# FORGE Telluric Monitoring Experiment Transfer Functions

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## ABSTRACT

The Utah Frontier Observatory for Research in Geothermal Energy (FORGE) attempted a stimulation at well 16A(78)-32 during April 2022. We recorded telluric and magnetotelluric data before, during, and after the well stimulation experiment using the FORGE Telluric Monitoring (FTM) array to constrain transients in the Earth's electrical structure caused by the stimulation. Here we outline the FTM survey and processing workflow pursued to obtain processed magnetotelluric transfer functions from the array. Transfer functions are organized into five time chunks covering the duration of the expected offset and decay of the electric structure response. An assessment of transfer function data quality and the structure of the corresponding archive is provided. Finally, we include suggestions for future 4D MT field monitoring efforts.

## 1. INTRODUCTION

A three-stage hydraulic stimulation experiment was to be conducted in April 2022 to test critical EGS technologies at the Utah FORGE (Frontier Observatory for Research in Geothermal Energy) site near Milford, Utah. The experiment consisted of a three-stage fracking experiment conducted at well 16A(78)-32 within hot-dry crystalline basement, with the ultimate intent of verifying needed technologies to enhance geothermal energy production from the underlying geothermal heat reservoir.

Several studies have shown that fluid migration associated with EGS activities may be resolvable with electromagnetic methods. Peacock et al. (2012, 2013) processed data from several broadband magnetotelluric (MT) stations deployed two days before Petratherm Ltd. injected 3.1 million liters of saline fluid at a depth of ~3.7 km at a prospective EGS reservoir in Paralana, South Australia. Comparison of phase tensor principal components of the impedance responses of the sites before and after injection revealed changes in Earth's electrical structure above the noise floor. Changes to observed impedances were thought to be due to the injected saline fluid. Similar time-dependent changes in observed MT phase tensors were apparent at EGS projects in Cooper Basin, South Australia (Didana et al. 2017), and at the Rittershoffen geothermal site, France (Abdelfettah et al. 2018).

In light of these findings, a mixed magnetotelluric-telluric monitoring experiment (the FORGE Telluric Monitoring array, FTM) was designed and implemented over the Utah FORGE EGS site to coincide with the stimulation of Well 16A(78)-32. The monitoring experiment consisted of

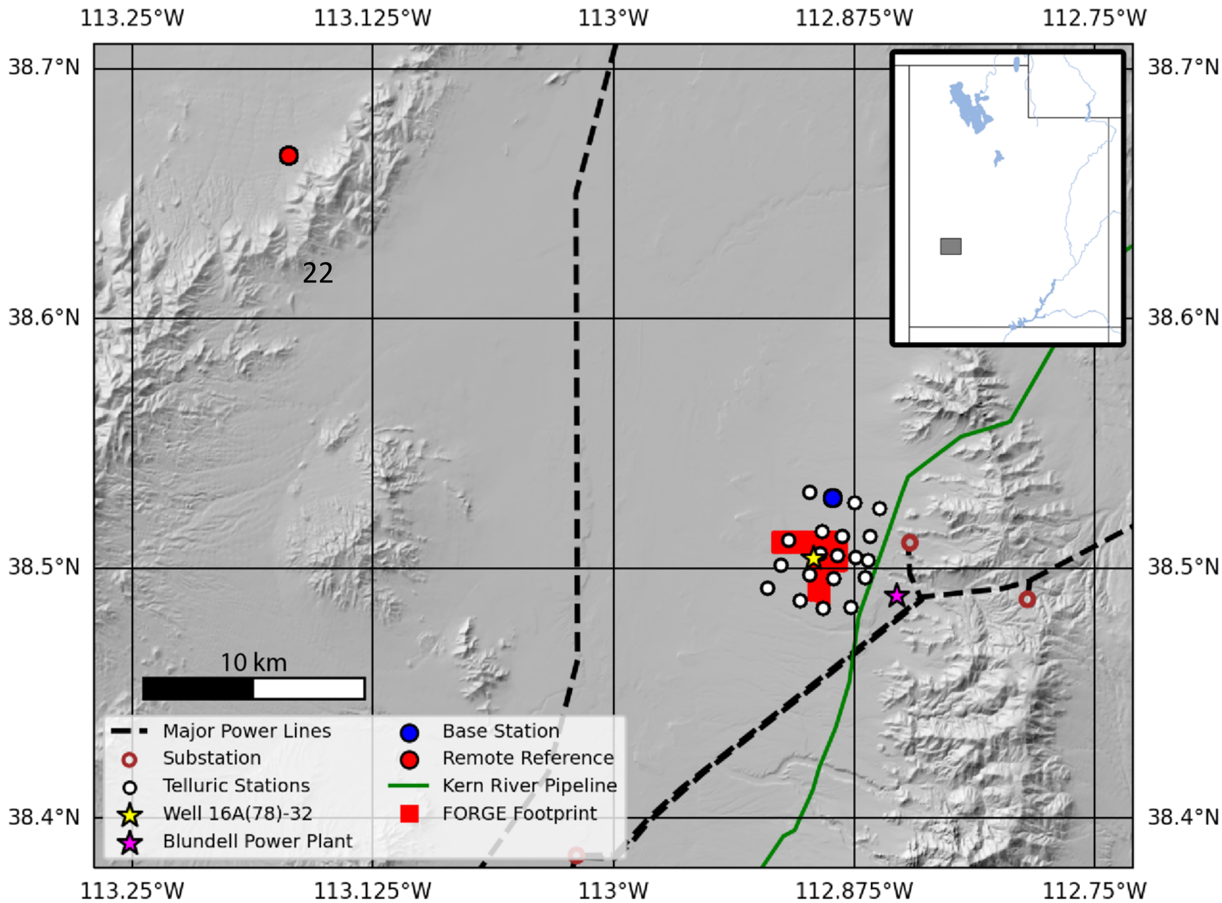



*Figure 1. Outline of the FTM survey footprint in relation to the Utah FORGE experiment and relevant infrastructure. Inset map shows the location of the map in relation to Utah. The remote reference site 22 is labeled in the upper left.*

several moving telluric-acquisition sites and two continuously operating full MT sites with magnetic and electric channels. This document outlines the survey design, processing workflow, and archival data structure obtained from the FTM monitoring experiment.

