Long-period magnetotelluric data collected on the north-east Greenland Ice Sheet, 2019

Report on the magnetotelluric data in the project/repository folder: MAGPIE.2019
(https://doi.org/10.5880/GIPP-MT.201913.1)

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The data are supplementary to:

Selway, K., Ramirez, F., Conrad, C., Weerdesteijn, M., 2020. How can geophysical imaging help contstrain mantle viscosity to improve glacial isostatic adjustment models?. In: *SCAR Open Science Conference 2020 Session 15 Ice Sheet-solid Earth Interactions: GIA, Landscape Evolution and Geothermal Heat Flux*, online, 1508 pp.

Abstract

The goal of MAGPIE is to improve estimates of present-day ice melting rates in Greenland by accurately correcting observed uplift rates for glacial isostatic adjustment (GIA) from past deglaciation. A key parameter required for constraining uplift rates for GIA is mantle viscosity, which can best be calculated from combined seismic and MT measurements. The data in this repository represent the first year of MAGPIE data collection.

Central Coordinates: *75.537722 N, -36.414700 E*
Experiment time frame: *from 03 June 2019 to 20 June 2019 (data embargo ends: 01 July 2023)*
Keywords: *Mantle, Glacial isostatic adjustment*

1. Introduction

The 2019 MT data collection was focussed around the EastGRIP ice drilling camp, located on the North-East Greenland Ice Stream at approximately 76N, 36W. EastGRIP is an international collaborative camp between Iceland, Norway, Sweden, Denmark, Germany, Switzerland, France, Italy, China, South Korea, Japan and the USA. The focus of the data collection was a grid of long-period MT stations with the goal of imaging upper mantle conductivity. These data were collected in a 'hub and spoke' pattern, with eight stations positioned on 'spokes' radiating out from EastGRIP station, with a 'hub' base station close to EastGRIP itself.

The original publications which originated from these data are: Selway et al. 2020.

2. Experimental setup and schedule

Magnetotelluric (MT) data was collected between 03 June 2019 and 20 June 2019. Fig. 1 shows a site map.

Data were recorded at nine stations spaced at approximately 50 km intervals within a grid that extends approximately 150 x 150 km.

A description of the equipment used is provided in section 4. More details on a per site basis on instruments, serial numbers, hardware and recording settings, and available data are given in Appendix 1.

3. Station locations

The table below provides a complete listing of all measured stations. The columns give site number, start and end times of the measurements, station locations (latitude, longitude and altitude) and available data sets (time series).

						level 0	
Site	**Start date**	**End date**	**Latitude**	**Longitude**	**Altitude**	**lmt**	**em-lmt**
0001	2019-06-05	2019-06-20	75.630300	-35.997500	2660	✓	✓
0002	2019-06-03	2019-06-14	75.638900	-37.810300	2740	✓	✓
0003	2019-06-05	2019-06-16	74.896300	-38.020000	2850	✓	✓
0004	2019-06-05	2019-06-16	75.256500	-36.987000	2670	✓	✓
0005	2019-06-06	2019-06-18	76.257500	-38.650000	2670	✓	✓
0006	2019-06-06	2019-06-17	75.943900	-37.297800	2670	✓	✓
0007	2019-06-08	2019-06-17	74.984500	-33.539000	2740	✓	✓
0008	2019-06-08	2019-06-17	75.310700	-34.757200	2710	✓	✓
0009	2019-06-10	2019-06-19	75.920900	-34.673500	2570	✓	✓

4. Instrumentation

4.1 Data acquisition systems: 6-channel EDL.

The Earth Data Logger PR6-24 (EDL, EARTH DATA, U.K.) is a digital recording system predominantly designed for seismic applications. To provide the necessary interface electronics for MT sensors, the EDL loggers are typically used in combination with the CASTLE preconditioning units of the Geophysical Instrument Pool Potsdam. These sensor boxes provide necessary high-impedance amplifiers for electric field recordings and a range of analogue high- and low-pass filters to match typical MT applications.

EDL loggers are available as 3 and 6 channel systems, labelled EDL3 and EDL6 respectively. For MT applications the 6-channel logger is more commonly used. EDL systems are GPS synchronized and provide sampling rates between 1 Hz and 1 kHz. Data conversion is with 24-bit analogue to digital converters. EDL data logger store the recorded time series in the MiniSEED format.

