From Surface to Mantle; An Overview of Downloadable MT Data from South Australia

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SUMMARY

Magnetotelluric (MT) techniques measure natural time variations of the Earth's magnetic and electric fields to infer subsurface electrical conductivity structure. Data are collected over a range of frequencies, providing insights into how this structure varies with depth. Depending on the Earth conductivity and frequencies used, information can be obtained from the near surface to depths of hundreds of kilometres.

MT surveying has been used in a wide variety of geological scenarios, from investigations of continental-scale structures to mineral and geothermal exploration, and in the search for ground-water, and many such surveys have now been undertaken in South Australia. Recently, surveys have been conducted by Geoscience Australia (GA) under the Australian Government's Onshore Energy Security Program (OESP) along deep crustal seismic reflection transects, in part in collaboration with the University of Adelaide (UA), the Geological Survey of South Australia, Primary Industry and Resources South Australia (GSSA, PIRSA) and the Australian National Seismic Imaging Resource (ANSIR) across the Gawler Craton and Curnamona Province. Given the wide range of applications for MT data, it is proposed to deliver these data online as industry-standard electrical data interchange (EDI) files, starting with the most modern datasets.

This paper presents an overview of the MT data and reports presently available for South Australia. All MT data are available for download online from the South Australian Resources Information Geoserver (SARIG), and both seismic and MT data acquired by GA and collaborators under the OESP are available for download from the GA web site.

Key words: magnetotellurics, South Australia, online delivery.

INTRODUCTION

Magnetotelluric techniques measure time variations of the Earth's magnetic and electric fields, with the internal components induced by passive external sources such as spherics and magnetic storms. The relationship between the internal induced fields and the external source fields can be used to infer the conductivity structure of the subsurface. Field variations are recorded over a wide range of frequencies giving depth constrained information from tens of metres to hundreds of kilometres below the surface.

MT data, in combination with Geomagnetic Depth Sounding (GDS) data (which uses only magnetic field variations), were first acquired in South Australia (SA) in 1970 by Gough *et al.* (1972) and Lilley and Tammemagi (1972). These datasets cross through central SA and into New South Wales (NSW) with 7 MT/GDS and 12 GDS sites located within SA. Since then, measurements have been made at hundreds of sites in SA funded through academic, industry and government initiatives.

There are many examples of MT surveys within SA and around the world. Within mineral exploration MT has been used to investigate crustal-scale structures under Olympic Dam, the world's largest uranium deposit, located in the Gawler Craton, SA (Heinson *et al*., 2006). At the mine scale, surveys have been used to locate kimberlite pipes for diamond exploration in Africa (Jones *et al*., 2009) and to directly identify graphitic shear zones associated with unconformity-related uranium in the Athabasca Basin (Tuncer *et al*., 2006).

Generally, seismic techniques are preferred for petroleum exploration; however, MT offers an alternative in regions of difficult terrain or where volcanic, salt or carbonate horizons attenuate the seismic signal. Vozoff (1972) describes using MT to explore in sedimentary basins, recommending the technique for early stage basin evaluation. Development of marine systems capable of mapping at periods between 1 s and 1000 s has allowed MT to also be used for offshore exploration (Constable *et al*., 1998). Key *et al*. (2006) were able to use data collected with this system to delineate salt dome structures in the Gulf of Mexico, an important target for petroleum exploration.

South Australia has a vibrant geothermal industry, with over 100 active exploration licenses within the state as of June 2011. MT is being used as an exploration tool by many of these companies, and a number of these datasets are available to download.

GA has acquired MT data along several new deep crustal seismic reflection lines in SA, in part in collaboration with GSSA, UA and ANSIR using AuScope equipment, and some by contract. This acquisition was part of the OESP (2006-2011), designed to test the potential for onshore energy resources, including geothermal (Geoscience Australia, 2011; Duan *et al*., 2010a). The MT data provide complimentary information for interpretation of the seismic images, along with magnetic and gravity data. The surveys enable an understanding of the crustal architecture of sedimentary basins and their tectonic relationship to older basement terrains. The results and interpretations of the seismic and MT surveys are available in several workshop reports (http://www.ga.gov.au/minerals/projects/current-projects/onshore-energy-geodynamic-framework.html) and the seismic and MT data are available from GA (http://www.ga.gov.au/minerals/projects/current-projects/seismic-acquisition-processing.html).

