

# **EAGLE**

**Ethiopia – Afar Geoscientific Lithospheric Experiment**



**Ethiopia Afar Geoscientific  
Lithospheric Experiment  
2001 - 2003**

## **PHASE III: The Controlled Source Project**

### **Profile 1 CMG-6TD Huddle Test and Field Report**

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**Report prepared for SEIS-UK  
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## 1. Introduction

EAGLE (Ethiopia Afar Geoscientific Lithospheric Experiment) is a major initiative to investigate how the African continent is splitting along the Ethiopian Rift in the Horn of Africa. The project involves the Universities of Leicester, Leeds and Royal Holloway from the United Kingdom, Stanford University, California and the University of Texas, El Paso both from the United States. There is significant involvement from other European and US institutions. These groups are working with principal counterparts from the Geophysical Observatory and the Department of Geology and Geophysics at the University of Addis Ababa together with many scientists from the Ethiopian Geological Survey and the Petroleum Operations Department of the Ethiopian Ministry of Mines. The whole project is co-ordinated by the Commission of Science and Technology of the Democratic Federal Republic of Ethiopia. The work involves a combination of controlled source and passive seismic recording to provide an image of the top 100 km or so of the Earth over a region encompassing the north-eastern part of the Main Ethiopian Rift where it enters Afar. The results will provide a 3-D picture of a continental rift system immediately prior to the formation of an ocean basin, a missing snapshot in the study of the break-up of a continent.

This report focuses on the deployment of Guralp CMG-6TD broadband seismometers along the controlled source profile 1 as part of Phase III of the EAGLE project.

### 1.1. EAGLE Phase III

EAGLE is divided into 4 phases (Figs 1 & 2):

*Phase I* involved 30 long-term continuously recording seismic instruments being deployed over an approximately 250 x 250 km<sup>2</sup> centred on the volcanic segment in the Rift Valley immediately to the north-east of the town of Nazret. These recorders were distributed in October 2001 and recovered at the end of January 2003.

*Phase II* (the Rift Valley Experiment) involved the deployment of 50 x Guralp CMG-6TD recorders from September 2002 – February 2003 within the Phase 1 array, concentrating the density of recording in the centre of this region.

*Phase III* known as the controlled source seismic study was undertaken principally in January 2003. This involved the deployment of 1000 single component RefTek “Texan” instruments and 91 x 3 component Guralp CMG-6TD seismometers along two profiles (a cross rift and an along rift profile) and a central array. Due to the logistical impracticalities in deploying all these instruments over a two day period as necessitated by the battery life of the Texan instrument and also to extend the scope of this phase the decision was made to deploy the 6TD instruments along Profile 1 (the cross rift profile) in November/December 2002.

The instruments were deployed along a 450 km long profile from Goha Tsion in the northwest to Delo Sebro in the SE (Fig. 1) with a nominal station spacing of 5 km. The instruments were tested and deployed over a 27 day period between the 15<sup>th</sup> November and 13<sup>th</sup> December 2002. They were then recovered at the end of the controlled source phase between the 15<sup>th</sup> and 18<sup>th</sup> January 2003 after a maximum of

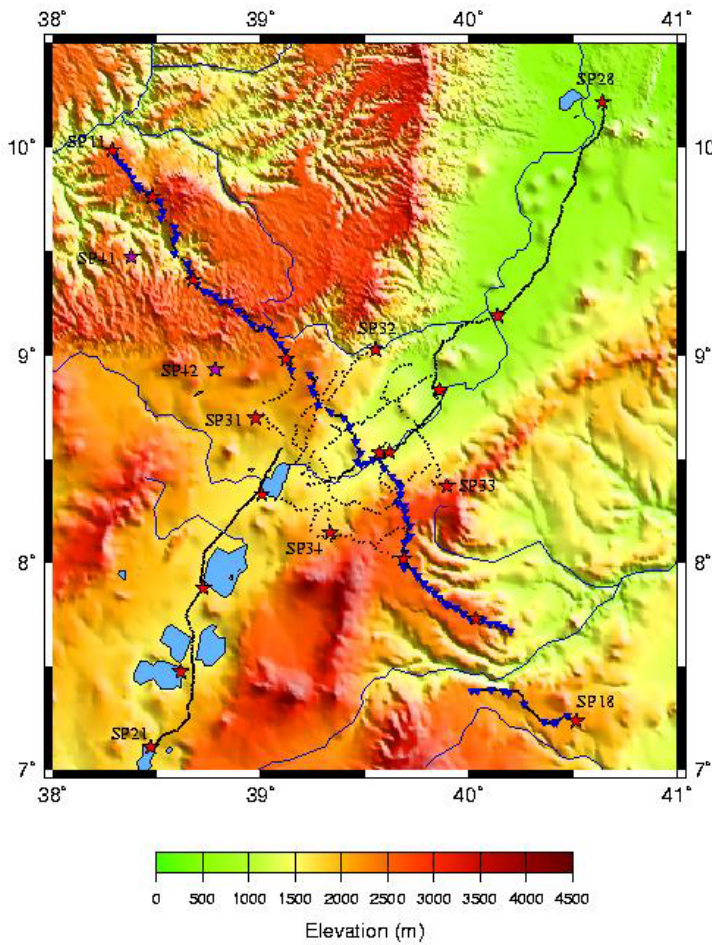
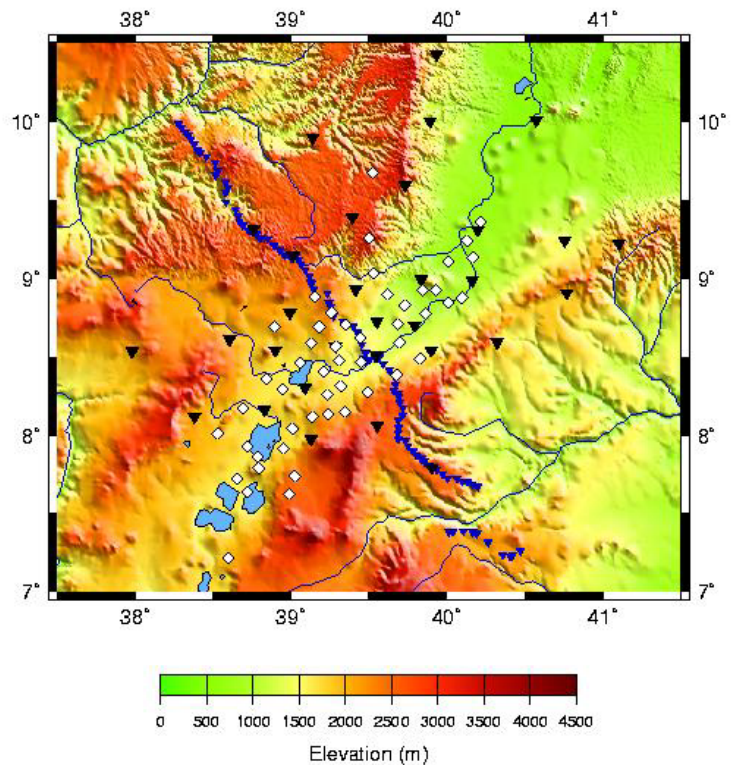


Figure 1: Topography of the central Ethiopian Rift Valley with the location of the CMG-6TD's (blue inverted triangles) deployed by University of Leicester along profile 1. Also indicated are the locations of the January 2003 RefTek "Texan" controlled source instruments (black dots), controlled source shot points (red stars) and quarry blasts (purple stars).