## 2. SURVEY DESIGN

The FTM monitoring array was designed to fulfill several logistical constraints, including cost, ease of access, location of known near-field EM sources, and proximity to well 16A(78)-32. The planned stimulation depth (~3.3km, McLennan et al. 2021) motivated an array aperture aspect of about 2x in width, with minimally inferred station density sufficient to capture a gradation from well-centric impedance transients towards presumed static regional impedance structure. Three likely cultural noise sources are proximal to the FTM array: (1) A regional 1000kV high voltage DC line west of the FORGE site trending N-S., (2) two ~100kV AC lines trending NE just south of the array., and (3) a galvanically protected regional gas pipeline which directly abuts the eastern edge of the FTM survey footprint. Other unmapped powerlines, substations, compressor stations, and the Blundell geothermal power plant are also close to the FTM footprint. EM noise from EGS injection and other geophysical monitoring activities were not expected to be significant.

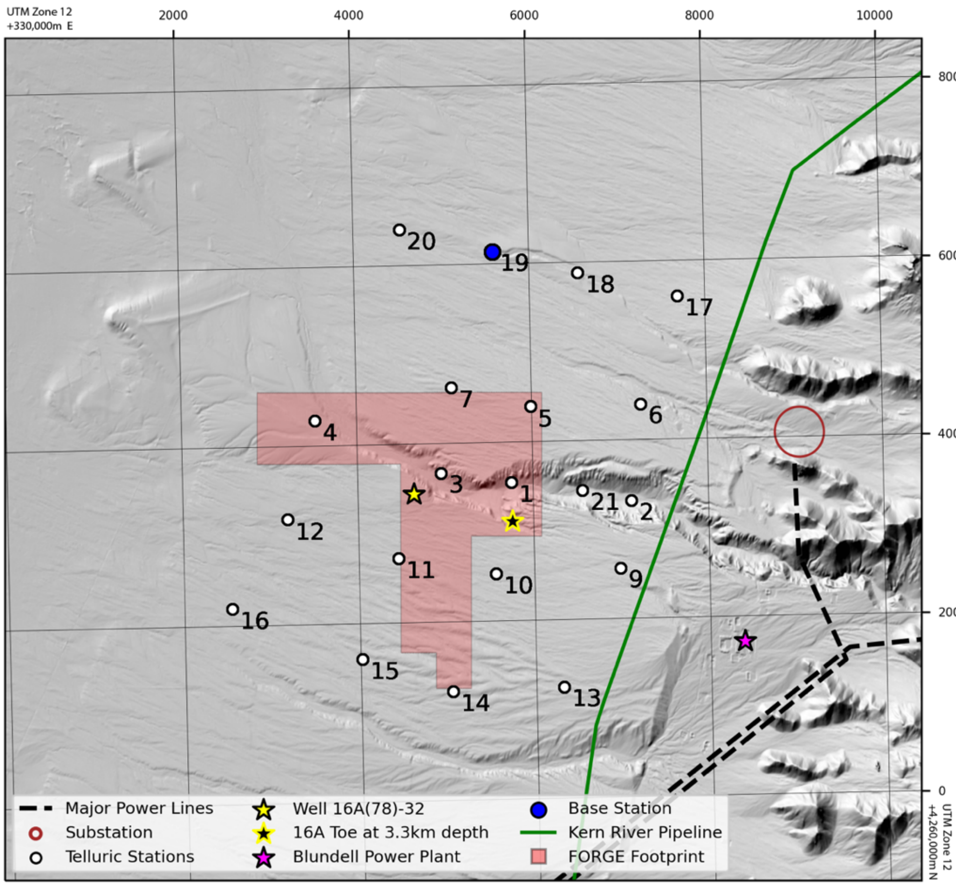



*Figure 1. Close up view of the FTM survey with station numbers indicated. The location of well 16A(78)-32 and its toe at depth are shown with yellow-black stars.*

Six Zonge Zen recorders produced by Zonge Geophysics and six coils were obtained on loan from Oregon State University (OSU). Coils and data recorders were modified in-house at OSU to simplify field logistics. The provided equipment was enough for two nominal MT stations when paired with Ag-AgCl electrodes loaned from the USGS, though one coil was retained in reserve in case of equipment failure. Due to the density of the planned survey footprint, the H fields recorded at a designated "base station" would be used for H field estimates at the other telluric sites.

The final survey configuration is illustrated in Figures 1 and 2. A full MT site designated 22 was placed > 20km NW of the FORGE footprint with three coils and two electric field monitoring channels to act as our remote reference. The base station was deployed within the survey footprint with two coils and two electric field monitoring channels at site 19. The location was chosen because of its distance to a galvanically protected pipeline and several large powerlines which trace near the FORGE site.

