Geophysical Resources and Services Pty. Ltd.

- 2003 MBO MIM Exploration Geophysical Assets
- Inc. 300 Channel MIMDAS
- Operating MIMDAS since 2003
- Induced Polarisation / Magnetotellurics / EM Surveys
- General Geophysical Consultancy
- Offices in Brisbane, Australia and Santiago, Chile

Geophysical Resources and Services Pty. Ltd.

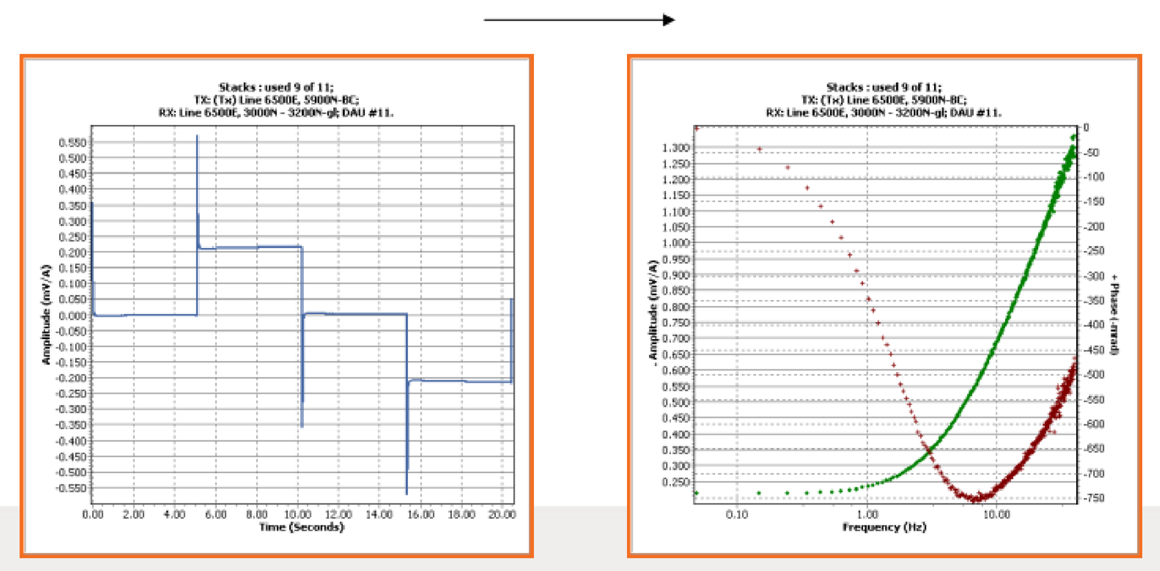
- History of Innovation
- MIMDAS – 1st commercially available DAS IP/MT/EM
- Routine Telluric Cancellation x5 increase in S to N
- Routine "Remote" MT Cross Referencing
- True 3D Data Collection and Inversion since 2002
- Lately, CSEM/MT Joint Inversion

MARE2DEM (Scripps Institute, Kerry Key) GRS Project Sponsor

- MARE2DEM (pronounced mahr-ey 2DEM) is a parallel adaptive finite element code for 2D forward and inverse modeling for electromagnetic geophysics. It was developed with funding support from the Scripps Seafloor Electromagnetic Methods Consortium. After a period of exclusive access for consortium members, the code is now being made freely available. MARE2DEM was originally designed with marine controlled-source electromagnetic (CSEM) and marine magnetotelluric (MT) applications in mind, but it can also be applied to onshore electromagnetic modeling problems. Two main features of MARE2DEM are (1) it uses fully automatic mesh generation so that end users are free from the burden of designing numerically accurate grids for complicated models and (2) it is open-source and freely available. The code package has reached a fairly mature state, but there are several planned new features and development is ongoing, so stayed tuned for updates.
- Features:
- Forward calculations using fully automatic goal-oriented adaptive finite elements
- Non-linear inversion using a new faster implementation of Occam's method
- Models electric & magnetic dipoles and magnetotelluric (MT) plane waves
- Models marine, land and borehole transmitters and receivers (but is not yet configured for airborne EM)
- Models point or finite length dipole wires
- Models isotropic, transversely isotropic or triaxial anisotropic conductivity
- Inverted conductivity parameters can be bounded using non-linear transforms
- Run in parallel on laptops to large clusters. The forward code uses a parallel data decomposition for a nearly linear speedup with the number of processors. The inversion code performs dense matrix operations efficiently in parallel using the ScaLAPACK library.
- Model Builder Assistant (Mamba2D) for MATLAB
- Inversion model and response plotting tools for MATLAB
- Open source under the GNU GPL license
- Languages: Fortran (modern), C, MPI. Requires the Intel C and Fortran compilers.