Figure 2: Topographic map of central Ethiopian Rift valley showing the location of all EAGLE broadband stations. Leeds (Phase I) are indicated by black inverted triangles, white diamonds are the Phase II Rift Valley Array and Phase III are indicated by the blue inverted triangles.



58 days continuous recording. This deployment took advantage of the wrap around memory of the 6TD allowing the instruments to be left in the field without being serviced and without the risk of losing the data from the controlled source survey in January.

The results from this 450 km long broadband linear array will provide additional evidence for variations in crustal thickness and underplate across the rift, as well as information on seismic anisotropy beneath the array. The data will provide both a high resolution teleseismic residual and receiver function profile across the rift and allow examination of SKS and SKKS splitting variations.

Integration of the results with those from the EAGLE Phase I and II potentially allow the resolution of the rift structure and extension directions at different levels in the crust and mantle.

*Phase IV* involved the recording of a magnetotelluric profile across the rift, coincident with the central 200 km of the cross-rift controlled source seismic profile 1. The results should provide constraints on the nature and distribution of crustal heterogeneity and image melt accumulation zones. The MT survey was conducted in late January 2003, immediately following the completion of Phase III.

## 1.2. SEIS-UK Equipment Borrowed

EAGLE Phase III involved the intended deployment of 100 6TD broadband sites. The following equipment was provided by SEIS-UK.

- 100 x Guralp CMG-6TD broadband seismometers
- 105 x solar panels
- 102 x 12V dry cell battery + 31 x battery chargers
- 100 x GPS
- 100 x breakout boxes
- 6 x DFD disk units
- 1 x Sun Blade, with monitor, RAID system and DLT drive
- 4 x Palm pilot
- Installation tools (spanners etc) and assorted cables

## 2. Site Selection & Permissioning

Permissioning and location of all the 446 sites required for the Phase III deployment along line 1 at a nominal spacing of 1 km was conducted in April – June 2002. From these 97 were identified with a nominal spacing of 4 – 5 km where it was felt the security was adequate to deploy the 6TD's. Four of the permissioned sites were used as part of the Phase II deployment and in addition a further two Phase II sites were coincident with line 1 leaving 91 proposed sites. In general site choices for 6TD deployment was governed by security considerations often at the expense of scientific considerations (e.g. low noise levels). Typical sites were in fenced or guarded locations such as schools, clinics, Wareda (District) Offices and private residences.

The identification and permissioning of sites was conducted by Dr G Mackenzie (Leicester) and field assistance was provided by Ms Louise Quigley (DIAS), Dr

Dereje Ayalew (DGS), Ms Yodit Tefere (Oromia Council), Ato Gishu (EGS), Ato Ketsella Tadesse (POD). Permission was obtained by a letter that was sent to Dr. Laike Asfaw of the Geophysical Observatory, who in turn requested that the Commission of Science and Technology obtain permission for the project to be conducted. In turn the Commission requested permission from the Regional Councils. Letters outlining the project, explaining instruments were to be deployed every 1 km and requesting assistance were then obtained from the Oromia Council, Ministry of Mines and hand delivered to the 4 Zonal offices in which the work was to be conducted: North Shoa (Fiche), East Shoa (Nazrat), Arsi (Asela) and Bale (Bale Robe). In turn these offices provided letters to be delivered to the relevant Waredas. A final “To Whom it May Concern” letter was then provided by the Waredas which was delivered to the Kebeles (Farming Associations), schools and clinics where it was hoped to deploy instruments.

The process of identification and permissioning, including driving the complete length of the line, took just under 3 months.

### 3. Huddle Tests

The 100 6TD instruments to be deployed along profile 1 were shipped to Ethiopia in two batches; 80 x instruments with all solar panels, batteries and computers were shipped in mid October and had cleared Ethiopian customs upon the deployers’ arrival. The remaining 20 x 6TD units were not shipped until late October and did not clear customs until after the deployment had begun. As a consequence it was necessary to undertake the huddle test in two parts.

#### 3.1. Huddle Test Procedure

The procedure for both huddle tests was the same. The sensors were removed from their cases and placed next to them on the floor (all cables remained connected in the boxes). The sensors were all oriented in the same direction (parallel to the room sides) and levelled using the levelling feet (Fig. 3). A GPS repeater was used that had been installed during the EAGLE Phase II huddle test, with an external antenna on the roof of the building and a re-radiating antenna placed inside. This arrangement provided sufficient GPS signal to test all units.



Fig. 3: 6TD's laid out in the equipment centre for the huddle test.

Each box was powered with a 12V dry cell battery, with the box connections then providing power to each individual unit. Each sensor was then checked using a Palm pilot running SHOUT and PTELNET software for the following items

- Unit serial number
- Firmware Version
- GPS power cycle set to 0 (continuous GPS)
- 3 x 100 sps channels active
- 3 x 5 sps channels active
- Mass position for each component (should be < 3 – 4 million, values over 8 million indicate stuck mass)
- GPS lock status

The instruments recorded overnight and the data downloaded onto portable DFD disk units and analysed on a Sun workstation using PQL software the next day (Fig. 4). Details of the two huddle tests are shown in Appendix A and summarised in the following sections.

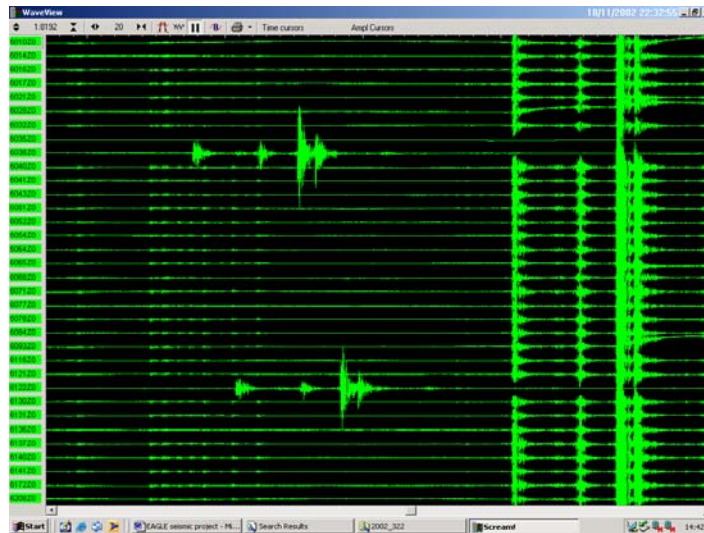


Fig 4. Results of a huddle test using the PQL software. T6122 and T6138 can be seen to have gross timing errors.