| FTM Station | Easting | Northing | Latitude | Longitude | Elevation (m) | Ex Azimuth | Ex Bipole Length | Ey Azimuth | Ey Bipole Length | Hx Coil # | Hy Coil # | Hz Coil # | Hx Azimuth | Hy Azimuth | Hz Azimuth | Hz Inclination |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 335753.5 | 4263545.6 | 38.50515 | -112.88366 | 1673 | 11.29 | 101.0 | 101.29 | 99.0 | | | | | | | |
| **2** | 337118.0 | 4263319.6 | 38.50336 | -112.86797 | 1726 | 11.29 | 104.0 | 101.29 | 95.0 | | | | | | | |
| **3** | 334950.6 | 4263665.9 | 38.50608 | -112.89290 | 1645 | 11.29 | 105.0 | 101.29 | 91.0 | | | | | | | |
| **4** | 333524.4 | 4264282.1 | 38.51137 | -112.90939 | 1600 | 11.29 | 99.0 | 101.29 | 107.0 | | | | | | | |
| **5** | 335985.2 | 4264393.5 | 38.51283 | -112.88121 | 1697 | 11.29 | 100.0 | 101.29 | 105.0 | | | | | | | |
| **6** | 337241.1 | 4264396.6 | 38.51308 | -112.86681 | 1752 | 11.29 | 95.0 | 101.29 | 95.0 | | | | | | | |
| **7** | 335088.6 | 4264621.1 | 38.51471 | -112.89154 | 1652 | 11.29 | 106.0 | 101.29 | 100.0 | | | | | | | |
| **9** | 336977.4 | 4262563.2 | 38.49652 | -112.86941 | 1773 | 11.29 | 98.0 | 101.29 | 105.0 | | | | | | | |
| **10** | 335557.7 | 4262525.0 | 38.49592 | -112.88567 | 1696 | 11.29 | 98.0 | 101.29 | 110.0 | | | | | | | |
| **11** | 334446.8 | 4262720.0 | 38.49747 | -112.89845 | 1648 | 11.29 | 99.0 | 101.29 | 99.0 | | | | | | | |
| **12** | 333191.2 | 4263179.9 | 38.50138 | -112.91295 | 1598 | 11.29 | 106.0 | 101.29 | 106.0 | | | | | | | |
| **13** | 336309.3 | 4261245.1 | 38.48453 | -112.87676 | 1748 | 11.29 | 107.0 | 101.29 | 101.0 | | | | | | | |
| **14** | 335042.4 | 4261219.6 | 38.48406 | -112.89127 | 1690 | 11.29 | 104.0 | 101.29 | 103.0 | | | | | | | |
| **15** | 334016.1 | 4261600.7 | 38.48731 | -112.90312 | 1644 | 11.29 | 102.0 | 101.29 | 102.0 | | | | | | | |
| **16** | 332536.7 | 4262188.8 | 38.49233 | -112.92021 | 1591 | 11.29 | 101.0 | 101.29 | 108.0 | | | | | | | |
| **17** | 337681.9 | 4265597.4 | 38.52398 | -112.86204 | 1748 | 11.29 | 99.0 | 101.29 | 102.0 | | | | | | | |
| **18** | 336555.1 | 4265877.1 | 38.52629 | -112.87502 | 1687 | 11.29 | 107.0 | 101.29 | 106.0 | | | | | | | |
| **19** | 335585.9 | 4266134.3 | 38.52843 | -112.88619 | 1643 | 11.29 | 102.0 | 101.29 | 102.0 | 2454 | 2544 | | 11.29 | 101.29 | | |
| **20** | 334530.7 | 4266399.6 | 38.53063 | -112.89836 | 1598 | 11.29 | 104.0 | 101.29 | 106.0 | | | | | | | |
| **21** | 336562.6 | 4263444.5 | 38.50438 | -112.87437 | 1702 | 11.29 | 96.0 | 101.29 | 97.0 | | | | | | | |
| **22** | 311286.9 | 4281870.3 | 38.66532 | -113.16905 | 1572 | 11.29 | 100.0 | 101.29 | 100.0 | 2374 | 287 | 307 | 11.29 | 101.29 | 0 | 90 |

*Table 1. FTM station geographic and basic MT station metadata as initially deployed.*

The remaining sites were outfitted with two sets of ~100m bipoles oriented to the local magnetic N-S and E-W. We refer to these sites as telluric stations, as their function is solely to record electric field timeseries. All telluric sites were outfitted $Cu\text{-}CuSO_4$ electrodes purchased from Zonge Geophysics.


*Figure 2. Station uptime during the FTM survey. Red vertical bar indicates the approximate start of well stimulation activities. Also indicated are the start of the base and remote reference recording blocks.*

## 3. DATA ACQUISITION CAMPAIGN

The FTM survey data acquisition campaign began on 4/07/2022 23:00 UTC with the installation of the remote reference site FTM022 in the southeastern Sevier Desert. All sensors were aligned with either Magnetic North (x+) or Magnetic East (y+). FTM022 was deployed with an ANT4 coil oriented towards the north and ANT7's oriented east and vertically. Electric bipole lines were deployed in an X pattern with the coils, battery, and Zen data recorders located at the center. Electrodes were buried on average about 50cm deep. The remote site was outfitted with several deep-cycle marine batteries to reduce needed site visits due to its distance from the FORGE footprint.

After the deployment of the remote reference, the base station FTM019 and telluric sites were deployed. The base station was deployed with two ANT4 coils oriented north and east. Telluric station electrodes were placed within premixed bentonite clay-filled burlap sample bags, and 1 gallon of water was used per electrode hole to maintain good electrical contact with the Earth. Contact resistances were all initially below 5k Ohm. All bipoles were deployed in the same orientation as FTM022's. Bipoles were a mix of 18 gauge steel and copper multi-stranded wires.

Out of the six available data recorders, two were permanently fixed to FTM022 and FTM019, and four were designated 'rovers,' moving once per day. Deep-cycle marine batteries were deployed with the recorders. Battery voltage never dipped below 10.5V upon recorder retrieval. Data recorders, batteries, and battery harnesses were placed in reusable clear plastic bags to protect them from moisture.