MT data are applicable to a wide range of geological scenarios and there is an increasing collection of datasets within SA. Thus there is an urgent requirement to capture, archive and distribute MT and other ground-acquired EM data. This issue is addressed here for SA data.

METHOD

A new geophysical electrical techniques (ET) database module is currently under construction by PIRSA and is due for completion in December 2012. This module will form part of SA Geodata, PIRSA's primary corporate geoscientific data repository.

The ET module will contain basic survey information (i.e. survey name, data originator) and site information (i.e. location information). Onto each record (either survey or site) multiple documents can be attached. This enables a wide variety of electrical data to be delivered in their native formats. There is also the ability to attach documentation such as metadata or logistics reports. All data will be available through the South Australian Resources Information Geoserver (SARIG, www.sarig.pir.sa.gov.au).

The first stage of populating the ET database will be the upload of MT data. MT data will be stored in EDI format files commonly used within industry, government and academia. All datasets undergo a basic quality assurance process aimed at ensuring data are correct and complete prior to their inclusion. Metadata, operations reports and other associated references will also be uploaded to ensure that sufficient information is available for viable use of the data. References to analysis, modelling and interpretation publications are also stored with the survey records in the database.

RESULTS

Numerous datasets from government and academia along with a number of industry surveys are being prepared and will be loaded into the database. Further data will be added as it becomes available. A brief summary of currently available datasets is given below, with locations shown in Figure 1.

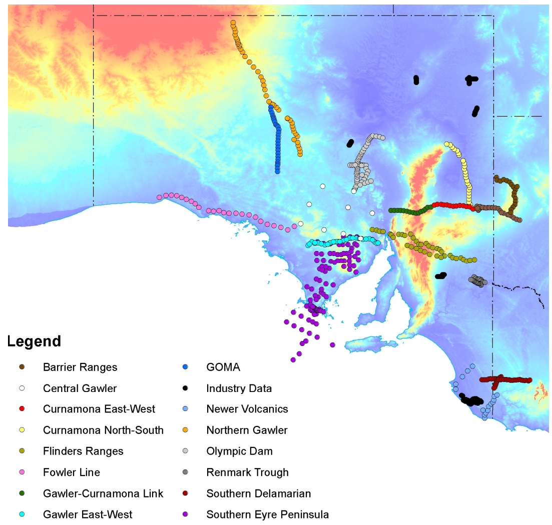

Figure 1: Locations of currently available MT data overlying a digital elevation model image.

Barrier Ranges

The Barrier Ranges dataset was collected in 2002 and 2007 by UA (Adam, 2007). The dataset contains 38 long period MT sites, recorded in the Olary and Broken Hill domains, crossing from SA into NSW. The survey targeted the boundaries of these domains and investigated changes across the Mundi Mundi fault.

Central Gawler

MT long period data were collected at 8 sites in 2005. These data were used to infill a larger compilation of GDS and MT datasets in order to construct a 3D electrical resistivity model of the Gawler Craton, SA (Maier *et al*., 2007).

Curnamona East-West

Auscope equipment under ANSIR agreement was used in 2010 by GSSA in collaboration with GA and UA to collect both broadband and long period data at 18 sites along the 2003/2004 Curnamona Province Seismic Survey line (Goleby *et al*., 2006). The data extends the Gawler-Curnamona Link Line (see below) across to the NSW border. This line intersects with the southern end of the Curnamona North-South line (see below), and also crosses the axis of the Flinders Conductivity Anomaly (FCA) (Gough *et al*., 1972; Chamalaun, 1986), enabling it to be better defined.

Curnamona North-South

MT data were acquired for GA in 2008 by contract at 25 broadband sites, spaced 10 km apart, along the N-S Curnamona Province seismic line as part of the OESP (Milligan and Lilley, 2010). The FCA also influences these data, particularly at the southern end.

