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Bérubé CL, Chouteau M, Shamsipour P, Olivo GR, 2016, BISIP: a program for Bayesian inference of spectral induced polarization parameters, and application to mineral exploration at the Canadian Malartic gold deposit, Quebec, CA, Abstract, EGU, Vienna, Austria

Spectral induced polarization (SIP) parameters can be extracted from field or laboratory complex resistivity measurements, and even airborne or ground frequency domain electromagnetic data. With the growing interest in application of complex resistivity measurements to environmental and mineral exploration problems, there is a need for accurate and easy-to-use inversion tools to estimate SIP parameters. These parameters, which often include chargeability and relaxation time may then be studied and related to other rock attributes such as porosity or metallic grain content, in the case of mineral exploration. We present an open source program, available both as a standalone application or Python module, to estimate SIP parameters using Markov-chain Monte Carlo (MCMC) sampling. The Python language is a high level, open source language that is now widely used in scientific computing. Our program allows the user to choose between the more common Cole-Cole (Pelton), Dias, or Debye decomposition models. Simple circuits composed of resistances and constant phase elements may also be used to represent SIP data. Initial guesses are required when using more classic inversion techniques such as the least-squares formulation, and wrong estimates are often the cause of bad curve fitting. In stochastic optimization using MCMC, the effect of the starting values disappears as the simulation proceeds. Our program is then optimized to do batch inversion over large data sets with as little user-interaction as possible. Additionally, the Bayesian formulation allows the user to do quality control by fully propagating the measurement errors in the inversion process, providing an estimation of the SIP parameters uncertainty. This information is valuable when trying to relate chargeability or relaxation time to other physical properties. We test the inversion program on complex resistivity measurements of 12 core samples from the world-class gold deposit of Canadian Malartic. Results show that the Cole-Cole and Debye decomposition models converge quickly to a solution and often provide the best fit with experimental data. The Dias model requires the least amount of iterations to fully converge, but we note a small discrepancy between experimental data and mathematical model for most samples. Using petrographic analysis we test possible relationships between porosity, sulfur content and grain size with parameters obtained from the different models, and note that sulfur content influences both the chargeability and frequency dependence of the Cole-Cole model. Finally, we use our program to compare the different definitions of chargeability and relaxation time given by the three models. We note that these parameters tend to be correlated from one model to another. However, they have different electrochemical definitions and a single sample may possess different chargeability or relaxation time values depending on the model used. In the near future, the program will be used on a more extensive collection of samples from the Canadian Malartic gold deposit, the Highland Valley copper deposit, and the Millennium-McArthur uranium deposits.

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