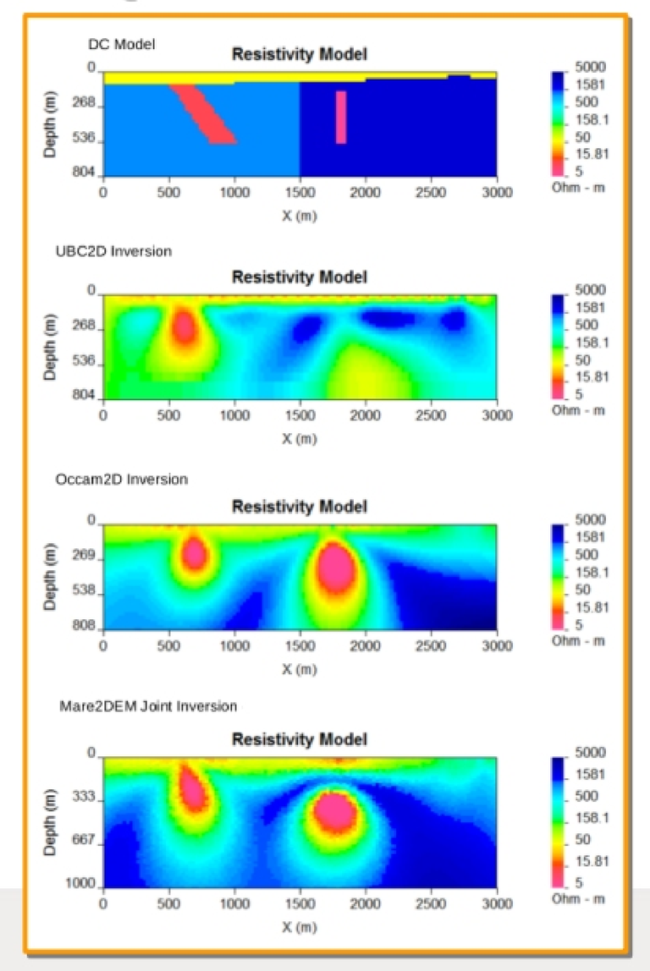
MARE2DEM CSEM Input

- MARE2DEM Input : Frequency Domain CSEM
- MARE2DEM Input : Tx Dipole or Bipole
- MIMDAS records full time series data of Tx I and Rx V
- Finely synced Tx and Rx recording allows Frequency Domain Transformation
- For Existing MIMDAS Datasets, Other Datasets v. unlikely;
- Superposition of Tx geometry to create arbitrary bipole



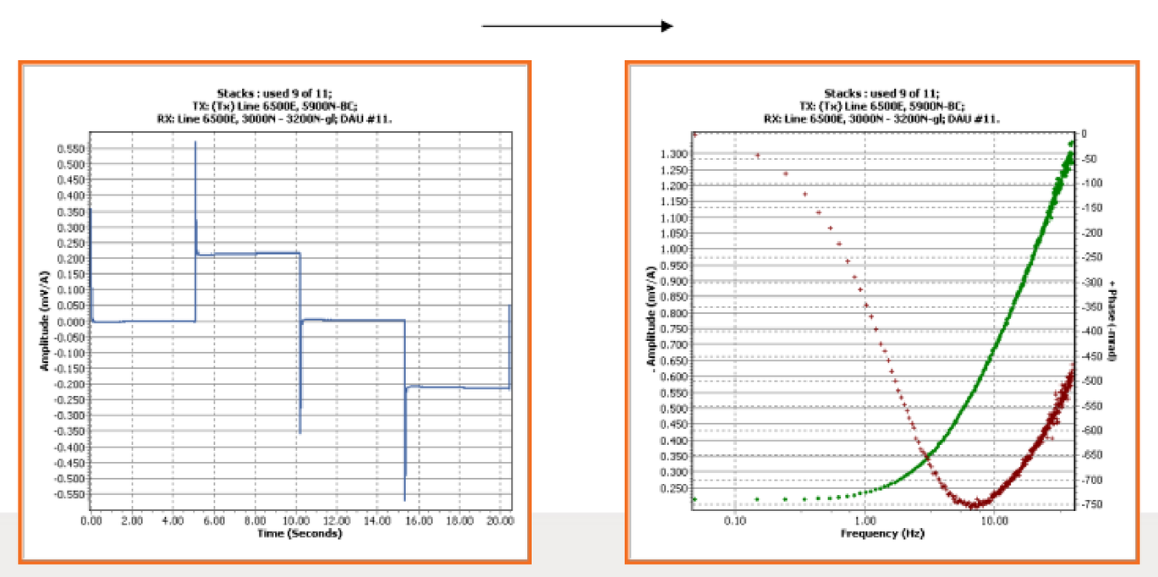
MARE2DEM Quick Test

- DC / MT Forward Modelling
- Pretend DC → 0.001 Hz CSEM
- Invert MT/DC together
- Joint Results – Most Information



