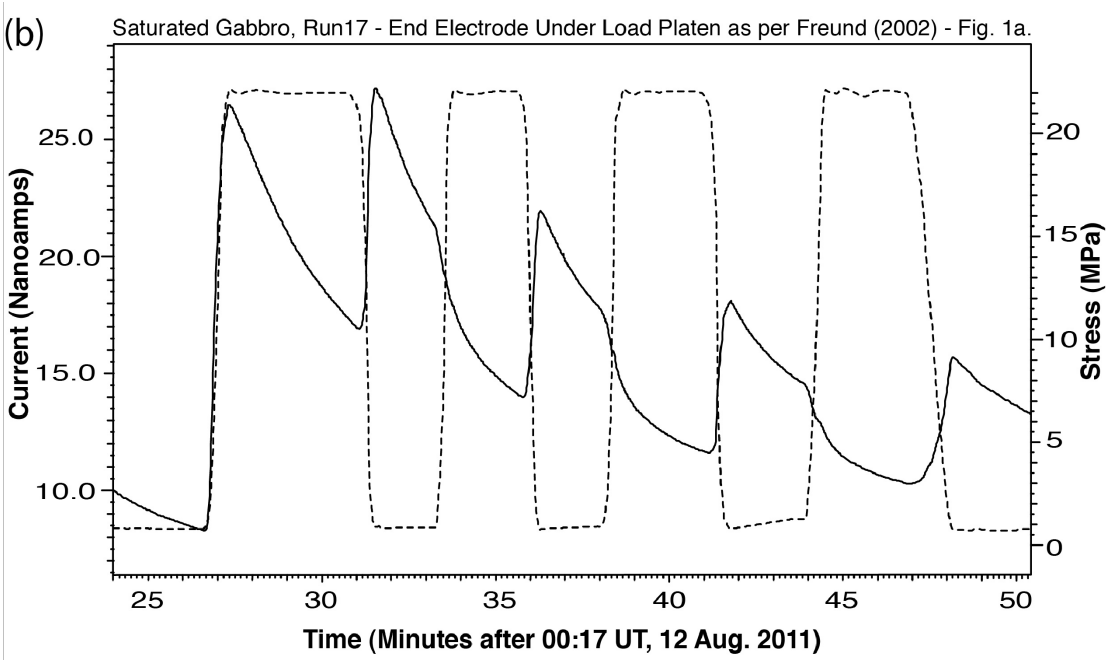

Fig. 1. Fig 4b, Dahlgren, et al. (2014)

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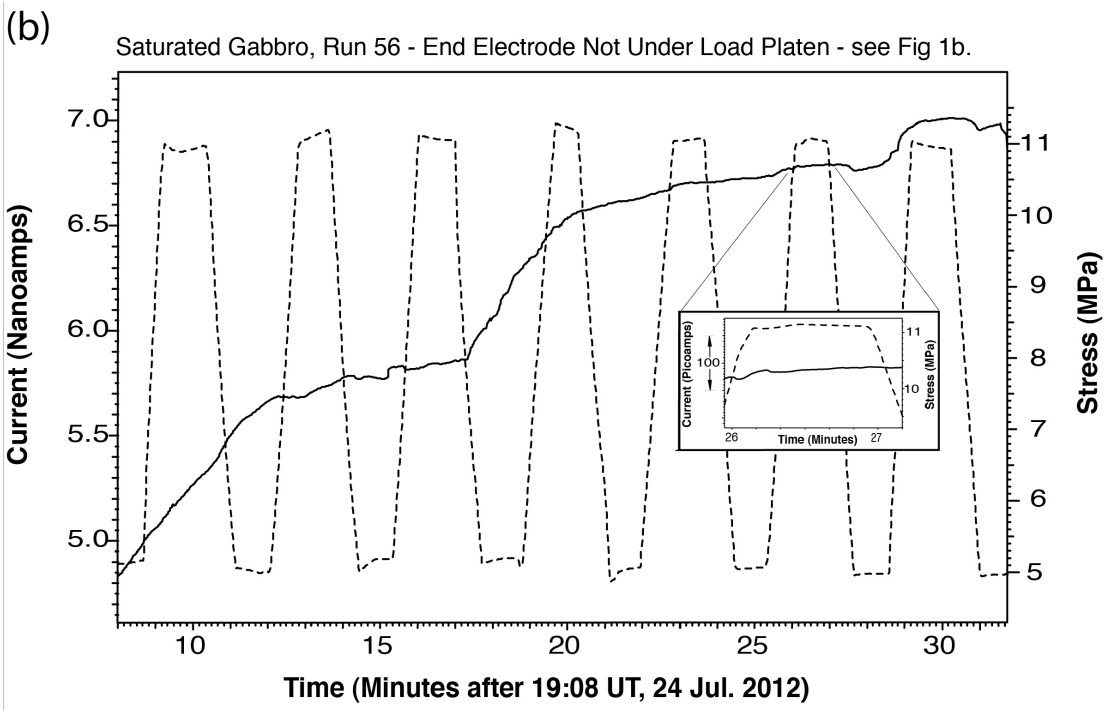

Fig. 2. Fig 5b, Dahlgren, et al. (2014)

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