Due to logistical constraints, the FTM survey was unable to adequately occupy each FTM site before the stimulation of well 16A(78)-32; stations 4, 18, and 21 only obtained a fraction of the intended baseline recording time. Field complications led to the incorrect deployment of coils on both the base and remote reference during installation. Site visits to the remote and base on 4/14/22 corrected the error. From then on, those MT sites had the following coil metadata:

| Station | Hx Coil # | Hy Coil # | Hz Coil # |
|---|---|---|---|
| FTM019 | 2454 | 2544 | |
| FTM022 | 2374 | 287 | 2524 |

*Table 2. Post April 14, 2022 FTM coil metadata.*

The Zonge software behaved inconsistently with the OSU-modified recorders; repeat records occasionally failed. Initially, 24 hr recording blocks at 256 Hz were attempted. Upon retrieval, no repeat recording period was observed. It was then decided to deploy all data recorders with a schedule of 6hr increments at 256 Hz with a five-minute delay time between recording blocks. All recording blocks were initialized during the last phase of site visits.

On 4/28/22, the 24 hr recording period non-repeating schedule was tried once more to simplify data collection after the data recorder firmware was updated. This was discontinued after both the base and remote station coils failed to record during station's FTM 10,11, 14, and 15 recording on 5/6/2022; the lack of magnetic records from these recording blocks rendered the data unanalyzable. A switch was made to 6 hr, then 12 hr, repeating records afterward. The change in field procedures was maintained until the end of the FTM survey.

Efforts were made to ensure each site was only visited by data recorders with the same serial number as previous visits. However, during the last phase of FTM recordings, it was determined that two of the Zen data recorders failed to record data, and the practice had to be abandoned.

All FTM sites were accessible by unmaintained BLM dirt roads. Servicing the sites necessitated the use of 4x4 vehicles. Brush and foliage were generally not an issue. Only in one instance were bipole lines observed to have been impacted by cattle.

## 4. TIME SERIES PROCESSING

*Overview*

Time series were processed using a proprietary magnetotelluric software processing suite provided for free by Zonge Geophysics. The software is theoretically capable of processing numerous time series simultaneously, provided nearby coils and remote references are available. However, due to the ad-hoc nature of the time block recording periods, we were unable to make use of this batch-processing feature. Instead, time series had to be processed one at a time, considering base coils and the target telluric time series, or base coils + remote coils + telluric time series. For several recording times, Zonge graciously allowed us to use some remote references which were operational in Northern Mexico; While the uptime of these sites was extremely limited, they proved instrumental in recovering several robust transfer functions.

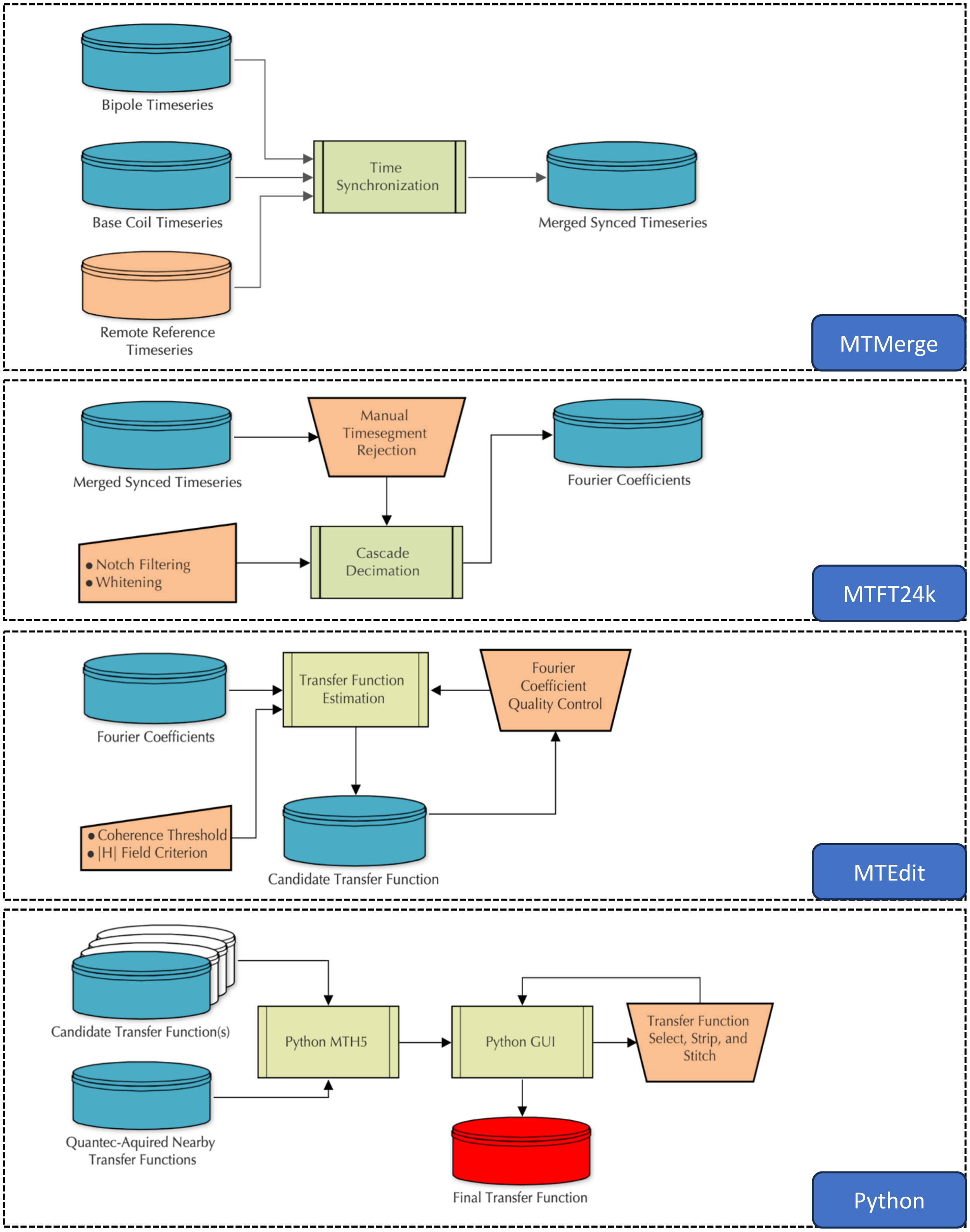
Time series were processed using three of the Zonge Geophysics core applications: 1. MTMerge for time synchronization, 2. MTFT24k for application of the cascade decimation algorithm (Wight, D., and F. Bostick, 1980)., and 3. MTEdit, for initial editing and quality control of the produced transfer function. Transfer functions were then refined and properly archived using in-house Python utilities.