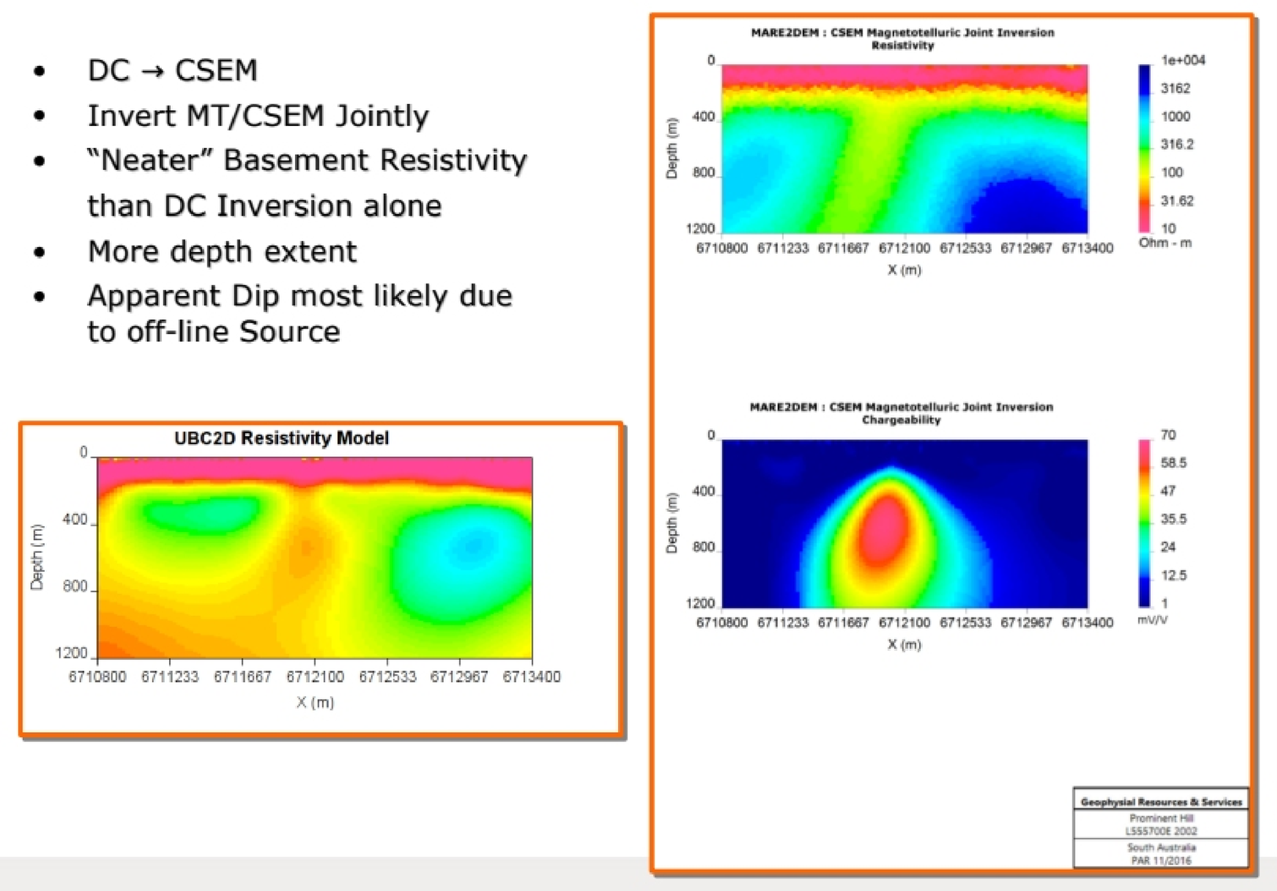
MARE2DEM Application to Historical Datasets Prominent Hill

- MARE2DEM Input : Frequency Domain CSEM/MT
- Prominent Hill : Line 555700E acquired in 2002
- Pole-Dipole, Tx Freq. 25/512 Hz = 20.48 sec period
- Tx Superposition, convert to 100m dipole-dipole
- Input 0.0488 Hz – 200 Hz (approx 7 pts per decade)



MARE2DEM Application to Historical Datasets Prominent Hill

- DC → CSEM
- Invert MT/CSEM Jointly
- "Neater" Basement Resistivity than DC Inversion alone
- More depth extent
- Apparent Dip most likely due to off-line Source



MARE2DEM Application to Historical Datasets Olympic Dam

- History

Survey Commissioned by B.H.P.B.
One 5km "Test" Line
5th – 8th November 2005
- 2 Days Setup / Induction etc.
- Morning 7th November, lost to thunderstorm
- Afternoon 7th November – MT
- 8th November – DC/IP

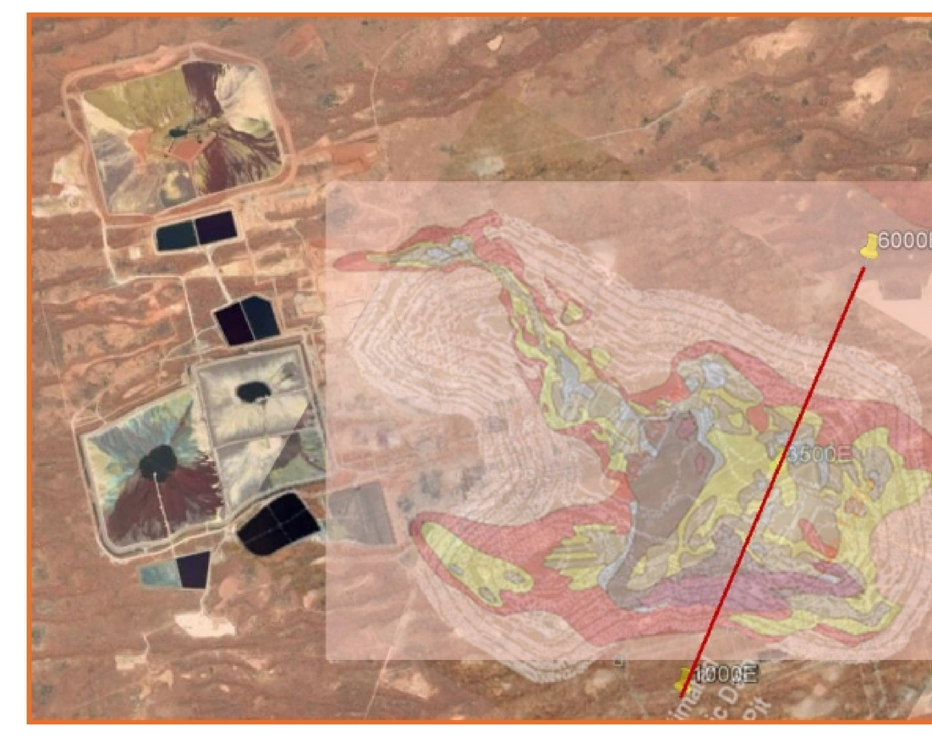
MARE2DEM Application to Historical Datasets Olympic Dam

