EarthScope Magnetotelluric Transportable Array Siting Workshop

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Report to the Electromagnetic Working Group (EMWoG) of Incorporated Research Institutions in Seismology (IRIS)

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With support from IRIS the Electromagnetic Working Group (EMWoG) organized an EarthScope Magnetotelluric (MT) Transportable Array (TA) siting workshop on May 12, 2013, one day before the EarthScope National Meeting in Raleigh, North Carolina. Approximately 40 participants discussed plans for deployment of the USArray MT-TA footprint over the next 5 years (2014-2018). EMWoG members Paul Bedrosian (USGS), Gary Egbert (OSU), and Maureen Long (Yale) chaired the meeting with logistical help from Andy Frassetto (IRIS). Paul Bedrosian acted as lead moderator for the meeting.

To date two large MT footprints have been completed as part of EarthScope (Figure 1). The first consisted of 325 sites, covering the northwestern corner of the continental United States (NWUS). Collected in 2006-2011, data from this first footprint have been used by several groups for 3D inversion studies (Patro and Egbert, 2008; Zhdanov et al., 2011; Kelbert et al., 2012; Zhdanov et al., 2012; Bedrosian and Feucht, 2013; and Meqbel et al., 2013). These studies have provided unprecedented three-dimensional views of electrical conductivity variations in the crust and upper mantle and shed new light on the physical state, tectonic history, and geodynamic processes of the region. The second footprint, covering the Mid-Continent Rift (MCR) includes 235 sites occupied from 2011-2013. As of this writing, the last of these sites were being completed and analysis and interpretation of these data is incomplete. All raw data and MT transfer functions are publicly available through the IRIS Data Management System.

The workshop began with overviews from Bob Woodard (IRIS) and Adam Schultz (OSU) on the history of the EarthScope MT facility, general financial considerations, typical field operations, and operational trade-offs. Based on per site costs and projections of funds likely to be available under the SAGE Award, it was estimated that 350-400 additional sites could be completed through 2018. At the end of this period, MT-TA coverage of the continental US would be about 55-60%. Gary Egbert (OSU) then provided a brief overview of the MT method, and summarized results obtained from the NWUS MT-TA data. The need for large footprints was emphasized, both to have the aperture for resolution of deep (hundreds of km) mantle conductivity structure, and to minimize “edge effects” i.e., ambiguity associated with possible unresolved

structures outside of the array. Maureen Long (Yale) and Christian Teyssier (UMN) closed the introductory session, respectively providing seismic and geological perspectives on issues that might be addressed by future MT deployments.

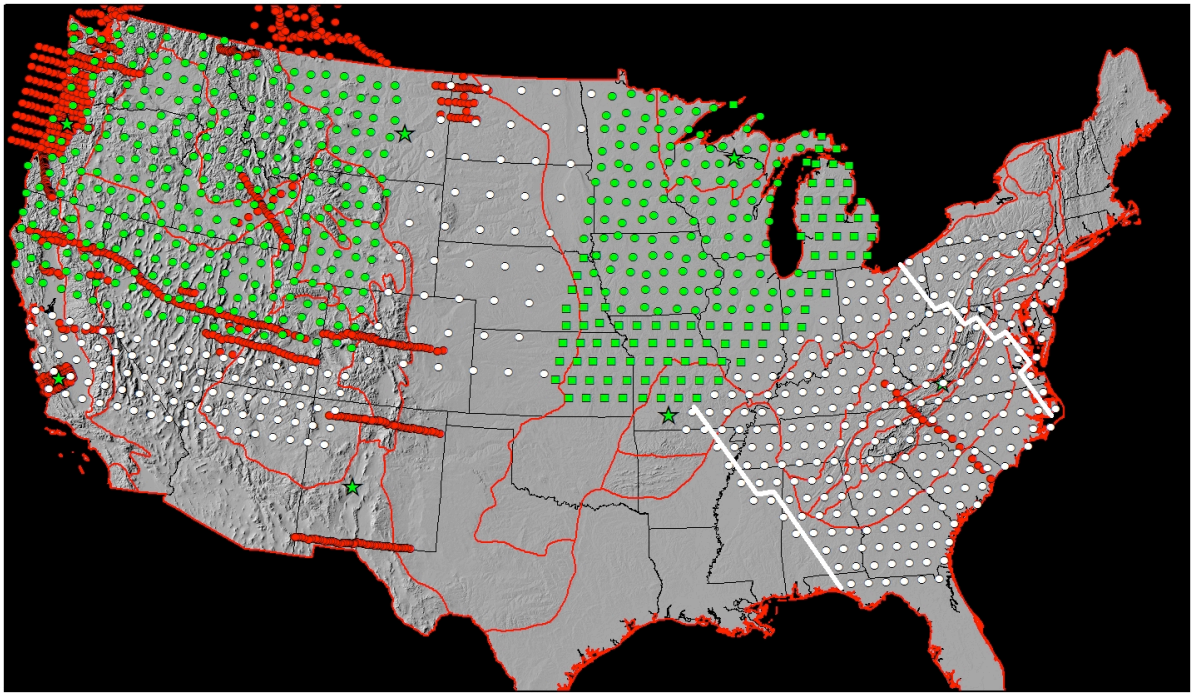

Figure 1: Completed (green dots) and proposed (white dots) MT-TA sites. Red dots denote other non-EarthScope long-period (T > 1 s) MT sites, mostly completed, and generally with only slightly lower quality than MT-TA impedances. White bars denote approximate northern and southern extent of a reduced, 210-station ENAM footprint.