Fowler

An MT profile extending from the Gawler Range Volcanics in the east through to the Eucla Basin in the west was collected in 2005. This dataset was aimed at delineating the electrical conductivity structure in this region, including modelling the highly prospective Meso-Proterozoic Fowler Domain (Thiel and Heinson, 2010). Twenty-four long period sites from this survey are available for download.

Gawler-Curnamona Link
Broadband and long period data were acquired in 2009 at 15 sites spaced 10 km apart along the Gawler-Curnamona Link deep seismic line in a collaborative project between PIRSA, GA and UA. This line, designed to investigate the crustal-scale relationship between the Curnamona Province and the Gawler Craton, crosses the Flinders Ranges. AuScope equipment was used under ANSIR agreement (Dhu *et al*., 2010).

Gawler East-West
MT data were acquired at 40 broadband sites and 12 long-period sites along the east-west Gawler seismic traverse in a collaborative project between GA and UA during 2008 and 2009 (Thiel *et al*., 2010a,b,c), using AuScope equipment under ANSIR agreement as part of the OESP.

GOMA
MT data were acquired from Tarcoola to near Coober Pedy by GA in 2008. Station spacing varied between 5 to 20 km along a 230 km profile coincident with the southern part of the GOMA (Gawler Craton, Officer Basin, Musgrave Province, Amadeus Basin) deep seismic reflection transect (Duan *et al*., 2010b). AuScope equipment under ANSIR agreement was used for this OESP project. There were 27 sites in total, with broadband data collected at all sites and long period measurements made at 12 of the sites

Industry Data
Numerous datasets are collected by industry and submitted to the government as part of the reporting process. A period of confidentiality is associated with these datasets; once they become open file they are also delivered through the ET module and SARIG. Presently over 250 mostly broadband MT sites reported through geothermal and mineral exploration are contained within the database.

Newer Volcanics
The Newer Volcanics survey consists of 16 long periods MT sites across two traverses in the south east of South Australia. The survey aims to image thermal anomalies in the crust and mantle beneath the SA portion of the western New Volcanic Province (NVP), which has had the most recent volcanism.

Northern Gawler
Long period MT data from 44 sites along a 480 km long profile in central Australia are available for download. These sites form part of a survey designed to investigate the relationship between the Gawler Craton and the Musgrave Block (Selway *et al*., 2011).

Olympic Dam
A number of MT and GDS surveys have been conducted in the vicinity of Olympic Dam. Downloadable are 51 long period MT sites and seven GDS sites. Many of these sites were used in the modelling work of Heinson *et al*. (2006) that imaged a crustal-scale conductor under the world-class Olympic Dam deposit.

Renmark Trough
Two profiles consisting of 10 long period and 15 broadband MT sites were surveyed across the Renmark Trough near the border between NSW, Victoria and SA. The data were collected by UA with the aim of delineating the basement structure of the Renmark Trough, as part of geothermal exploration efforts (Craven, 2009).

Southern Delamarian Line
39 broadband MT sites were collected crossing the southern border between Victoria and South Australia. The data were collected along the GA Southern Delamarian Seismic Survey Line,crossing the Southern Delamarian fold belt. AuScope equipment under ANSIR agreement was used for this survey.

Southern Eyre Peninsula
A series of MT and GDS surveys have been conducted on the Southern Eyre Peninsula from 1993 through to 2002 (Kusi *et al*., 1998, Popkov *et al*., 2000, Thiel *et al*., 2005). Over 100 GDS sites and 15 offshore MT sites are available for download.

Southern Flinders Ranges
Long period MT sites were recorded at 38 locations across the southern Flinders Ranges (Moradzadeh, A., 1998, Wang and Chamalaun, 1995). The MT sites are located to the south of the Curnamona East-West and Gawler-Curnamona Link MT lines. The survey investigates the structure of the Adelaide Geosyncline and the nature of the FCA.

CONCLUSIONS

MT data have been collected within South Australia since 1970, and recent acquisition has been aided by collaborative projects and the use of AuScope instrumentation under ANSIR agreement. A growing number of datasets are becoming publicly available and these will be archived and delivered by the Geological Survey of South Australia. MT and seismic data which have been acquired with involvement from Geoscience Australia are also available from the GA web site.

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