- Specifications

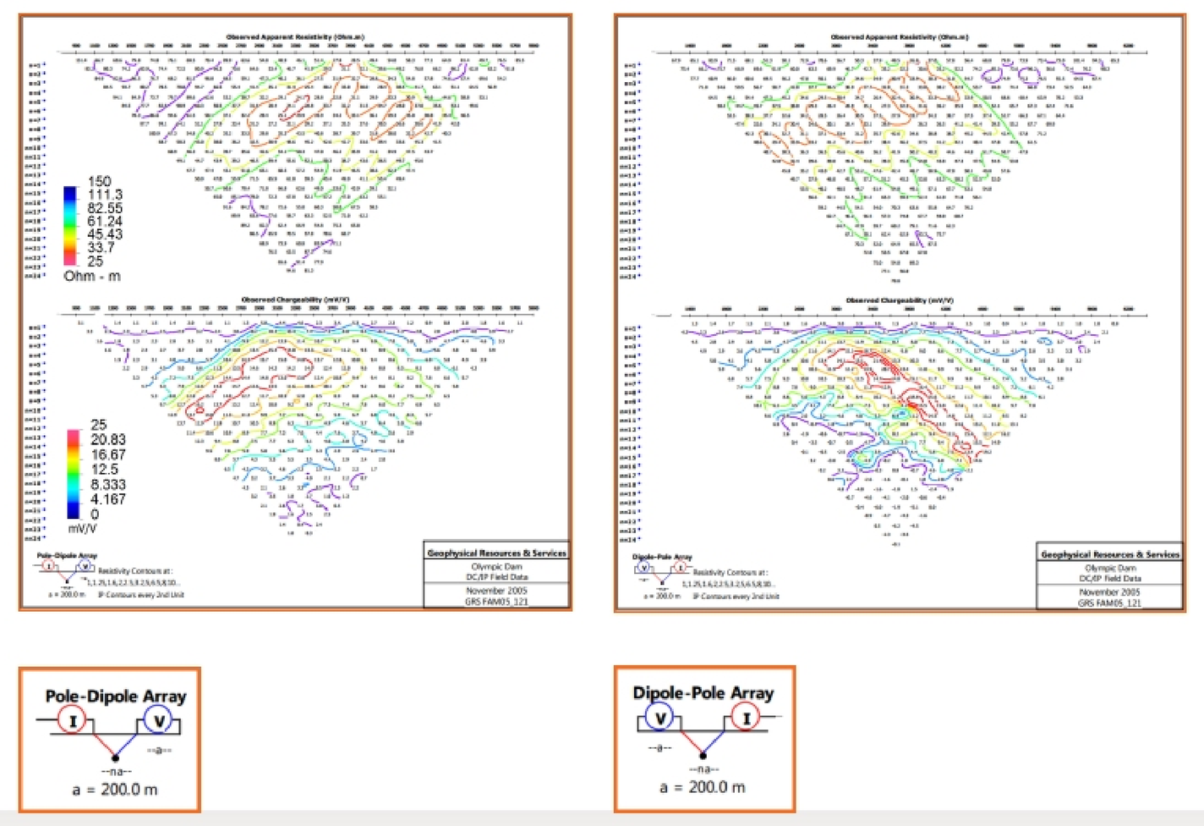
Tx = Zonge GGT-10 IP Transmitter
Rx = MIMDAS
200m a-spacing Pole-dipole / Dipole-pole with TC
Tx Freq. 25/512 Hz (5.12 secs off-time equivalent)
IP Time Slice 3.0-5.1 seconds
Average Current approx. 5 Amps

