MAGNETOTELLURIC MONITORING

by

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Dissertation submitted in partial fulfilment of
course work requirements for the degree of
Doctor in Philosophy in Geophysics
School of Earth and Environmental Sciences
University of Adelaide
November 2012

Contents

List of Figures

Abstract

Enhanced geothermal systems (EGS) are emerging as an alternative energy supply, though progress has been slowed due to multiple uncertainties in subsurface processes. The most important unknown that needs to be overcome is how to spatially characterize injected fluids. Micro-seismic tomography can locate fractures opening caused by hydraulic pressure, but cannot directly discriminate whether that fracture is fluid filled or connected to other fractures. Magnetotellurics (MT) is sensitive to volumetric electrical conductivity contrasts with depth, specifically thermally enhanced saline fluids in a resistive host rock. Presented in this dissertation are 2 experiments designed for employing MT as a monitoring tool to characterize a fluid injection for the first stage of an EGS at Paralana, South Australia. The first experiment utilizes 11 MT stations set around the injection well continuously measuring 2 days before, 5 days during and 2 days after the fluid injection. Comparing the MT response estimated before the injection with subsequent responses estimated in 24 hour blocks demonstrates a temporal variation associated with injection of an electrically conductive fluid. Residual phase tensor analysis suggests that injected fluids migrated NE of the injection well in a preferred NNE direction, which correlates well with a concurrent micro-seismic array. The second experiment is a time-lapse MT survey that measures the MT response before and after the fluid injection by repeating the same 56 station array. The array contains 2 orthogonal lines of 22 stations each and 2 off diagonal lines of 6 stations each. Multiple pre-injection surveys were collected to ensure data precision and accuracy with a repeatability between surveys being on the order of 0.4 percent for periods above 1 second. However, in the MT dead band (1-20 s) repeatability is on the order of 3-4 percent. This is because of poor source signal and noise from a near by pipeline. The post-injection survey was collected a week after the injection finished and repeatability between pre and post-injection at high frequencies is on the order of 1 percent. Residual phase tensor analysis again suggest fluids propagated NE of the injection well but mostly into an existing fracture network trending NNE. These experiments suggest that MT can be used as a monitoring tool for a fluid injection, but care must be taken in collecting precise and accurate data as well as a detailed analysis of what can cause an anomalous MT response. Residual phase tensor analysis proves to be the most useful representation of the MT response because it provides directionality and is insensitive to near surface distortions. Finally, it is suggested that a dense grid of MT and micro-seismic measurements be collected as complimentary pairs to fully characterize a fluid injection.

Acknowledgements

There have been a plethora of people who helped me get to where I am today especially my family. No doubt my parents Karl and Debby are the first to thank, for supporting me through everything I've done, even when I'm on the other side of the world. Thanks to my brother Ryan who has always been there pushing me every step of the way, instilling my ferocious competitive spirit. Thanks to all my friends back in Colorado who have been supporting me since I stepped on the plane. I've been in school a long time and there have been so many teachers, coaches and pupils that have taught me that life is one big research experiment and I thank all of them, especially Mr. John Martin for entrenching the scientific method into personal habit. Thanks to my advisors Dr. Stephan Thiel, Dr. Martin Hand, and Dr. Graham Heinson for first a useful project and then cultivating my research into a successful experiment. Especially, to Stephan for engaging conversations and great travel experiences, also Dr. Mike Hatch for useful banter and Grant Caldwell for insightful discussions. Thanks to Paul Pedrosian and Graham Hill for insightful reviews and insuring this work is of a high standard worthy of a PhD. Gratitude to all the PhD candidates and honors students for extending the expertise in magnetotellurics and making geophysics fun. Thanks to the South Australian Center for Geothermal Energy Research (SACGER) for support and all the enjoyable meetings with edibles. Also, to Department for Manufacturing, Innovation, Trade, Resources and Energy, Petratherm and SACGER for financial support of this project. Without the financial support from the University of Adelaide I would have never completed a post-graduate program in Australia. I am extremely grateful to Tammie Hamilton for being my Australian ambassador and family away from home, without her this research would not have been done. Finally, I would like to thank everyone on Team Tempo for letting me run with them and keep some sanity in my life, training was usually the best part of my day. Again, there are so many people to thank so I'll end with one big 'Cheers mate!'

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