In the case of MTFT24k, viewing the fourier spectra of time series subsets allowed for the identification of cultural EM contamination, like square waves, otherwise invisible periodic noise, and aliased RF energy. MTFT24k enabled the rejection of fourier coefficients contaminated problematic signals, as well as several options for notch filters applied to specific frequencies and their harmonics, spectrum prewhitening, and visual validation of cross-channel coherence. Segments of the time series that appeared visually problematic could also be manually rejected if necessary.

After MTFT24k produced the desired fourier coefficients, MTEdit enabled further filtering via coefficient property thresholding or by manual removal. Property thresholding auto-rejected coefficients based on an acceptable coherence or incident H amplitude range. Manual removal was done by comparing the coherence vs. time, H amplitude, and H azimuth, then rejecting coefficient clusters. Trends across frequencies and across tensor components allowed for the retrieval of robust transfer functions even with high degrees of cultural EM contamination.

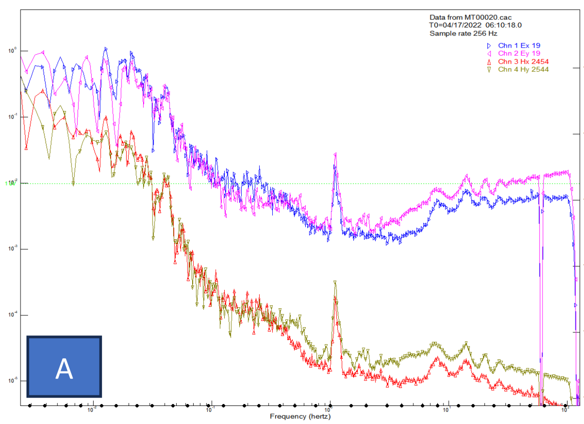
Finally, in-house Python workflows developed specifically for cleaning the FTM data allowed us to stitch together several candidate transfer functions by comparison with known nearby transfer functions of high quality. First, .avg files produced by MTEdit were converted to candidate .edi files using MTH5, a Python archiving utility designed specifically for manipulating MT data (Peacock et al., 2022). Once in .edi form, a python GUI using MtPy (Kirkby A.L., et al. 2019) and several other popular open-source datascience packages[3,4,5,7] allowed simultaneous comparison of multiple candidate transfer functions. Sections of each transfer function candidate that best matched the expected physics of MT transfer functions and nearby Quantec Geoscience-acquired MT sites were stitched together across modes and frequencies. The complete signal processing stack, including different processing options within the corresponding software, is illustrated in Figure 4.

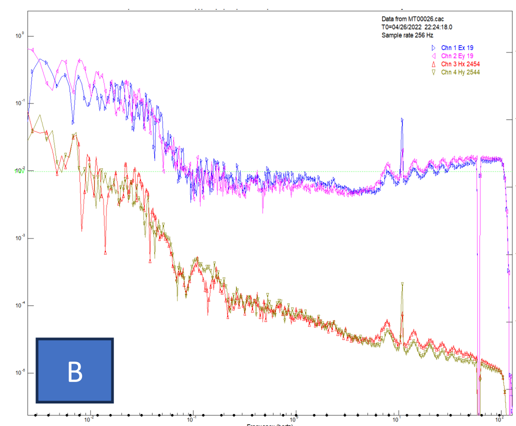
Figure 4. Generalized workflow for processing FTM data. Orange represents optional items, green represents algorithmic processing, and blue represents required inputs/definite outputs. Red database symbol at end is the final product. Workflow is subsegmented by the applications/software used.



*Cultural EM Contamination*

The recorded time series contained artifacts that were clearly anthropogenic in origin. Most recording groups had one or more artifacts. Especially during the latter half of the survey, recorded time series appeared to contain half or more of these signals. The use of the remote reference did little to remove the effect on the final transfer function. However, we discovered time series exclusion and notch filtering to be effective for most of the observed signals. This was a labor-intensive process that necessitated visual scanning of the time series at sub-hour intervals to identify problematic signals.



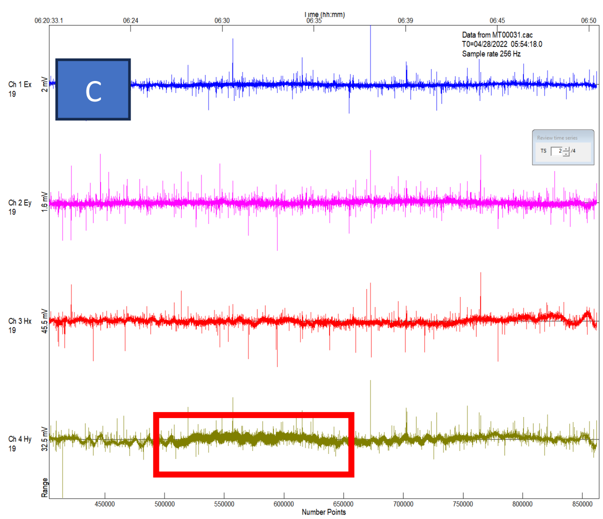




*Figure 5. (a) An example of a 1 and (b) A 10-11 Hz frequency spike. (c) Shows a region of higher RMS visible in the Hy timeseries. Spikes were observed on both E and H channels. All subfigures are from FTM019.*

The observed cultural contamination can be roughly grouped into three categories:

1. Single frequency spikes
2. Frequency spikes with harmonics
3. Time-domain evident signals

**Single Frequency Spikes**

Frequency spikes occurred in at least 15 recording blocks. Spikes centered around 1 Hz or 10-11 Hz and contained no visible harmonics. The effects were easily filterable with an applied notch filter or through fourier coefficient editing during the MTEdit phase of processing.