MT E-Map 200m a-spacing w. Remote X-Ref

MARE2DEM Application to Historical Datasets Olympic Dam

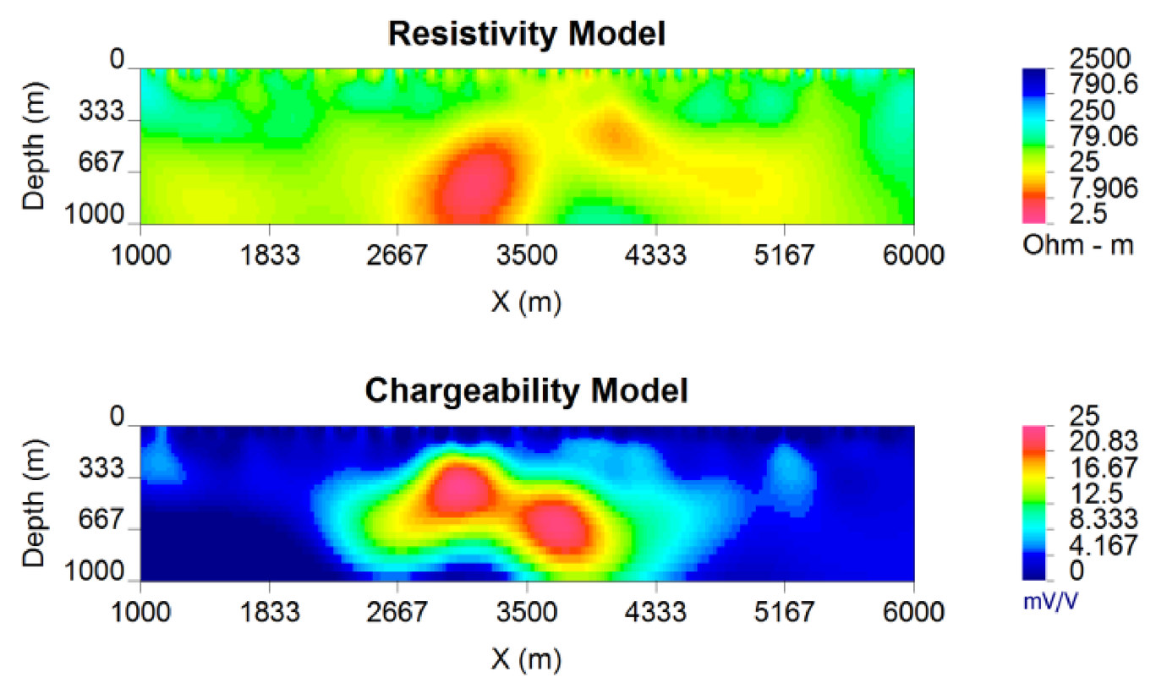


MARE2DEM Application to Historical Datasets Olympic Dam GRS Survey DC/IP Data



MARE2DEM Application to Historical Datasets Olympic Dam 2006 2D Inversions DC/IP

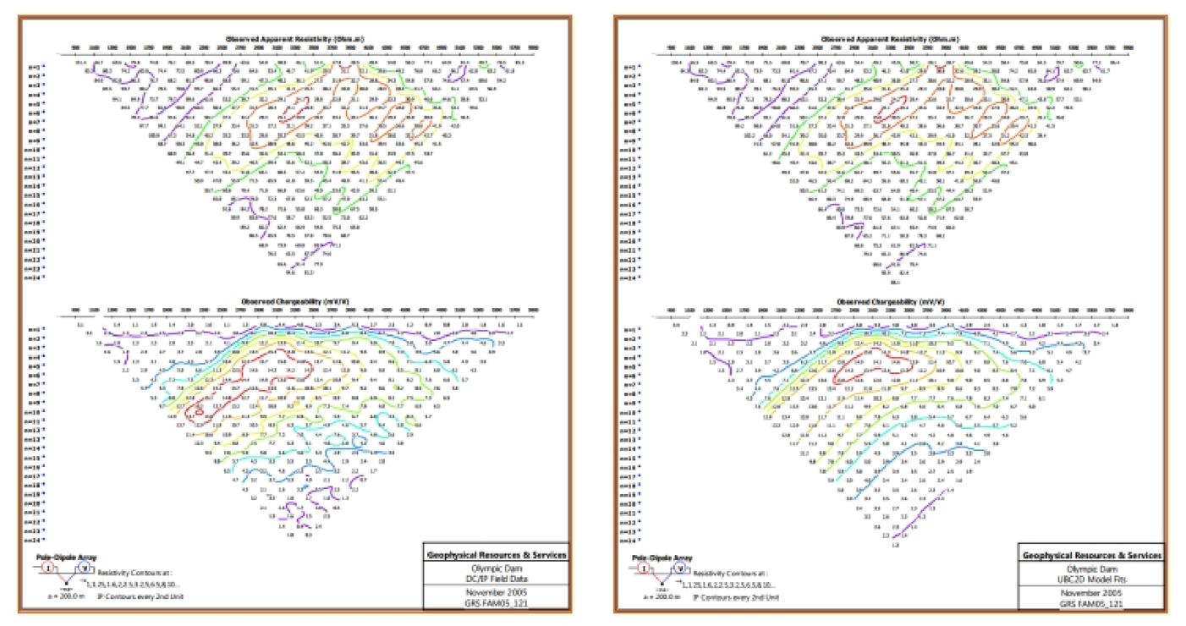
UBC2D using Inversion Defaults
Converges to RMS 1.0 with approx. 1% Vp and 0.8 mV/V