The following **6-channel EDL** loggers were used: 6002, 6014, 6018, 6019, 6020, 6022, 6024, 6027, 6029.

4.2 Sensor boxes: CASTLE

CASTLE sensor boxes provide the hardware interface between sensors (electrodes and induction coil magnetometers) and the SPAM3, SPAM4 and EDL data acquisition systems. Up to 3 sensors can be connected to a CASTLE sensor box. CASTLE sensor boxes are therefore usually used in pairs, with one sensor box receiving signals from magnetic field sensors and another one capturing electric field signals.

CASTLE sensor boxes provide programmable amplifiers with high input impedances (> 1 GOhm) and two adjustable low-pass filters. They contain control logic to measure contact resistances between electrodes, remove DC offsets from channels, generate test signals for the induction coils, toggle induction coils between low- and high frequency modes, and test the analogue signals for overloads.

The following **CASTLE** sensor boxes were used: 8, 9, 61, 70, 72, 73, 77, 79, 91.

4.3 Magnetic field sensors: Geomag fluxgates

The following **Geomag fluxgate** magnetometers were used: 11, 20, 22, 25, 30, 31, 41, 42, 47.

4.4 Electric field sensors: .

5. Recording settings

Data recording typically lasted for at least ten days per station. Station 0001 recorded for twenty days and its record overlaps with each of the other stations. Each station was recorded by a unique instrument. The typical sampling rate for continuous recording was 1 Hz

Details on recording times, sampling frequencies, and actual hardware configurations are summarized for each site in Appendix 1.