### 3.2. Huddle Test 1

The first huddle test was undertaken on the 19<sup>th</sup> and 20<sup>th</sup> November.

- Three instruments T6035, T6205 and T6223 had broken components. These were not deployed.
- One unit T6085 had to be reset by temporarily removing its internal lithium cell
- Two units T6095 and T6110 were in factory test mode and had to have “run ok-1q filetest” to get them out of this mode

- Two units T6026 and T6036 had no bubble levels and 1 unit had too large a bubble level. These were deployed using a cut-off plain level during deployment.

### 3.3. Huddle Test 2

This was undertaken on the 26<sup>th</sup> and 27<sup>th</sup> November

- One instrument, T6086, had a broken component and was not deployed.
- One instrument, T6025, could not be communicated with and was not deployed.
- One instrument, T6056, was broken and was not deployed
- Eight instruments failed to get a GPS lock – these were deployed with no problems in the field.

## 4. Deployment

### 4.1. Personnel

The following people were involved in the deployment of the 6TD's along profile 1.

Dr Graeme Mackenzie, University of Leicester

Mr Paul Denton, University of Leicester/SEIS-UK

Mr Dave Cornwell, University of Leicester

Mr James Blight, University of Leicester

Ato Ewenet Gashaw-Beza, Southern Nations & Nationalities Regional Council

Ato Kimemu Nurie, Ethiopian Geological Survey

Ato Kifle Damtew, Ethiopian Geological Survey

### 4.2. Deployment Procedure

Deployment was undertaken working initially as 2 teams then 3.

Upon arrival at the site the best site was chosen in terms of noise, clear view of sky for GPS and solar panel coverage.

A hole approx 50 cm in diameter and 70 cm – 1 m deep was dug for the 6TD. The base of this hole was covered in a thin layer of loose fine soil to aid the levelling of the 6TD. A second shallower hole for the battery, breakout box and cables was dug to the north and just beside this hole with a trench running between the two holes to bury cables. A 5 – 10 cm diameter hole was then dug to the north of these holes to place the post to hold the solar panel and GPS and 4 similar holes dug around the site to hold fence posts. All holes were dug first before starting to deploy to prevent damage to any of the instrumentation.

Whilst the holes were being dug the 6TD was prepared in the back of the vehicle. The battery voltage was checked and then connected to the solar panel to check that the panel was charging the battery. The firewire cable was connected to the 6TD which was then placed in a plastic bag. The battery, breakout box and cables were placed in a second plastic bag. Serial numbers of 6TD, solar panel and GPS were



noted on the deployment sheet. Unconnected cable ends and sockets were covered with a strip of electrical tape to prevent dust or dirt getting into the connection.

The 6TD was placed in its hole and levelled and oriented to magnetic north. The level and orientation were checked several times whilst compressing soil around the side of the 6TD. The bag containing the battery etc was placed in the second hole. The GPS antenna was attached to the post placed for the solar panel and the solar panel attached facing south and dipping slightly and all associated cables connected. A length of plastic drainpipe was used protect the cables running from the base of the solar panel into the hole with the breakout box and battery.

Once the 6TD had been buried up to the level of its top surface (generally between 30 – 50cm below ground level) the mass positions, software setup, GPS and recorded signal were checked via the data port of the breakout box using a Palm pilot running the SHOUT and PTELNET software. Once these had been checked and recorded on the deployment sheet (Fig. 5) the Palm pilot was disconnected, the data port on the breakout box covered, both bags sealed using cable ties and equipment fully buried ensuring all cables were covered. It was attempted to keep the breakout box and firewire cable easily accessible should the instrument be serviced. The position of the site was waymarked using a handheld Garmin eTrex GPS unit and the UTM location in the Adindan (Ethiopia) datum noted on the deployment sheet. Finally the site was fenced using chicken wire (Fig. 6) and a responsible person identified and requested