MARE2DEM Application to Historical Datasets Olympic Dam 2006 2D Inversion Fits

Field Pole-Dipole

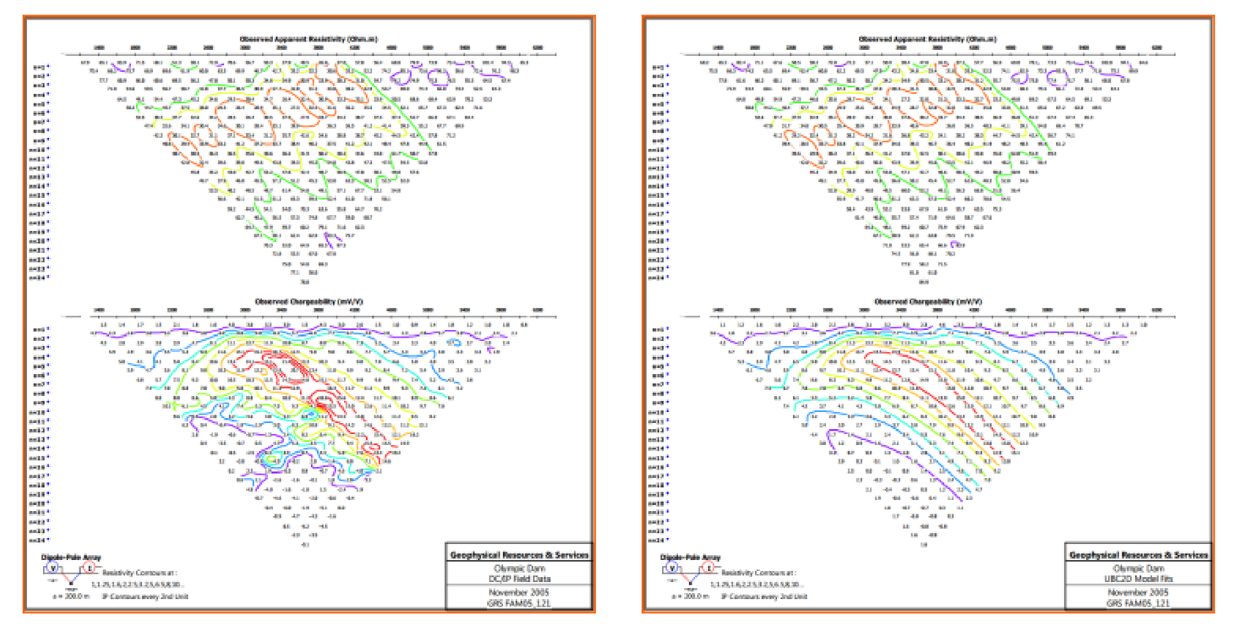
Fits



MARE2DEM Application to Historical Datasets Olympic Dam 2006 2D Inversion Fits

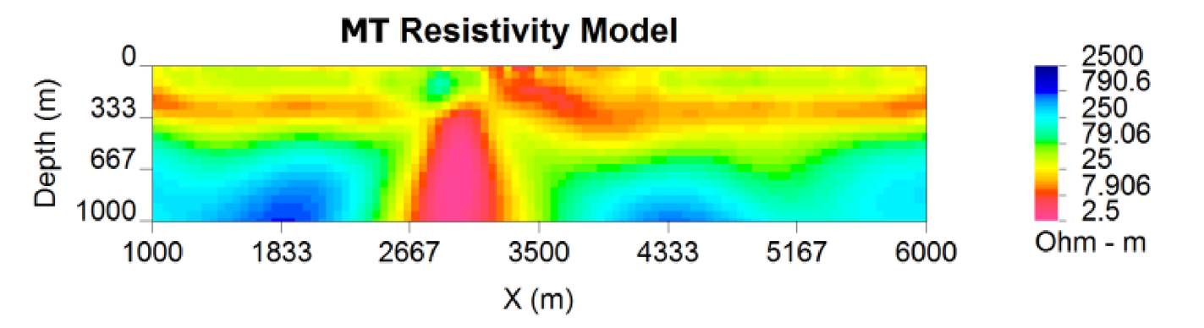
Field Dipole-Pole

Fits



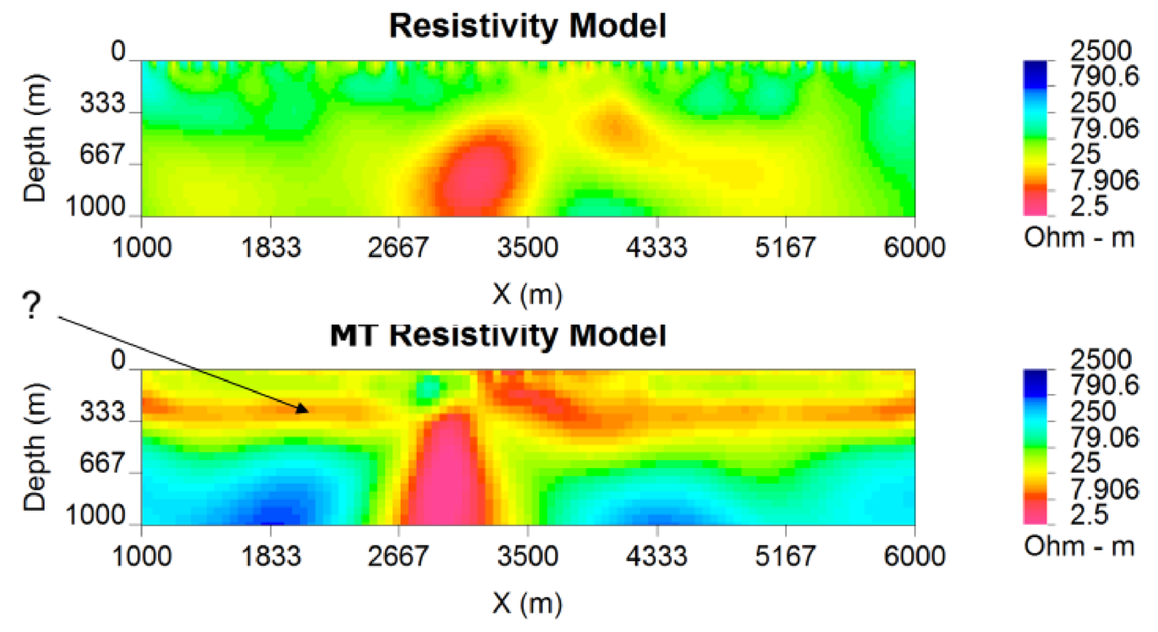
MARE2DEM Application to Historical Datasets Olympic Dam 2006 2D MT Inversion

Occam2D using Inversion Defaults Converges to RMS 1.0 with Errors of approx 2% of Apparent Resistivity 0.6 degrees of Phase



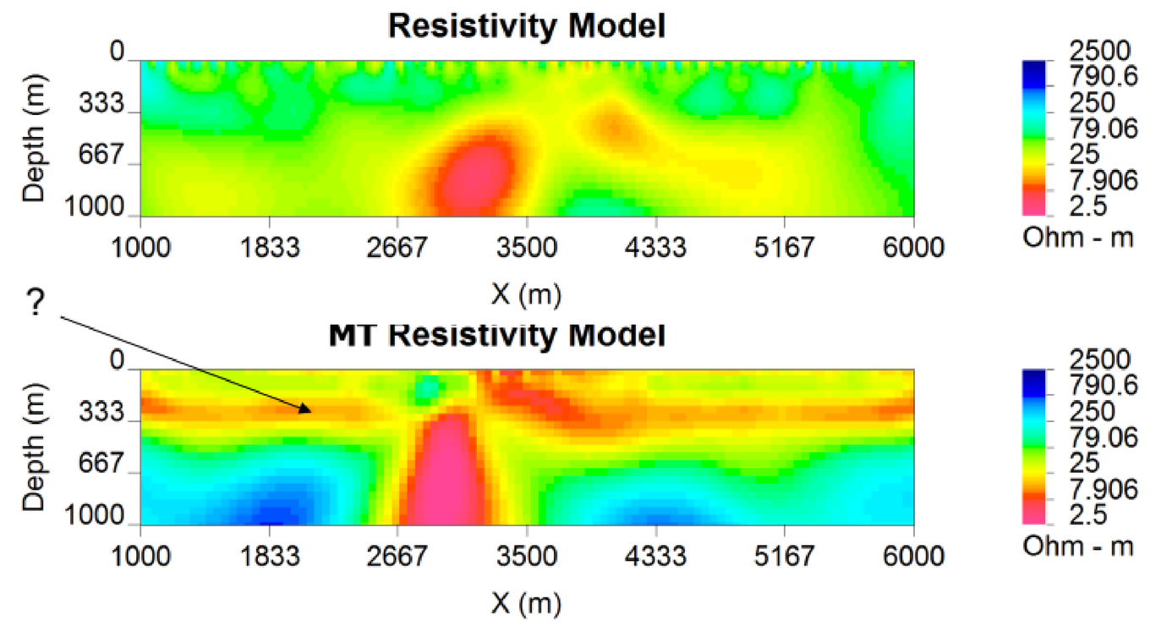
MARE2DEM Application to Historical Datasets Olympic Dam 2006 DC/MT Differences