The 10-11 Hz spikes appeared highly correlated in time and occasionally had visible manifestations in the time domain. All spikes were visible both on the E and H channels.

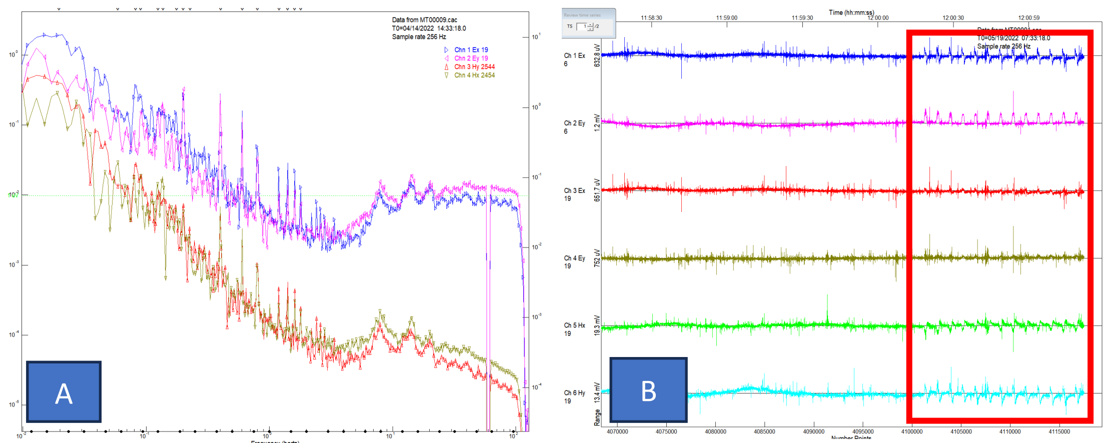



*Figure 6. (a) An example of a 2 (s) frequency spike with multiple harmonics. (b) Its localized manifestation in the time domain on both FTM019 and FTM006.*

## Frequency Spikes with Harmonics

Frequency spikes with harmonics were observed often, sometimes visible across most of the record. This type of noise had fundamental frequencies of 5 (s) or 2 (s). The lower frequency 5 (s) sometimes exhibited up to 30 or 40 harmonics.

When only a few harmonics were visible, notch filtering proved sufficient to create robust transfer functions. When the number of harmonics exceeded ~4-5, removal of the offending time series was the only procedure that could recover the MT signal. The time domain manifestation of these signals resembled square waves with a 50% duty cycle.

## Time Domain Evident Signals

Several signals were observed that had undetectable fourier space manifestations but were clearly visible in the time domain. These consisted of level shifts evident in either Hx or Hy.

Transfer functions created by the inclusion of these signals resulted in large static offsets in the corresponding mode. When the recording period was long enough, exclusion of the affected time segment was sufficient to create robust transfer functions.

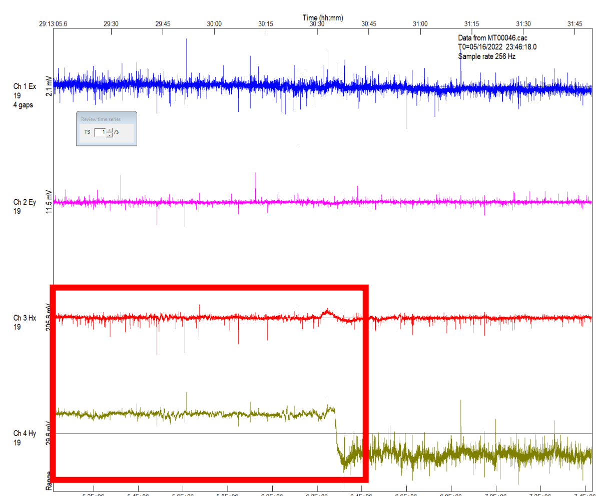
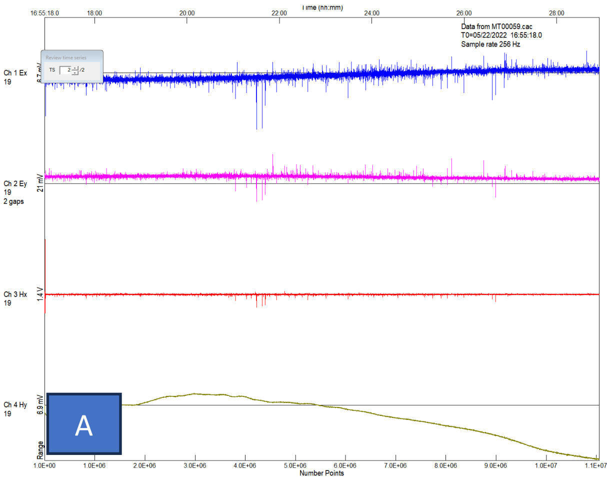