<p>Arrival Time (DD/MM/YYYY): <u>14:55</u> <u>26/11/02</u> GMT <input checked="" type="checkbox"/> <u>UTC</u></p> <p>Departure Time (DD/MM/YYYY): <u>15:45</u> <u>27/11/02</u> GMT <input checked="" type="checkbox"/> <u>UTC</u></p> <p align="center"><b>SEIS-UK 6TD DEPLOYMENT SHEET</b></p> <p>Site Name <u>YATA MICHAEL SCHOOL</u> Site Code <u>1037 (?)</u></p> <p>Deployment team members <u>DC/SB/E/D</u></p> <p>UTM, Adindan co-ordinates <u>0446621 1076277</u> Altitude <u>KOBB 2674</u></p> <p>New GPS waypoint # <u>17B</u></p> <p>Distance to road and road type <u>N/A</u> Distance to power cables <u>N/A</u></p> <p>Distance to trees <u>5m</u> Distance to nearby buildings <u>5m</u></p> <p>Land use <u>SCHOOL GARDEN</u> Sensor Burial Material <u>SOFT EARTH</u></p> <p>Soil description <u>SOFT EARTH</u> Weather conditions <u>SUNNY, CALM, DRY</u></p> <p align="center"><small>(DRAW DETAILED SITE LOCATION AND SITE LAYOUT DIAGRAMS ON REVERSE)</small></p> <p>Sensor serial no. <u>1061</u> Alignment: Grid N / <input checked="" type="checkbox"/> Mag. N (Declination _____)</p> <p>Sensor Type: 6TD? GPS serial no. <u>1061</u> Solar panel barcodes <u>16</u></p> <p>Sensor Depth (to top): <u>25cm</u> Battery Type <u>PH10</u> Ext. Battery voltage <u>12.97</u></p> <p>Baud Rate: 19200? Mass pos.: MSZ: <u>231765</u> M9/N: <u>153212</u> MA/E: <u>127995</u></p> <p>Taps?: <u>Z0-100, N0-100, E0-100, Z6-5, N6-3, E6-5</u> GPS cycle 1 hour? <u>Y/N</u> (CONT)</p> <p>Velocity output offsets: Z0 <u>546944</u> N0 <u>626822</u> E0 <u>35974</u></p> <p>Show Flash: Last flush CHIP <u>0000FFFF</u> Last write CHIP <u>0000755</u> (Repeat): Last flush CHIP <u>0000FFFF</u> Last write CHIP <u>0000756</u></p> <p>Firmware Version: v. <u>1.28</u> GPS lock? <input checked="" type="checkbox"/> Y/N Offset/Drift Reasonable? <input checked="" type="checkbox"/> Y/N -30646</p> <p>GPS Lat _____ GPS Lon _____ GPS Sync. time <u>12:26:50</u> <small>(Note as much GPS data as possible. If no lock available in a reasonable time - ensure 6T is receiving NMEA data and antenna has clear sky view)</small></p> <p>Bag around battery <input checked="" type="checkbox"/> Y/N Solar Panel Charging? <input checked="" type="checkbox"/> Y/N Breakout Box in bag <input checked="" type="checkbox"/> Y/N Cables secured (and sketched)? <input checked="" type="checkbox"/> Y/N Connections? GPS ANTENNA <input checked="" type="checkbox"/> BREAKOUT BOX to PANEL <input checked="" type="checkbox"/> SOLAR PANEL to BATTERY <input checked="" type="checkbox"/> BREAKOUT BOX to GPS <input checked="" type="checkbox"/></p> <p>Contact Details: <u>Mesay. Asrat, 3. Kebelesh. Debebe</u></p> <p align="center"><small>Further Comments and Site Plans Overleaf</small></p> <p align="center"><u>60 B'n DC</u></p>	<p>The right side of the deployment sheet contains two hand-drawn diagrams. The top diagram is a site location map showing a 'LINE OF TREES' at the top, a 'school building corrugated roof' in the center, and a 'SCHOOL GARDEN' below it. A 'SITE' is marked with a square in the garden. A 'KILL' is marked with a circle to the right. The bottom diagram is a site layout diagram showing a 'SOLAR PANEL' mounted on a 'POST' with a 'GPS' antenna. A 'B.O. BOX' and 'BATT.' are connected to the system. A 'FENCE' is indicated by a dashed line. A 'SENSOR' is also shown connected to the system. A north arrow points downwards.</p>
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Figure 5: Completed front (left) and rear (right) of a 6TD deployment sheet .

to look after the station, repair any damage to the fence caused by animals and report any disturbance of the instrument to the local Wareda. Waredas were informed of the deployment and requested to inform the Geophysical Observatory of any problems.

Deployment of a station could be completed in 30 – 60 minutes with on average 5 stations being deployed in 1 day by a team. Deployment details are provided in Appendix B.



Figure 6: Installation of a 6TD site

### 4.3. Equipment

The deployment of a 6TD site required the following equipment:

Guralp CMG-6TD seismometer: provided by SEIS-UK

Guralp breakout box: provided by SEIS-UK

Guralp GPS antenna: provided by SEIS-UK

Solar panel: provided by SEIS-UK

12V dry cell battery: provided by SEIS-UK

Cables: provided by SEIS-UK

Palm pilot and spare AAA batteries: provided by SEIS-UK

Tools: spanner, wire cutter, spade, trenching tool, saw: provided by SEIS-UK or obtained locally

Consumables: electrical tape, cable ties, plastic bags, nails: provided by SEIS-UK or obtained locally

Wooden posts: obtained locally

Plastic drainpipe: obtained locally

Chicken wire: obtained locally

Handheld GPS unit: provided by University of Leicester/EAGLE project

Compass: individually owned

#### 4.4. Deployment Problems

A number of problems were discovered during the deployment. These can be split into specific instrument problems and generic problems/difficulties.

Generic deployment problems/difficulties:

- Levelling: a number of the 6TD's had no bubble level on them or the bubble was too big (this had been noted during the huddle test) and so a standard bubble level had to be cut down to size and used. This proved difficult since it could only level in one direction at a time. It would be useful for future projects to have a number of circular bubble levels as back-up.
- GPS lock: the GPS often took 20 – 30 minutes to achieve lock (or even see 1 satellite) whilst the handheld unit would show 6+ satellites in a good constellation.
- Flatlining: the 6TD's could often take a while for the mass positions to settle down enough to show a velocity output especially if they had been transported across very rough tracks.
- Mass positions: the mass positions when displayed in SHOUT did not correspond to the order they were shown on the deployment sheets. This was not realised until about half way through the deployment, most deployment sheets therefore have the incorrect mass positions shown.
- Brackets missing on solar panels: several solar panels had no brackets for either setting the angle of the panel or for attaching the panel to the base of a pole. Cable ties could be used in place of the second (although this still proved to be slightly unstable so stones had to be used to weigh down the bottom spar to prevent movement) but the former had to rely on tightening the nuts on the panel as much as possible to prevent the angle changing.

Specific instrument problems:

- One Palm pilot died mid deployment and lost all programs which had to be reloaded on return to the instrument centre. The remaining instruments for that day had to be deployed and then returned to, to check mass & GPS information.
- One breakout box was found to be faulty and replaced by a spare.
- T6208: Z flatlining, mass position stuck.
- T6082: could not be communicated with.
- T6203: (deployed site 1274) flatlining N-S, E-W. E-W mass at end stop moved away after tilting but immediately returned. Auto centre switched off to prevent spiking on remaining channels.
- T6075 (deployed site 1081) flatlining N-S, E-W. E-W mass at end stop, N-S mass position high but not at end stop, auto centre switched off.
- T6190: (deployed site 1290) N-S flat line, mass stuck at end stop, auto centre switched off.
- T6023: (deployed site 1310) E-W flat line, mass stuck at end stop.
- G2674/SEIS-UK0765: GPS failed.
- Solar panel SEIS-UK1120 possibly not charging (deployed at site 1125, T6010).

In addition 1 GPS snapped at the base of the connection between the GPS and screw in plastic post.

## 5. Instrument Recovery

Recovery of the 6TD instruments took place during and immediately after the recovery of the RefTek 'Texans' following the controlled source project in January 2003. 6TD's and associated equipment were retrieved from the field and returned to the Equipment Centre in Addis Ababa where the data was downloaded. No data recovery was conducted in the field. Data from 3 of the instruments (T6042, T6047 and T6112) were unable to be downloaded. The recovery of all the 6TD's took 4 days. In many cases a sturdier fence had been built around the instrument by locals (Fig. 7).

Problems discovered during the recovery were:

- T6124 (site 1014): cable had been cut.
- T6057 (site 1356): solar panel cable disconnected.
- T6085 (site 1381): blue cable disconnected from 6TD (possibly occurred during retrieval).



Figure 7: 6TD site upon retrieval.

## 6. Data Recovery

Detailed data recovery information is provided in Appendix C and summarised below.