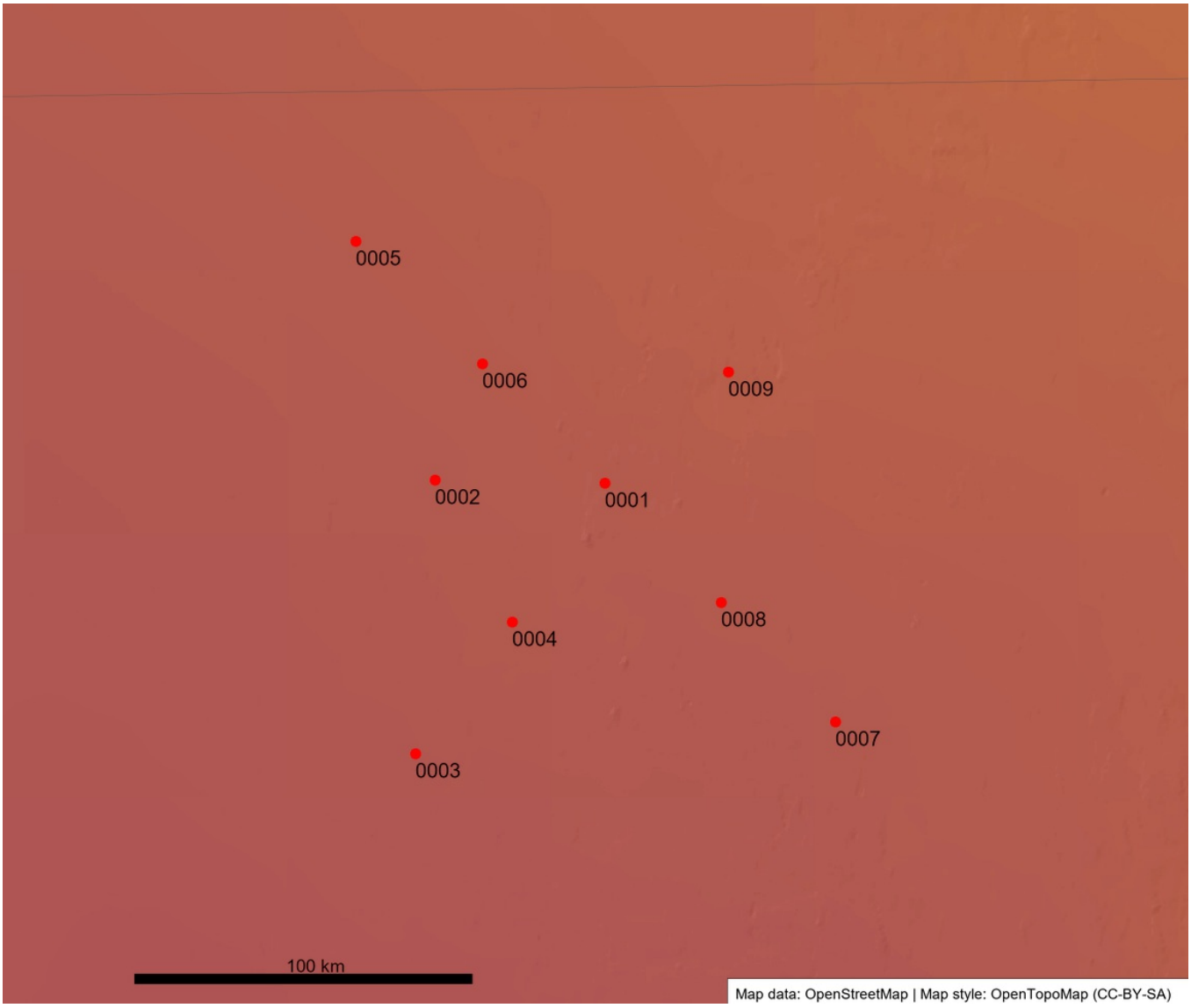

Figure 1: *Location of the MT stations (red dots).*

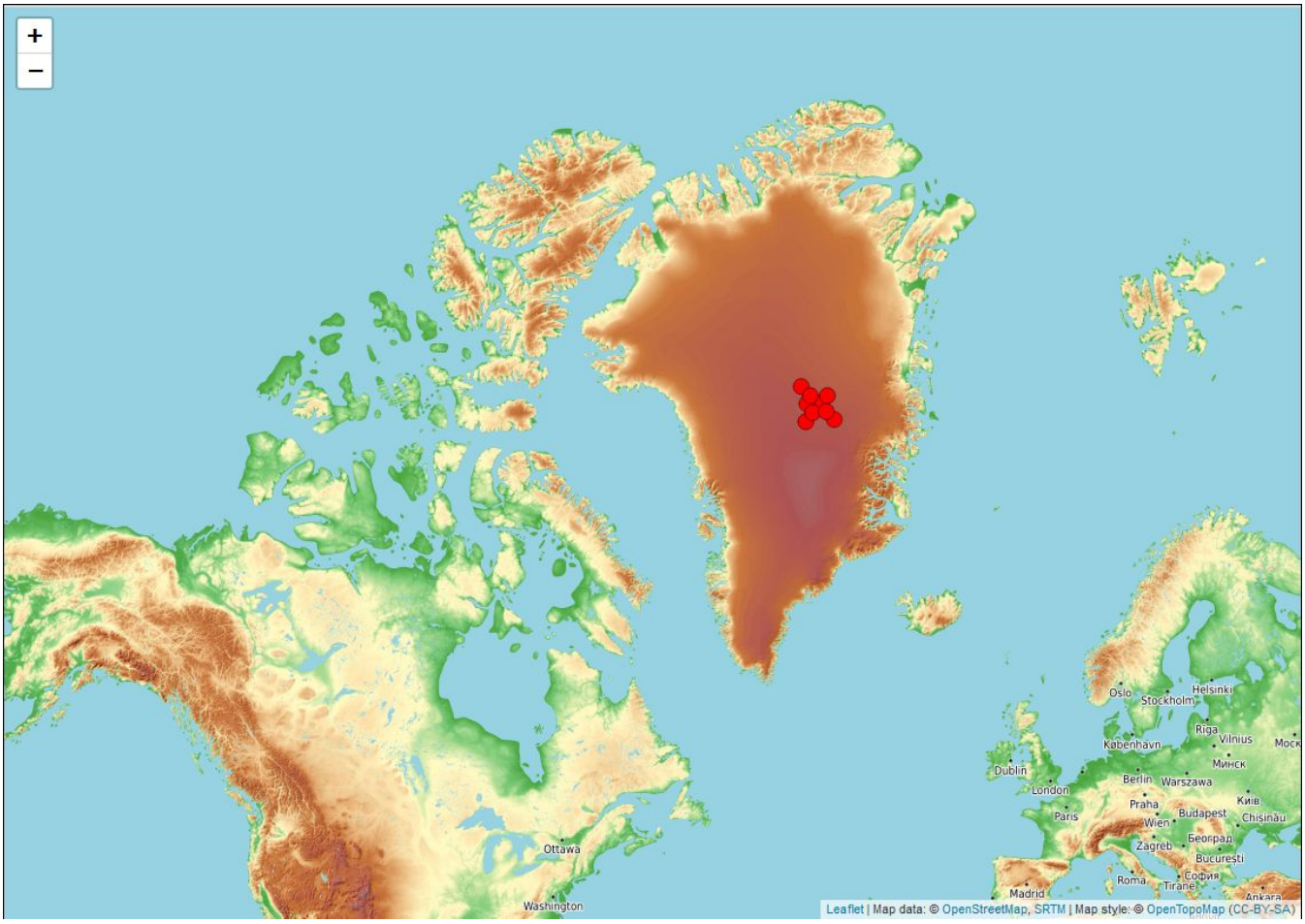

Figure 2: *verview map with MT station locations (red dots).*

6. Archive structure and data formats

The principle form of data in the repository are time-series of electromagnetic field components acquired with heterogeneous sets of sensors, recording instruments, and sampling rates. The repository provides the links between the data and their physical meaning by means of meta-data. The repository is organized as a combination of data files and associated meta-data in a defined folder (directory) structure, with the data files being sorted into sub-folders. Meta-data are provided as XML (Extensible Markup Language) formatted files.

The times series data are available in the so-called EMERALD format. EMERALD data files typically come in pairs of two files with the same name but differing file name extensions, e.g. RAW and XTR files. XTR (extract) files are plain ASCII files, EMERALD- type data files are in most cases binary. The EMERALD- type data files store data in matrix form (any number of channels), but do not contain any description of the data. This information is stored in the according .XTR files. In 2015 the original .XTR files were replaced by a modernized version based on the Extensible Markup Language (XML). The new files have the extension .XTRX. The EMERALD format is described in detail in Ritter et al. (2015).

Sample code to read and write the EMERALD data format can be obtained from GFZ's Gitlab repository (as supplementary data of Ritter et al., 2019). Other low-level data formats can be provided on request, including time series data of EDL data loggers in Mini-Seed format or time series data of SPAM3 and SPAM4 data loggers in proprietary format.