- GRS has been inverting both datasets for more than a decade and have found that DC and MT 2D models usually match quite well.

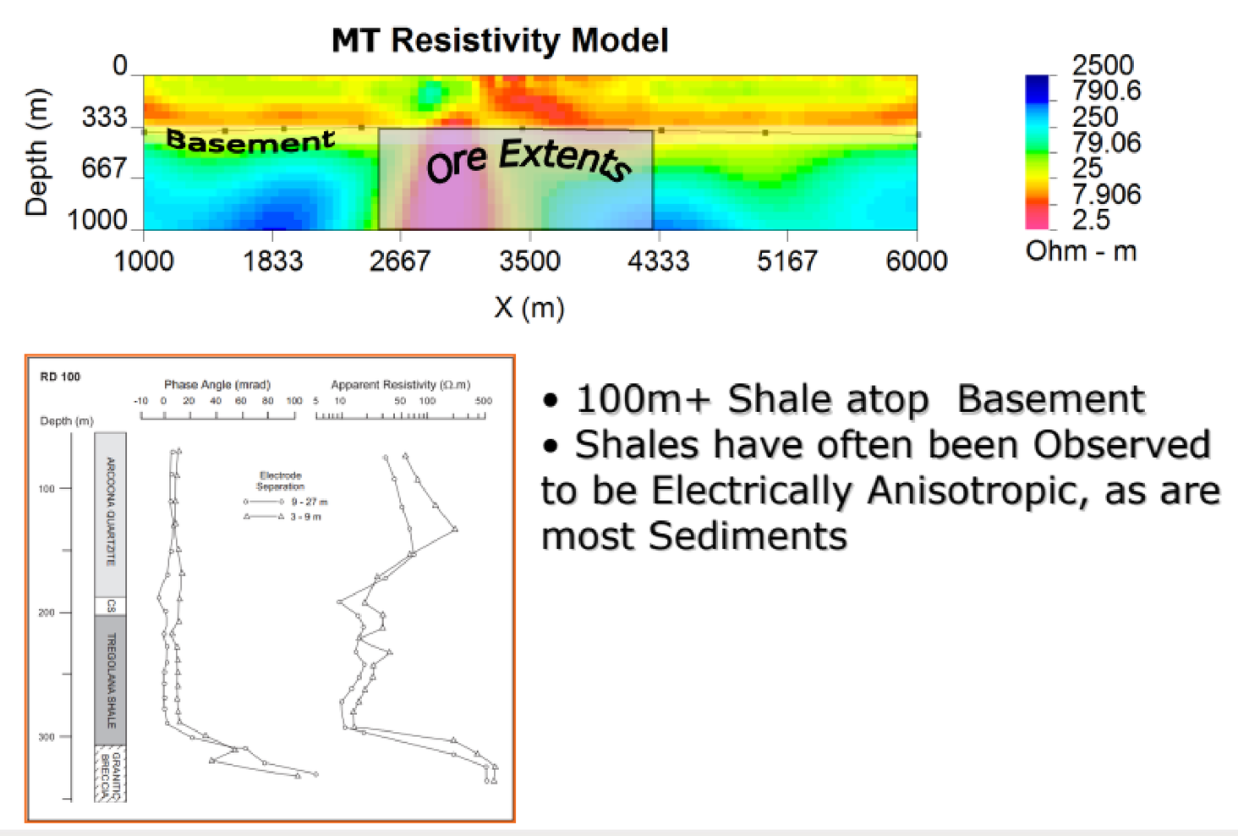


MARE2DEM Application to Historical Datasets Olympic Dam 2006 DC/MT Differences

- The Horizontal Conductor's Location (MT) matches the Stratigraphic Location of the Tregolana Shale