- 3 instruments (T6042, T6047 and T6112) data could not be downloaded from.
- 11 instruments stopped recording prior to their retrieval.
- 3 instruments (T6111, T6124, T6071) had no (less than 1 day) data recorded.
- 28 instruments are assumed to have wrapped around the memory. This occurred after between 25 and 50 days with an average of 41 days. This resulted in a 'loss' of 151 days data (3.6%).
- Initial calculations of data recovery is 86.8% (assuming 100% recovery between first and last recording days, based on vertical component data and correcting for overwriting of memory).
- 54 days (1.5%) have no GPS lock and/or timing offset is unacceptably high for data to be used.

Specific instrumentation problems were:

- T6010: died after 2 days – solar panel 0387 believed to have been faulty.

- T6085: recorded for only 16 days, instrument had lost its settings so data is at incorrect sample rate (note this instrument was found to have had the blue cable disconnected on recovery although it is unclear whether these are related).
- T6075 (deployed site 1081), dead N-S.
- T6203 (deployed site 1274), dead E-W.
- T6190 (deployed site 1290), dead N-S.
- T6023 (deployed site 1310), dead E-W, auto centering spikes on Z, N-S (auto centre was not switched off on deployment).

In addition T6036 (deployed site 1238) has spikes on all 3 channels from the auto centering suggesting that it may not have been levelled correctly upon deployment.

## 7. Data QC and Processing

The following data processing and quality check was conducted.

- Raw GCF format data was downloaded from tape, converted to miniseed volumes and the data headers were updated before a comprehensive check on missing or improperly converted data.
- Deployment information was added in the form of a dataless seed volume (e.g. station names, locations and instrumentation).
- A list of events (greater than magnitude 5.5) was produced using the USGS/NEIC (PDE) earthquake database and changed into weed format for event extraction from the miniseed volumes into SAC format data.
- Data were extracted within convenient windows about the theoretical phase arrival times (e.g. 60 s either side of expected P-wave arrival) according to IASP91 model. Where windows spanned subsequent days, miniseed volumes (i.e. one miniseed volume per day) were meshed together.
- The 3-component raw output files for 50 events were examined to identify phase arrivals and data quality for the whole waveform (Fig. 8) and then for

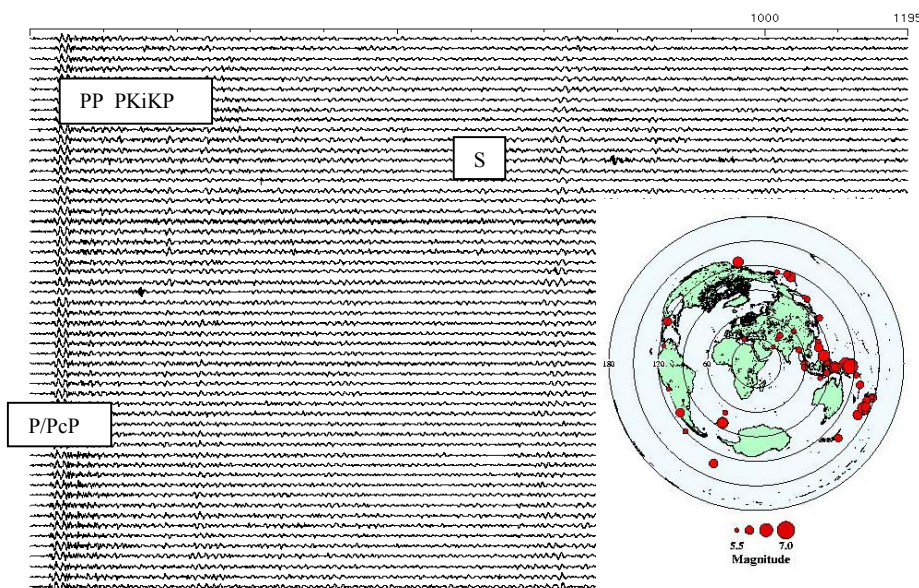


Figure 8: M6.3 event recorded on Z-component of 60% of the available Profile 1 6TD seismometers. Inset shows the location of all recorded events greater than M5.5.

60 seconds before and after the expected P-wave arrival.

- Examination of GPS log files for quality control and identification of suspect timing within the data.
- 3 minute long shot windows were extracted from the raw GCF format and converted to individual SEG-Y traces using `6td_gcf2txnsegy_long.csh`, SEG-Y header information was added using `segymod` and shot gathers (Fig. 9) created using `txn2segy`. These gathers were then merged with the Texan gathers to create a final dataset.

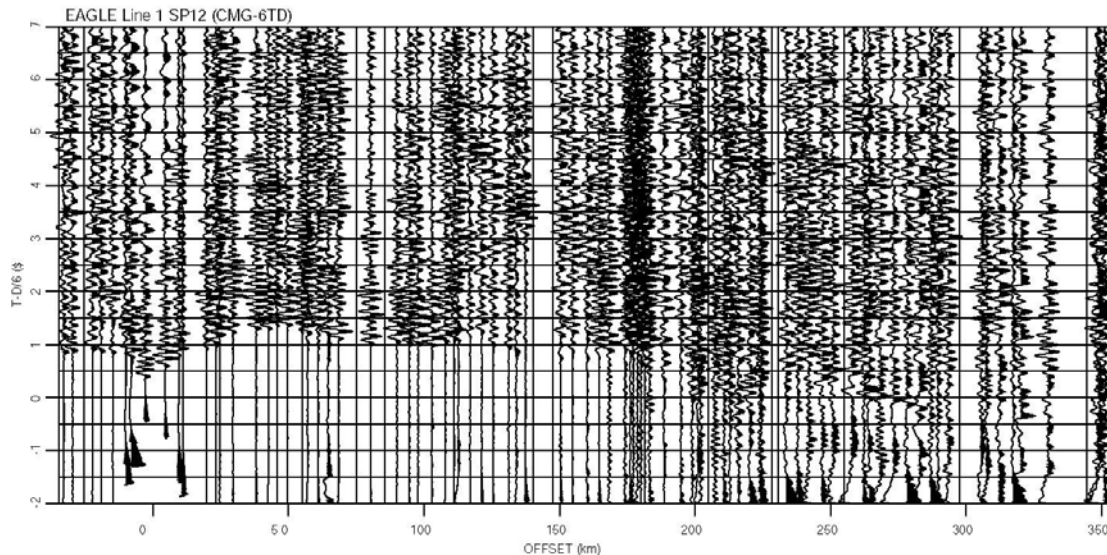


Figure 9: Vertical component seismic section of SP12 recorded on the CMG-6TD's. Section is plotted with a reduction velocity of  $6\text{kms}^{-1}$  and bandpass filtered from 0.5 – 10 Hz.