6.1 Compilation history of this report

This report was generated semi-automatically from the metadata of this project. The table below summarizes the metadata (xml files) and scripts (powershell) used to compile this document.

xml file	File version	Script	Version	Script date
report.xml	1.10	ArchiveCreateReport.ps1	1.24	13.12.2019
project.xml	2.20	ArchiveCreateXMLs.ps1	2.45	23.11.2020
maps.xml	1.30	ArchiveCreateXMLs.ps1	2.43	28.09.2020
sites.xml	2.20	ArchiveCreateXMLs.ps1	2.43	28.09.2020
instrumentation.xml	1.10	ArchiveCreateXMLs.ps1	2.43	28.09.2020
publications.xml	1.20	ArchiveQueryPublications.ps1	2.45	23.11.2020
revisions.xml	1.10	ArchiveCreateXMLs.ps1	2.43	28.09.2020
config.xml	2.00	ArchiveCreateConfig.ps1	2.51	28.03.2019

7. Acknowledgements

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8. References

Ritter, O., Klose, R., Weckmann, U., 2015. EMERALD Data Format for Magnetotelluric Data. Deutsches GeoForschungsZentrum GFZ, Potsdam, 50 pp., https://doi.org/10.2312/GFZ.b103-15082.

Ritter, O., Muñoz, G., Barth, R., Tietze, K., Rulff, P., Stephan, S., 2019. MT Repository : user manual. 67 pp., https://doi.org/10.2312/GFZ.b103-19065.

Selway, K., Ramirez, F., Conrad, C., Weerdesteijn, M., 2020. How can geophysical imaging help contstrain mantle viscosity to improve glacial isostatic adjustment models?. In: *SCAR Open Science Conference 2020 Session 15 Ice Sheet-solid Earth Interactions: GIA, Landscape Evolution and Geothermal Heat Flux*, online, 1508 pp.