MARE2DEM Application to Historical Datasets Olympic Dam 2006



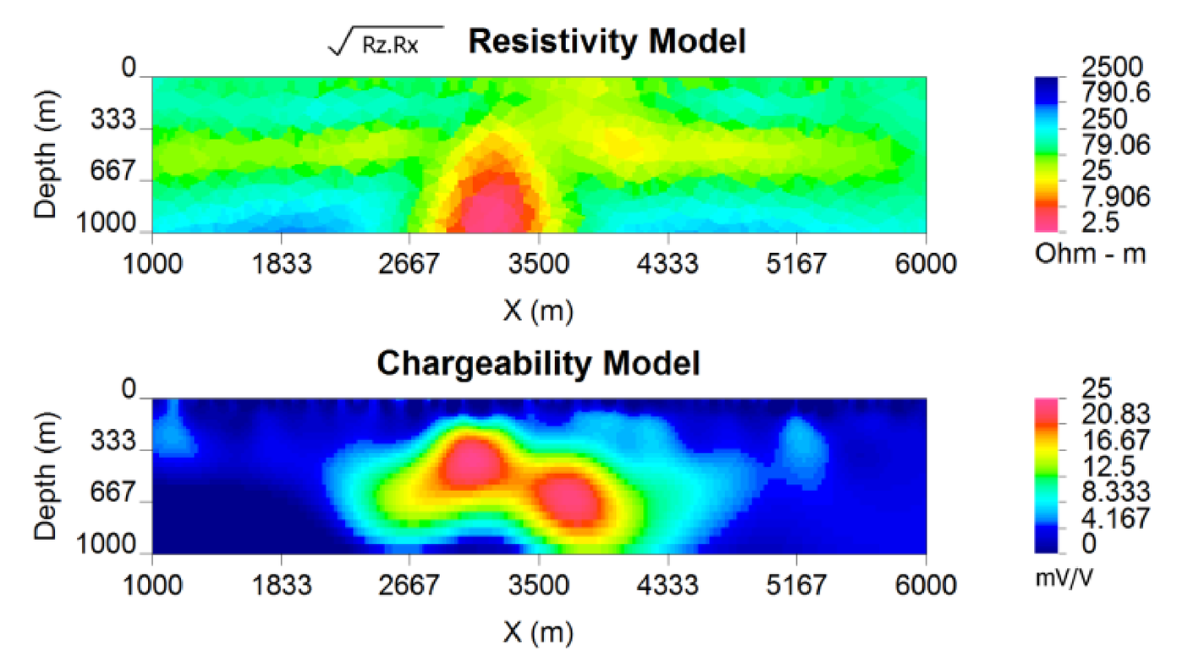
- 100m+ Shale atop Basement
- Shales have often been Observed to be Electrically Anisotropic, as are most Sediments

MARE2DEM Application to Historical Datasets Olympic Dam 2006 Anisotropy

- Terry got to thinking about the Anisotropy Aspect after a chat with James Macnae after he posted a comment on SEGMIN about "systematic differences between airborne and ground resistivities over sediments but not regolith"
- MT, Horizontal Current Flow
- Surface Resistivity Arrays, a Large Component of Flow will be Vertical
- MARE2DEM can solve for Anisotropy

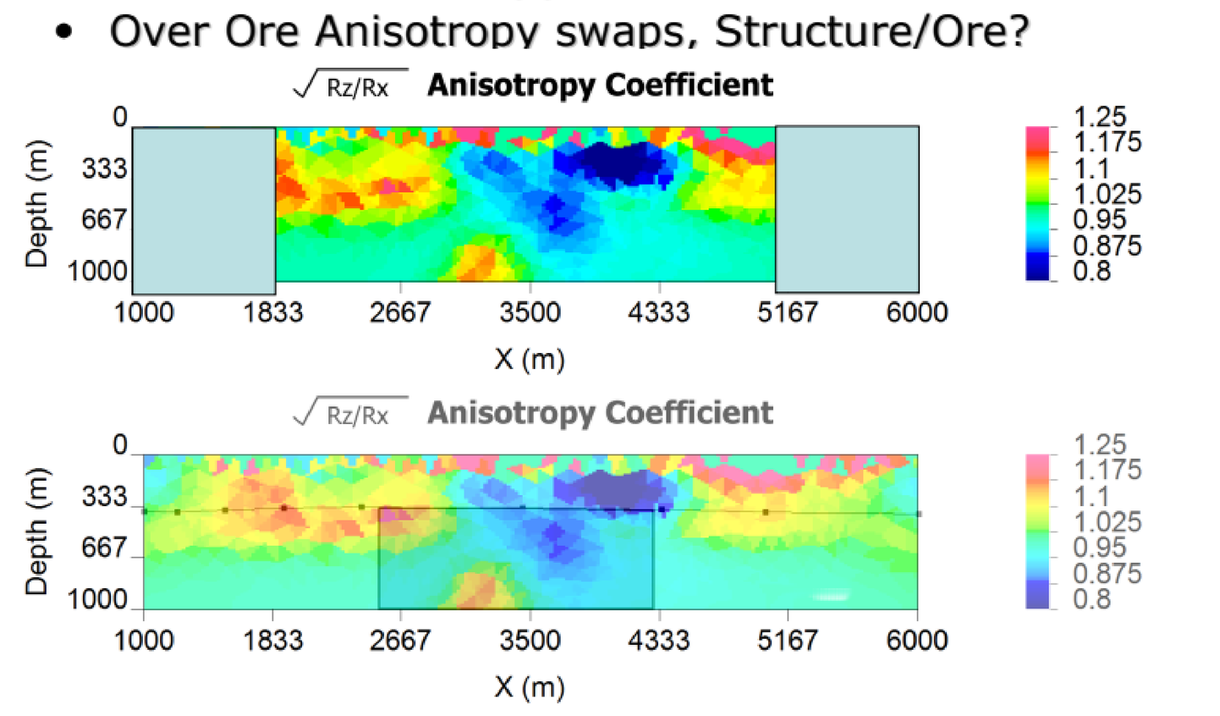
MARE2DEM Application to Historical Datasets Olympic Dam 2016 Joint Inversion

- Solving for Anisotropy adds value (Shale and IP Source associated with Vertical Anisotropy)
- Reposing Surveys as CSEM makes EM Coupling part of the solution and not part of the problem



MARE2DEM Application to Historical Datasets Olympic Dam 2016 Joint Inversion

- Superposition has left us 1850E – 5150E
- Horizontal Anisotropy clear
- Over Ore Anisotropy swaps, Structure/Ore?



Joint MT-CSEM Resistivity/IP Inversion MARE2DEM