## 8. Acknowledgements

There were a large number of other personnel involved in the project, without whom it could not have taken place. We would like to acknowledge the assistance from the following people and organisations:

Dr Laike Asfaw, Dr Atalay Ayele & the staff of the Geophysical Observatory, University of Addis Ababa

Dr Bekele, Dr Tilahun Mammo, Dr Dereje Ayalew and other staff members of the Department of Geology and Geophysics, University of Addis Ababa.

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The Oromia Regional Council especially Ato Asefa Kumsa and Ms Yodit Tefere

The Ethiopian Geological Survey: Ato Befekadu, Kimemu, Kifle and Gishu

Ethioder, Addis Ababa, especially drivers Alex, Fitsum, Micky, Jaffa, Dereje, Soloman and Mulegeta.

Rift Valley Hotels, Nazret

Shenkkor Ethiopia, Addis Ababa

The British Embassy in Addis Ababa

The Ethiopian Embassy in London

SEIS-UK, Leicester

EAGLE is a collaborative project between the following research groups:

UK: Universities of Leicester, Leeds and Royal Holloway, University of London

USA: University of Texas, El Paso, Stanford, Penn State and Southwest Missouri State University.

Ethiopia: Addis Ababa University, Ethiopian Geological Survey and the Ethiopian Science and Technology Commission.

EAGLE was funded by grants from the Natural Environmental Research Council, National Science Foundation Continental Dynamics Programme, the Texas Higher Education Coordinating Board and the University of Leicester.

## Appendix A: SEIS-UK Huddle Test

Title of Project:	EAGLE Phase III: Controlled Source Project
Personnel:	Paul Denton <sup>1,2</sup> , Graeme Mackenzie <sup>2</sup> , David Cornwell <sup>2</sup> , James Blight <sup>2</sup> , Kifle Damtew <sup>3</sup> , Ewenet Gashaw-Beza <sup>4</sup>
Affiliation:	<sup>1</sup> SEIS-UK, University of Leicester; <sup>2</sup> Dept of Geology, University of Leicester; <sup>3</sup> Ethiopian Geological Survey, Addis Ababa; <sup>4</sup> Southern Nations
Date of Tests:	Test 1: 19 <sup>th</sup> November 2002 (80 instruments) Test 2: 26 <sup>th</sup> November 2002 (20 instruments)
Location of Tests:	Ethiopian Science and Technology Commission Scientific Equipment Centre, Addis Ababa, Ethiopia
Comments:	Seismometers on concrete floor of conference room ~10 x 10 m on first floor.
GPS:	SEIS-UK GPS repeater used. Problems with reception on several instruments. Huddle test 1 instruments with timing problems retested. Due to lack of time problematic GPS during test 2 were marked and lock checked in field.



**EAGLE Phase III Profile 1 CMG-6TD Huddle Test 1**

Start Day 323 19<sup>th</sup> Nov 2002

End Day 324 20<sup>th</sup> Nov 2002

Serial No	GPS Cycle	mass1	mass2	mass3	GPS lock	PQL QC	Comment
6010	0	601	148	635	3d		
6011	0	842	1294	563	3d	ok	
6013	0	372	2541	-438	3d		
6014	0	1059	1872	-2321	3d		
6016	0	704	133	-666	3d		
6017	0	931	2006	1404	3d		
6018	0	699	777	615	3d		
6021	0	891	293	3120	3d		
6022	0	1514	189	658	3d	ok	
6024	0	981	47	-157	3d	ok	
6026	0	884	-2251	2249	?		no bubble level
6028	0	599	799	-923	3d		
6029	0	700	1310	1920	?	timing trouble	no fix, checked later ok
6031	0	517	1597	399	3d	ok	
6032	0	249	-252	143	3d		
6035	0	3388	1296	2148	?	spike on Z	
6036	0	492	658	242	3d	ok	no bubble level
6038	0	234	1965	434	3d	timing trouble	checked ok
6039	0	-128	217	-1172	3d	ok	
6040	0	944	-53	303	?	gps checked OK	No lock? GPGSA followed by: 1.....*
6041	0	779	2711	1313	3d		
6043	0	-252	1210	1149	3d		
6045	0	825	1678	-1028	3d	ok	
6046	0	291	1884	691	3d		
6049	0	531	253	-968	3d	ok	
6051	0	-223	1549	2658	3d		
6052	0	158	1159	-1330	3d		
6054	0	-779	2615	862	3d		
6057	0	-319	-261	-1471	3d		
6058	0	700	-349	286	3d		
6064	0	-447	1080	3061	3d		
6065	0	-1280	-203	976	3d		
6068	0	1303	2701	722	3d		
6068	0	1304	3044	722	3d		
6070	0	-34	4317	2307	3d	ok	
6071	0	-1822	-1778	1095	3d		
6072	0	453	876	1133	3d	ok	
6074	0	1112	1043	1611	3d		
6075	0	749	327	2647	?		no text
6076	0	233	609	151	3d		
6077	0	-291	-804	969	3d		
6078	0	-564	-1016	301	3d		
6083	0	842	-453	856	3d		
6084	0	952	2100	639	3d		
6085	0	1120	1746	2222	3d		only 134sps - interal battery temporarily removed and restarted with factory defaults seems ok then
6087	0	131	-488	204	3d	ok	
6088	0	4308	1675	-1401	3d		taken by D Keir 23.11.2002
6089	0	618	1775	252	3d	ok	
6093	0	889	-286	1309	3d		
6095	0	852	277	831	3d	will not download	run ok-1q filetest
6099	0	852	-8358	1380	?	pql OK ZNE	
6105	0	40	2421	436	3d		
6110	0	1479	1333	-6604	3d	will not download	run ok-1q filetest
6111	0	822	613	-264	3d	ok	
6116	0	149	351	136	3d		
6117	0	-581	1807	1893	3d		
6118	0	810	-564	2103	?		blue cable unplugged on arrival
6120	0	-726	1951	3057	3d		
6121	0	565	715	127	3d		
6122	0	-516	1921	588		timing trouble	checked ok
6125	0	-337	-585	1048	3d		
6126	0	1082	474	-877	3d		
6130	0	-821	2702	1522	3d		
6131	0	-102	-1235	331	3d		
6132	0	-881	1176	144	3d	ok	
6136	0	343	-219	1556	3d		