*Figure 7. A level shift signal evident in the Hy line of the base coil.*



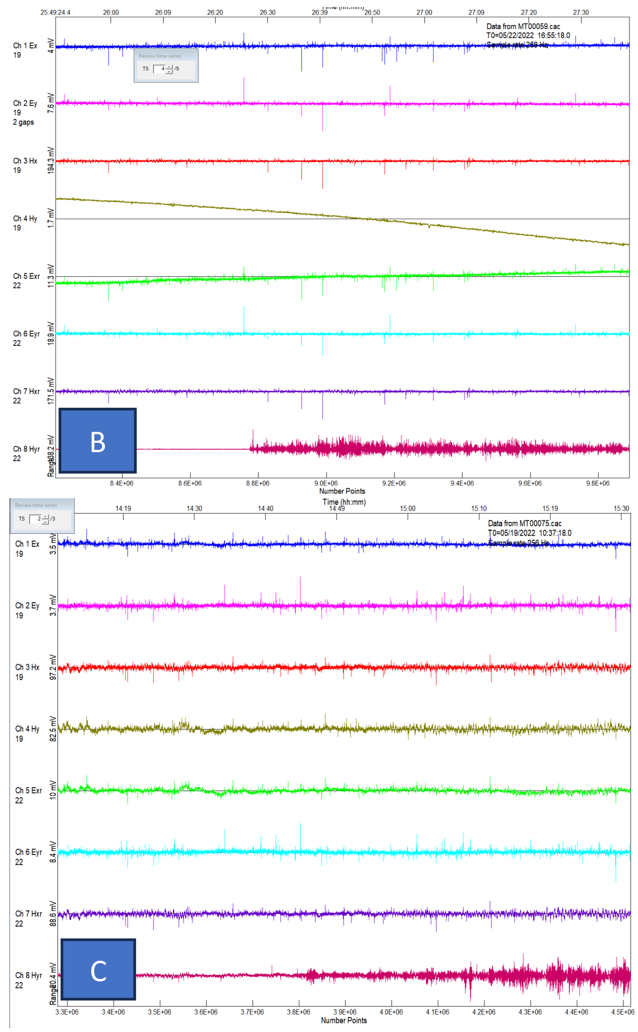




*Figure 8. Equipment failure related signals. (a) What appears to be low frequency energy only evident on the Hy coil of the base station. (b-c) Hx coil increasing RMS observed on the FTM022 remote station.*

Based on personal communications with other MT processors, we determined that the phenomenon is likely a result of high amplitude RF energy forcing the ADC preamplifiers into a diode-like state. Several such level shifts are visible on the Hx and Hy coils near the base station of the site. When evident, they appear to affect only one coil direction.

### *Signal Compromised by Equipment*

While several processing options were identified for cultural EM noise-contaminated time series, some signals appeared to be due to coil failures. Equipment-related failures manifested as slowly increasing RMS noise or an absence of high-frequency signal in the H lines. Several processing variations were tried to recover transfer functions during these times, but none proved effective. See Figure 8 for examples of equipment failure time series.

## 5. ARCHIVED DATA

### *Overview*

The data provided along with this document consists of transfer functions and images of apparent resistivity and phase. Transfer functions are chunked into four time blocks (see Figure 9):

(a) Pre-stimulation
(b) Immediate post-stimulation
(c) Intermediate post-stimulation
(d) ~1 Month post-stimulation

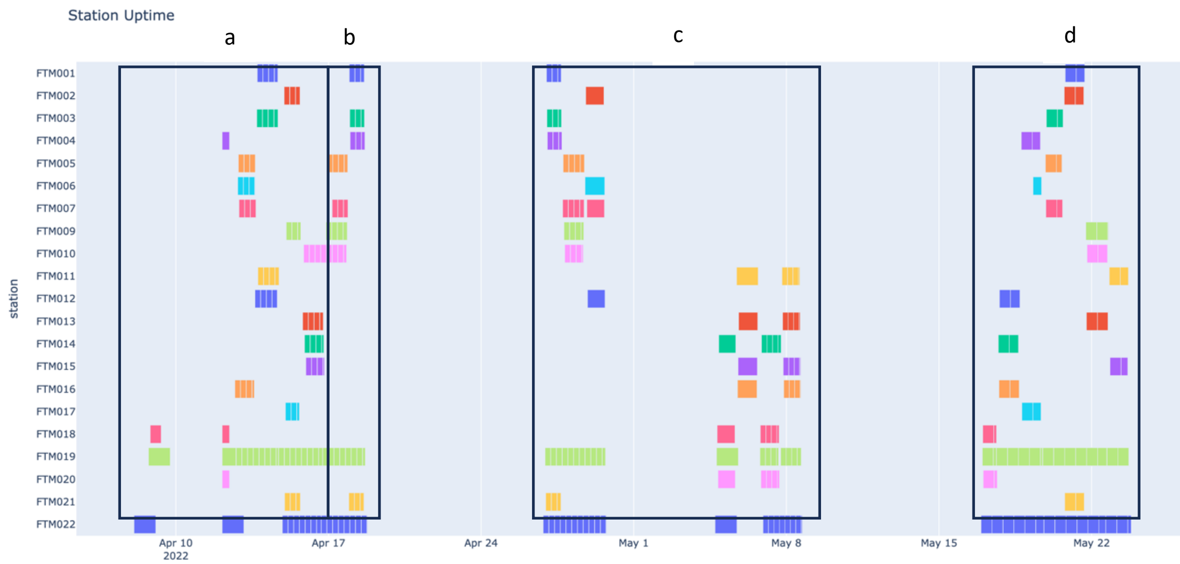



*Figure 9. Time chunk scheme of the FTM survey. Time blocks are labeled (a-d) from left to right. Note that the FTM022 Remote's transfer function is excluded from this report. The time block segment domains are adjusted to reflect this.*

Unfortunately, robust transfer functions were unable to be recovered for every site and every time block. Some sites appeared to suffer the effects of a near-field EM source evidently invisible in either the time domain or frequency domain. When manifested, the near-source effect causes the opposite mode to mirror the apparently unaffected mode but with higher apparent resistivity. The effect is most notable in the XY mode. Both the affected high fidelity and marginal fidelity transfer functions are provided within the archive. An overview of the assessed data quality is provided in Table 3, and the exact time block definitions are in Table 4.

*Archive Structure*

The archived data are provided in a .zip file containing transfer functions organized by time block. Directly next to the time block folders is a .csv copy of Table 1. Within each time block folder, one subfolder contains .png snapshots corresponding to the .edi files contained within a separate subfolder. Transfer function snapshots were created with MtPy.