Appendix 1

This appendix provides a summary of the recording configurations for each site, including sampling frequencies, frequency bands, scheduled recording times, filter settings, sensors used, etc.

Internally the configurations are organized as runs. Each run corresponds with a particular set of instruments or hardware settings. If, for example, inductions coils were switched between low frequency (LF) and high frequency (HF) modes, their frequency response changes. Therefore, they count as different instruments, which is reflected in different runs.

The headers of the tables summarize for how long a particular configuration was active. A recording period consists of an uninterrupted set of time series data, described by start and end dates. Numbers in brackets after the dates specify the corresponding day of the year. Recordings can be continuous over longer time spans or shorter time segments can be repeated a number of times.

Each table contains seven columns defining types and serial numbers of data loggers, sensor boxes, sampling frequencies, the number of recorded channels, and their physical meaning, e.g. if electric- or magnetic field sensors were attached. Electric sensors (i.e. electrodes) usually have sensor number 0 as their IDs are not accounted for. The tables provide one row for each channel, if information extends for more than one row, it applies to all encompassed channels.

Site 0001

Run: 001

Recording Period 05 Jun 2019 (156) 00:00:00 - 11 Jun 2019 (162) 16:19:59 (continuous 59min 59.00s) 12 Jun 2019 (163) 00:00:00 - 20 Jun 2019 (171) 21:03:59 (continuous 59min 59.00s)						
Logger (EDL6)	**SBx ()**	**Sampling Frequency**	**Channel Nr.**	**Name**	**Sensor Type**	**Sensor Number**
6027		1.00 s	001	Bx	Geomag_Fluxgate---TYPE-0001_X	011
			002	By	Geomag_Fluxgate---TYPE-0001_Y	011
			003	Bz	Geomag_Fluxgate---TYPE-0001_Z	011
	070		004	Ex	TelluricElectrode-TYPE-Titanium-Sheet	000
			005	Ey	TelluricElectrode-TYPE-Titanium-Sheet	000

Site 0002

Run: 001

Recording Period 03 Jun 2019 (154) 15:10:37 - 14 Jun 2019 (165) 12:40:59 (continuous 59min 59.00s)						
Logger (EDL6)	**SBx ()**	**Sampling Frequency**	**Channel Nr.**	**Name**	**Sensor Type**	**Sensor Number**
6022		1.00 s	001	Bx	Geomag_Fluxgate---TYPE-0001_X	020
			002	By	Geomag_Fluxgate---TYPE-0001_Y	020
			003	Bz	Geomag_Fluxgate---TYPE-0001_Z	020
	008		004	Ex	TelluricElectrode-TYPE-Titanium-Sheet	000
			005	Ey	TelluricElectrode-TYPE-Titanium-Sheet	000

Site 0003

Run: 001

Recording Period 05 Jun 2019 (156) 15:00:00 - 16 Jun 2019 (167) 15:13:59 (continuous 59min 59.00s)						
Logger (EDL6)	**SBx ()**	**Sampling Frequency**	**Channel Nr.**	**Name**	**Sensor Type**	**Sensor Number**
6029		1.00 s	001	Bx	Geomag_Fluxgate---TYPE-0001_X	041
			002	By	Geomag_Fluxgate---TYPE-0001_Y	041
			003	Bz	Geomag_Fluxgate---TYPE-0001_Z	041
	061		004	Ex	TelluricElectrode-TYPE-Titanium-Sheet	000
			005	Ey	TelluricElectrode-TYPE-Titanium-Sheet	000

Site 0004

Run: 001

Recording Period 05 Jun 2019 (156) 17:41:43 - 15 Jun 2019 (166) 09:50:59 (continuous 59min 59.00s) 16 Jun 2019 (167) 12:43:32 - 16 Jun 2019 (167) 12:43:59 (27.00s once)						
Logger (EDL6)	**SBx ()**	**Sampling Frequency**	**Channel Nr.**	**Name**	**Sensor Type**	**Sensor Number**
6018		1.00 s	001	Bx	Geomag_Fluxgate---TYPE-0001_X	042
			002	By	Geomag_Fluxgate---TYPE-0001_Y	042
			003	Bz	Geomag_Fluxgate---TYPE-0001_Z	042
	077		004	Ex	TelluricElectrode-TYPE-Titanium-Sheet	000
			005	Ey	TelluricElectrode-TYPE-Titanium-Sheet	000