6137	0	28	-137	-591	3d		
6140	0	-79	1212	-7860	3d	pql OK ZNE	
6141	0	419	3245	1462	3d		
6149	0	978	-693	1545	3d	ok	
6156	0	-610	1125	831	3d		
6172	0	-180	-3531	745	3d		
6173	0	487	2603	1504	?	timing trouble	checked later ok
6190	0	1195	-134	103	3d		
6203	0	999	-351	1221	3d		
6205	0	-907	-8388	136	3d	east comp problem	try disassembly 24.11.2002
6208	0	71	72	1914	3d		
6216	0	1494	103	1050	?		
6221	0	1067	-1040	1204	?		
6223	0	8388	-22	496	3d	z comp flatlining	try disassembly 24.11.2002

Duplicate Readings

6010	0	604	-702	-97	3d		
6014	0	1001	2090	-1170	?		
6017	0	826	1220	1335	?		
6028	0	590	116	-767	3d		
6032	0	2477	-296	766	3d		

**EAGLE Phase III Profile 1 CMG-6TD Huddle Test 2**

Start Day 330 26<sup>th</sup> Nov 2002

End Day 331 27<sup>th</sup> Nov 2002

Serial No	GPS Cycle	mass1	mass2	mass3	GPS lock	PQL QC	Comment
6019	0	847	-807	310	3d		
6023	0	819	1288	1459	no lock		
6025	0	498	-85	-321	garbage on gps status		
6042	0	1349	-264	375	no lock		
6044	0	814	1069	1315	no lock		
6048	0	825	1231	-676	no lock		
6056	0	16	474	1712	locked		could not download or communicate !
6066		362	-643	-1766	ok 3d		
6082	0 set	877	40	1187	3d		
6086		303	559	-8388	no lock		
6091		319	604	1205	no lock		
6107	0	290	1544	1621	ok3d		
6112	0	805	311	1123	3d		
6113	0	-165	-240	-993	locked		
6123	0	353	-146	1522	3d		
6124	0	505	265	1663	3d		
6135	0 set	433	61	1310	3d		
6142	0 set	614	451	392	3d		
6158	0	638	407	1787	no lock		
6214	0	926	1374	627	no gps		

indicates instruments was not deployed

## Appendix B: Deployment Details

### EAGLE Phase III Profile 1 CMG-6TD Deployment Details

Site #	Instrument	UTM (Adindan Zone 37)		WGS84		Elevation	Deploy Day	Retrieval Day
		Easting	Northing	Latitude	Longitude			
1001	6041	420999	1103579	9.9845	38.2801	2530	25/11/02	18/01/03
1004	6054	422868	1100870	9.9600	38.2973	2562	25/11/02	18/01/03
1008	6024	425606	1097736	9.9318	38.3222	2554	25/11/02	18/01/03
1011	6130	427754	1095392	9.9106	38.3419	2592	25/11/02	18/01/03
1014	6022	429876	1093009	9.8891	38.3613	2559	24/11/02	18/01/03
1018	6065	432129	1089262	9.8552	38.3819	2588	24/11/02	18/01/03
1023	6084	434605	1084831	9.8152	38.4045	2560	25/11/02	18/01/03
1026	6149	435914	1083230	9.8005	38.4165	2572	25/11/02	18/01/03
1030	6070	440547	1080633	9.7773	38.4588	2593	25/11/02	18/01/03
1037	6043	446618	1076276	9.7380	38.5142	2673	26/11/02	17/01/03
1042	6116	448339	1070937	9.6897	38.5300	2565	26/11/02	17/01/03
1046	6121	446995	1067397	9.6577	38.5177	2486	26/11/02	17/01/03
1054	6132	454408	1062671	9.6150	38.5854	2669	26/11/02	15/01/03
1058	6131	455639	1058847	9.5805	38.5966	2555	26/11/02	17/01/03
1062	6078	454081	1055341	9.5487	38.5824	2450	26/11/02	15/01/03
1069	6091	454248	1048723	9.4889	38.5840	1506	12/12/02	18/01/03
1077	6066	461070	1043304	9.4399	38.6462	2385	11/12/02	18/01/03
1081	6075	462919	1038778	9.3990	38.6631	2426	11/12/02	18/01/03
1085	6125	463794	1035199	9.3667	38.6711	2484	21/11/02	18/01/03
1089	6083	466195	1032144	9.3390	38.6930	2602	21/11/02	18/01/03
1094	6021	470172	1028505	9.3062	38.7293	2578	23/11/02	18/01/03
1097	6105	472626	1028101	9.3025	38.7516	2614	21/11/02	17/01/03
1101	6136	475965	1025951	9.2831	38.7820	2717	23/11/02	17/01/03
1105	6046	478646	1023343	9.2595	38.8064	2889	11/12/02	17/01/03
1110	6093	483573	1022863	9.2552	38.8513	3262	23/11/02	17/01/03
1114	6124	488109	1018109	9.2122	38.8926	2968	06/12/02	16/01/03
1120	6123	491944	1014703	9.1814	38.9275	2645	06/12/02	17/01/03
1125	6010	495632	1010990	9.1478	38.9611	2548	23/11/02	17/01/03
1131	6013	500218	1009156	9.1313	39.0028	2538	06/12/02	17/01/03
1138	6028	505292	1007790	9.1189	39.0490	2523	22/11/02	17/01/03
1141	6068	507200	1005109	9.0946	39.0664	2531	23/11/02	17/01/03
1146	6016	510126	1000834	9.0560	39.0930	2525	22/11/02	17/01/03
1151	6014	513096	996816	9.0196	39.1200	2484	22/11/02	17/01/03
1155	6032	513574	992717	8.9825	39.1244	2403	22/11/02	17/01/03
1157	6126	514209	991095	8.9679	39.1301	2348	04/12/02	17/01/03
1163	6117	516065	986922	8.9301	39.1470	2309	04/12/02	17/01/03
1171	6142	525837	984528	8.9084	39.2359	2356	08/12/02	16/01/03
1179	6038	526760	977480	8.8447	39.2442	2415	08/12/02	16/01/03
1182	6095	527906	974572	8.8183	39.2546	2377	08/12/02	16/01/03
1189	6111	530075	968163	8.7604	39.2743	2263	08/12/02	16/01/03
1195	6042	536778	964361	8.7259	39.3352	1746	07/12/02	15/01/03
1204	6019	543958	961314	8.6983	39.4005	1536	07/12/02	15/01/03
1209	6074	547001	956666	8.6562	39.4281	1460	02/12/02	17/01/03
1219	6135	549954	948248	8.5801	39.4548	1870	07/12/02	15/01/03
1226	6077	552660	942598	8.5289	39.4794	1817	03/12/02	15/01/03
1231	6052	550843	938089	8.4882	39.4628	1479	03/12/02	15/01/03
1235	6141	552983	936423	8.4731	39.4822	1453	03/12/02	15/01/03
1238	6036	555752	937407	8.4819	39.5074	1414	09/12/02	15/01/03
1242	6026	559320	938980	8.4961	39.5398	1316	07/12/02	15/01/03
1246	6113	562679	939835	8.5038	39.5704	1266	07/12/02	15/01/03
1252	6064	565140	934688	8.4572	39.5926	1325	02/12/02	15/01/03
1258	6173	569545	930325	8.4177	39.6326	1803	07/12/02	16/01/03
1262	6120	572261	927202	8.3894	39.6572	2087	07/12/02	16/01/03
1266	6048	573884	924317	8.3633	39.6719	2170	26/11/02	17/01/03
1270	6112	573801	920289	8.3269	39.6711	2591	07/12/02	16/01/03
1274	6203	572538	915690	8.2853	39.6596	2606	08/12/02	16/01/03
1278	6214	575871	914139	8.2712	39.6898	2646	08/12/02	16/01/03
1281	6017	576406	911658	8.2488	39.6946	2708	08/12/02	16/01/03
1285	6221	576783	907614	8.2122	39.6980	2686	08/12/02	16/01/03
1290	6190	579066	903781	8.1775	39.7186	2687	08/12/02	16/01/03
1296	6107	578827	898226	8.1272	39.7164	2616	08/12/02	16/01/03
1301	6158	575971	894788	8.0962	39.6904	2602	08/12/02	16/01/03
1306	6044	576178	889615	8.0494	39.6922	2549	08/12/02	16/01/03
1310	6023	575588	885927	8.0160	39.6868	2531	08/12/02	16/01/03
1315	6040	575824	881534	7.9763	39.6889	2478	04/12/02	16/01/03
1320	6089	580781	880526	7.9671	39.7338	2472	04/12/02	17/01/03
1324	6087	582785	876868	7.9340	39.7520	2476	04/12/02	17/01/03
1329	6172	586372	873282	7.9015	39.7844	2477	04/12/02	17/01/03

