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A comparison of DC and time-varying measurement of electrical conductivity in randomly generated two-phase networks.

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Most electromagnetic (EM) geophysical methods focus on the electrical properties of rocks and sediments to determine reliable images of the subsurface, images routinely used in a broad range of applications. Often laboratory measurements of the same EM properties return equivocal results that are difficult to reconcile with observations obtained by EM imaging techniques. These inconsistencies lead to major interpretation problems.

Different numerical approaches have been investigated in order to understand the consequences of the presence or absence of interconnected networks of fractures and pores on EM field measurements. These networks have a crucial effect on the EM field measurements, given that they can be permeated by conductive fluids that enhance the conductivity measurements of the whole environment.

Most of the above-mentioned studies restrict their examination to direct current (DC) sources only.
Bearing in mind that the time-varying nature of the natural electromagnetic sources play a major role in field measurements, we numerically model the effects of such EM sources on the conductivity measured on the surface of a randomly generated three-dimensional body buried in a uniform conductivity host by simulating a magnetotelluric (MT) station measurements on the top of the target random host itself.
As a second experiment we simulated a DC measurement of the target bulk conductivity.

The spatial distribution and shape of the conductor network allows in fact the propagation of time-varying EM fields by induction, leading the two different methods to measure a different numerical value for the bulk of the same physical property.

We have compared the results from the simulated measurements obtained considering time-varying and DC sources with electrical conductivity predicted by both Hashin-Shtrikman (HS) bounds and Archie's Law, and we have compared these results with statistical properties of the model themselves.

Our results suggest that for time-varying source fields there are areas in the models that contribute to the conductivity but not to the connectivity of the (simulated) rock.

Further studies are needed to highlight these inconsistencies.