Site 0005

Run: 001

Recording Period 06 Jun 2019 (157) 16:00:00 - 18 Jun 2019 (169) 13:35:59 (continuous 59min 59.00s)						
Logger (EDL6)	**SBx ()**	**Sampling Frequency**	**Channel Nr.**	**Name**	**Sensor Type**	**Sensor Number**
6019		1.00 s	001	Bx	Geomag_Fluxgate---TYPE-0001_X	030
			002	By	Geomag_Fluxgate---TYPE-0001_Y	030
			003	Bz	Geomag_Fluxgate---TYPE-0001_Z	030
	073		004	Ex	TelluricElectrode-TYPE-Titanium-Sheet	000
			005	Ey	TelluricElectrode-TYPE-Titanium-Sheet	000

Site 0006

Run: 001

Recording Period 06 Jun 2019 (157) 20:00:00 - 17 Jun 2019 (168) 12:19:59 (continuous 59min 59.00s)						
Logger (EDL6)	**SBx ()**	**Sampling Frequency**	**Channel Nr.**	**Name**	**Sensor Type**	**Sensor Number**
6024		1.00 s	001	Bx	Geomag_Fluxgate---TYPE-0001_X	022
			002	By	Geomag_Fluxgate---TYPE-0001_Y	022
			003	Bz	Geomag_Fluxgate---TYPE-0001_Z	022
	009		004	Ex	TelluricElectrode-TYPE-Titanium-Sheet	000
			005	Ey	TelluricElectrode-TYPE-Titanium-Sheet	000

Site 0007

Run: 001

Recording Period 08 Jun 2019 (159) 14:45:00 - 17 Jun 2019 (168) 01:33:59 (continuous 10min)						
Logger (EDL6)	**SBx ()**	**Sampling Frequency**	**Channel Nr.**	**Name**	**Sensor Type**	**Sensor Number**
6002		100.00 Hz	001	Bx	Geomag_Fluxgate---TYPE-0001_X	047
			002	By	Geomag_Fluxgate---TYPE-0001_Y	047
			003	Bz	Geomag_Fluxgate---TYPE-0001_Z	047
	079		004	Ex	TelluricElectrode-TYPE-Titanium-Sheet	000
			005	Ey	TelluricElectrode-TYPE-Titanium-Sheet	000

Site 0008

Run: 001

Recording Period 08 Jun 2019 (159) 19:00:00 - 17 Jun 2019 (168) 04:18:59 (continuous 59min 59.00s)						
Logger (EDL6)	**SBx ()**	**Sampling Frequency**	**Channel Nr.**	**Name**	**Sensor Type**	**Sensor Number**
6014		1.00 s	001	Bx	Geomag_Fluxgate---TYPE-0001_X	031
			002	By	Geomag_Fluxgate---TYPE-0001_Y	031
			003	Bz	Geomag_Fluxgate---TYPE-0001_Z	031
	091		004	Ex	TelluricElectrode-TYPE-Titanium-Sheet	000
			005	Ey	TelluricElectrode-TYPE-Titanium-Sheet	000

Site 0009

Run: 001

Recording Period 10 Jun 2019 (161) 15:00:00 - 19 Jun 2019 (170) 11:57:59 (continuous 59min 59.00s)						
Logger (EDL6)	**SBx ()**	**Sampling Frequency**	**Channel Nr.**	**Name**	**Sensor Type**	**Sensor Number**
6020		1.00 s	001	Bx	Geomag_Fluxgate---TYPE-0001_X	025
			002	By	Geomag_Fluxgate---TYPE-0001_Y	025
			003	Bz	Geomag_Fluxgate---TYPE-0001_Z	025
	072		004	Ex	TelluricElectrode-TYPE-Titanium-Sheet	000
			005	Ey	TelluricElectrode-TYPE-Titanium-Sheet	000