Meeting attendees had been invited to prepare mini-presentations (2-3 slides, ~5 minute duration) on potential targets and/or important scientific issues. Fifteen of these short talks were presented at the meeting with seven focused on, or at least including, discussion of Appalachian and related Eastern U.S. targets. Three talks emphasized the value of extending the NWUS footprint further south, to cover a wealth of geologically and geophysically interesting targets, including the Basin and Range of Nevada and Utah, the Colorado Plateau, and the Rio Grande Rift. Two talks focused on the mid-continent region, suggesting that the MCR footprint could also usefully be extended further southward. Other potential targets discussed included southern Texas and the Salton Trough.

There was some general discussion of the possibility of increasing site spacing from the TA standard of 70 km to 100 or 140 km. This would allow covering more targets, albeit with reduced resolution. Adam Schultz, speaking for the EarthScope MT facility, estimated per-site cost increases of ~$1000 to increase spacing to 140 km. This would reduce the number of sites occupied by ~15-20%. Others pointed out that the 70 km spacing of the NWUS footprint was critical to the richness of its observations, and that much wider spacing would degrade resolution and increase the non-uniqueness of models and interpretations. Nonetheless, there was some support for using this strategy to fill the void between the NWUS and MCR footprints with a sparser 40-station deployment at 140 km spacing. Several participants thought that this would diminish edge effects that are present in both the NWUS and MCR footprints, even if the wide spacing was less than ideal for imaging regional structure within the gap. It was noted that earlier occupation of a 140km spaced Northern Great Plains footprint affords the possibility of identifying and occupying densified areas of interest before conclusion of the EarthScope MT-TA continental U.S. program, thus potentially mitigating concerns about the richness of observations.

Following on from the mini-presentations, much discussion focused on Eastern North America (ENAM), and a number of arguments were advanced for making this a priority area for future deployments. It is terra incognita, with many opportunities for unexpected discoveries. The EarthScope MT-TA represents a unique opportunity to explore an area that may be harder to justify in core EAR programs. Furthermore, fossil regimes in ENAM represent end-state processes, and contrasts with the active west are expected to be very informative about resistivity and linkages to geodynamic process. The area also encompasses numerous structures that are targets of near-term USArray Flexible Array (FA) seismic experiments; all of these would benefit from availability of MT-TA data during the interpretation phase. There was significant discussion about the spatial limits of a potential ENAM footprint. Many advocated that it would be critical to push the southern limit to southern Georgia/northern Florida, the only part of the margin with clear evidence of contact between Laurentia and Gondwana. In addition several of the ongoing or planned FA campaigns are in this specific area. The value of connecting to

the existing MCR array in the west was also emphasized, as was ensuring that at least the edge of the footprint encompasses New Madrid. The group similar debated extending the footprint farther north (no matter where you put a boundary, there is always some feature that falls just outside!), but there was less agreement on how far the northern limit should be pushed, at least past Virginia, which was generally seen as a minimal northward extent. The possibility of using somewhat variable spacing was discussed briefly, again to allow coverage of a broader area with the limited number of sites available.

Extending the NWUS footprint southward also generated significant support. In particular, it was suggested that MT could make important contributions to understanding evolution of the Colorado Plateau, where seismic data and spatial and temporal trends in magmatism are consistent with several disparate geodynamic scenarios. There are also important questions that might be addressed with more complete coverage of the Basin and Range in southern Nevada/Utah and northern Arizona. On the other hand, there was also the sense that the presence of known important targets would make PI-driven proposals for MT more likely to be successful for the southwest compared to ENAM. For example, a series of dense profiles across the Rio Grande Rift have recently been collected, lessening the immediate need for TA coverage in that area. However, on balance, there was general consensus that if possible the NWUS footprint should be extended several rows to the south, extending from the Pacific coast across the Colorado Plateau.

Ultimately the group converged on three regions suitable for meeting the main community research goals of the MT-TA during 2014-2018, prioritized as follows:

(1) Eastern North America, extending from northern Florida to Pennsylvania and from the current MCR footprint to the Atlantic. This would require ~280 sites at 70 km nominal spacing.
(2) Northern Great Plains, filling the gap between the NWUS and MCR footprints, at doubled station spacing of 140 km. This would require ~45 sites.

(3) The Central Great Basin and adjoining regions, extending the NWUS footprint ~5 rows to the south at 70 km station spacing. This would require ~90 sites.

The three proposed new footprints (Figure 1) would build on previous deployments, minimizing edge effects, and result in a broad coast-to-coast swath of 3D MT coverage across a diversity of geologic targets.

The proposed numbers of sites in the suggested deployments are only estimates and were based on levels of funding requested in the IRIS SAGE proposal, the best information available at the time of the meeting. With the recent approval of the SAGE proposal at a reduced level, it is now known that the MT budget for 2014 will be 8% below requested. Assuming similar reductions for FY15-18, and barring supplement sources of funds, the likely number of sites that can be completed over EarthScope's final 5-year window is now ~350 (compared to ~415 summing the three proposed footprints). The tentative recommendation of EMWoG (based on discussions in a teleconference on September 26, 2013) would be to reduce the ENAM deployment to ~210 sites, primarily by curbing the northward extent of this footprint and omitting traditionally noisier stations around the large metropolitan areas. The white bars in Figure 1 denote the approximate northern and southern boundaries of such a reduced ENAM footprint.