*Table 3. Sounding Data Quality Summary of the FTM survey. Fidelity is ranked via the following: 4 (blue) Soundings of high quality., 3 (green) Soundings with few modes/frequencies of low quality., 2 (orange) Soundings with many modes/frequencies of low quality, but with regions of high quality., 1 (red) Soundings with most modes/frequencies of poor quality. Also indicated is whether there is a detectable near-field effect on the soundings.* ***N/A*** *indicates soundings that could not be recovered during the given time block and that are not provided as part of the FTM survey archive.*

| Station | Time Block a | | Time Block b | | Time Block c | | Time Block d | |
|---|---|---|---|---|---|---|---|---|
| | Fidelity Score | Near Field Effect? | Fidelity Score | Near Field Effect? | Fidelity Score | Near Field Effect? | Fidelity Score | Near Field Effect? |
| ftm001 | 3 | no | 3 | no | 4 | no | 2 | yes |
| ftm002 | 3 | no | N/A | | 3 | no | 3 | yes |
| ftm003 | 3 | no | 2 | no | 3 | no | 3 | yes |
| ftm004 | 1 | no | 3 | no | 4 | no | 3 | no |
| ftm005 | 2 | no | 4 | no | 4 | no | N/A | |
| ftm006 | 2 | no | N/A | | 3 | no | 3 | no |
| ftm007 | 3 | no | N /A | | 4 | no | N/A | |
| ftm009 | 4 | no | 3 | no | 4 | no | 3 | yes |
| ftm010 | 3 | no | 4 | no | 4 | no | 3 | yes |
| ftm011 | 2 | no | N /A | | 2 | yes | N/A | |
| ftm012 | 3 | no | N /A | | 3 | no | 4 | no |
| ftm013 | 3 | no | N /A | | 2 | yes | 2 | yes |
| ftm014 | 2 | no | N /A | | 2 | no | 4 | no |
| ftm015 | 3 | no | N /A | | 2 | yes | N/A | |
| ftm016 | 3 | no | N /A | | 2 | yes | 1 | yes |
| ftm017 | 4 | no | N /A | | 3 | no | 4 | no |
| ftm018 | 2 | no | N /A | | 3 | no | 3 | no |
| ftm019 | 4 | no | 3 | no | 4 | no | 4 | no |
| ftm020 | 2 | no | N/A | | 2 | no | 2 | no |
| ftm021 | 3 | no | 2 | no | 3 | no | 2 | yes |

*Table 4. UTC start and end times of time blocks.*

| Time Block | Start (UTC) | End (UTC) |
|---|---|---|
| a | 2022-04-08 00:00 | 2022-04-17 03:40 |
| b | 2022-04-17 03:40 | 2022-04-18 18:00 |
| c | 2022-04-26 20:21 | 2022-05-08 17:30 |
| d | 2022-05-16 22:17 | 2022-05-23 19:35 |

## 6. LOGISTICAL LEARNINGS

We would like to provide suggestions for other organizations planning similar 4D MT surveys.

(1) The use of combined telluric-magnetotelluric stations within a dense footprint allowed for the use of less equipment, simplified logistics, and longer battery life compared to an array of simultaneously recording full MT sites. Setting up telluric stations was comparatively easy. However, as evidenced by equipment failures across the FTM array, we recommend at least 2 full MT base stations and at least 2 remote references be outfitted with coils.

(2) The Zonge Zen data recorders provided ample capability to record telluric stations. However, their high procurement cost is a product of needing capabilities to record up to 5 channels of data as required. As cost is dominated by the Analog-to-Digital converter signal chain, in theory 2x more data recorders could be had for the cost of one. Future telluric monitoring arrays may want to consider acquiring or creating telluric-only recorders.

(3) Our survey utilized 12V deep cycle lead-acid batteries with about ~50 Amp-hrs of energy. The number available was just about adequate for the number of site visits required. Charging and moving these heavy, 20-30lb batteries was an additional logistical challenge and slight safety risk. We suggest future telluric monitoring experiments acquire or loan an excess amount of lithium battery packs to simplify logistics and increase safety.

(4) The most time-consuming activity of the FTM survey was producing transfer functions. Due to the nonstationary nature of the time series, each station-time block went through a thorough grid search over many possible processing options. Given the various observed categories of equipment and cultural noise, further automation of signal processing routines for square waves, frequency-spikes, etc; could greatly reduce the time-to-science for large MT arrays.

Given the current (2020-2023) cost and limited number of wideband and long period coils available to research groups within the US, expansion of telluric monitoring capability as per suggestion (2) has potential for expanding research capabilities within existing resources.

## 7. CONCLUSIONS

The Utah Frontier Observatory for Research in Geothermal Energy (FORGE) attempted a stimulation during April, 2022 which injected small amounts of saline water into hot, dry crystalline rock. A 4D MT survey called the FORGE Telluric Monitoring array (FTM) was designed to capture earth electrical structure transients related to the stimulation. In total, 19 telluric stations and one MT station was deployed and recorded sporadic timeseries of the ambient EM field across more than a month of observation.

Recovered timeseries data was determined to be contaminated with cultural EM noise. A processing workflow involving software provided by Zonge Geophysics, MTH5, and MtPy was designed to filter and produce robust MT transfer functions from these data. The resulting transfer functions are distributed across 4 time blocks starting before and ending a month after the injection of the FORGE reservoir.

The MT transfer functions provided along with this document range in quality. 12 of them appear to be affected by high-frequency noise which distored at least one of the off-diagonal modes across most frequencies. Complications with field procedures and equipment failures led to an incomplete FTM record. Transfer functions from 7 stations were obtained across each time block and 12 contain transfer functions from the pre-injection and at least one post injection time block. Provided data are contained in a .zip file in .edi format, along with .png images of the transfer functions and a .csv file containing station metadata.

Finally, we provide several suggestions for future 4D MT monitoring efforts. These include 1. additional base and remote reference deployments., 2 acquisition of low-cost telluric data recorders., 3 access to lighter-weight, high-capacity battery banks., and 4., further R&D efforts directed towards MT signal recovery in high cultural EM environments.

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