Site #	Instrument	UTM (Adindan Zone 37)		WGS84		Elevation	Deploy Day	Retrieval Day
		Easting	Northing	Latitude	Longitude			
1333	6137	588907	870164	7.8733	39.8074	2465	04/12/02	17/01/03
1337	6047	592025	867684	7.8508	39.8356	2489	04/12/02	17/01/03
1340	6051	594383	865814	7.8338	39.8570	2479	04/12/02	17/01/03
1344	6049	597394	862731	7.8059	39.8842	2474	04/12/02	16/01/03
1346	6018	598901	861529	7.7950	39.8979	2472	04/12/02	18/01/03
1351	6029	603202	859997	7.7810	39.9368	2462	04/12/02	16/01/03
1356	6057	607340	857006	7.7539	39.9743	2450	04/12/02	18/01/03
1360	6031	611186	853924	7.7259	40.0091	2458	06/12/02	18/01/03
1366	6011	617635	853858	7.7252	40.0676	2483	03/12/02	18/01/03
1370	6072	621384	851750	7.7060	40.1015	2485	03/12/02	18/01/03
1373	6099	625113	851838	7.7068	40.1353	2490	03/12/02	18/01/03
1377	6216	628549	849876	7.6889	40.1664	2498	03/12/02	15/01/03
1381	6085	632371	848087	7.6726	40.2010	2496	03/12/02	15/01/03
1384	6110	611877	815837	7.3815	40.0146	2342	28/11/02	16/01/03
1387	6140	614901	816089	7.3837	40.0420	2380	28/11/02	16/01/03
1394	6045	622220	816648	7.3886	40.1083	2380	29/11/02	16/01/03
1400	6156	628600	816005	7.3826	40.1661	2383	29/11/02	16/01/03
1403	6118	631509	814817	7.3718	40.1924	2388	29/11/02	16/01/03
1416	6058	639569	808702	7.3163	40.2653	2412	29/11/02	16/01/03
1430	6071	650140	799450	7.2323	40.3608	2361	29/11/02	16/01/03
1435	6039	655428	798679	7.2252	40.4086	2313	29/11/02	16/01/03
1437	6122	656858	799311	7.2309	40.4216	2273	29/11/02	16/01/03
1443	6076	662668	802459	7.2592	40.4743	2215	29/11/02	16/01/03

## Appendix C: Data Recovery

### EAGLE Phase III Profile 1 CMG-6TD Data Recovery (Vertical Component)

Instrument	Site #	Days in Field	Data Recovery (%) <sup>1</sup>	Data recovery accounting for wraparound (%) <sup>2</sup>	GPS Unreliable (%) <sup>3</sup>	Data recovery incl. GPS failure (%) <sup>4</sup>
6036	1238	37	100.0%	100.0%	13.5% (5)	86.5%
6046	1105	37	100.0%	100.0%		100.0%
6091	1069	34	100.0%	100.0%		100.0%
6066	1077	38	100.0%	100.0%		100.0%
6075	1081	38	100.0%	100.0%	18.4% (7)	81.6%
6019	1204	39	100.0%	100.0%		100.0%
6026	1242	39	100.0%	100.0%	7.7% (3)	92.3%
6042	1195	39	0.0% <sup>††</sup>	0.0% <sup>††</sup>		0.0% <sup>††</sup>
6113	1246	39	100.0%	100.0%	2.6% (1)	97.4%
6135	1219	39	84.6%	100.0%		100.0%
6017	1281	39	100.0%	100.0%		100.0%
6023	1310	39	87.2%	87.2%		87.2%
6038	1179	39	100.0%	100.0%		100.0%
6044	1306	39	61.5%	61.5%		61.5%
6095	1182	39	100.0%	100.0%		100.0%
6107	1296	39	100.0%	100.0%		100.0%
6111	1189	39	0.0%	0.0%		0.0%
6142	1171	39	100.0%	100.0%		100.0%
6158	1301	39	100.0%	100.0%		100.0%
6190	1290	39	100.0%	100.0%		100.0%
6203	1274	39	100.0%	100.0%		100.0%
6214	1278	39	100.0%	100.0%		100.0%
6221	1285	39	100.0%	100.0%		100.0%
6112	1270	40	0.0% <sup>††</sup>	0.0% <sup>††</sup>		0.0% <sup>††</sup>
6120	1262	40	100.0%	100.0%		100.0%
6173	1258	40	100.0%	100.0%		100.0%
6124	1114	41	0.0%	0.0%		2.4%
6013	1131	42	100.0%	100.0%		100.0%
6123	1120	42	88.1%	100.0%		100.0%
6052	1231	43	100.0%	100.0%		100.0%
6077	1226	43	97.7%	100.0%		100.0%
6085	1381	43	0.0% <sup>†</sup>	0.0% <sup>†</sup>		0.0% <sup>†</sup>
6141	1235	43	88.4%	100.0%	2.6% (1)	97.4%
6216	1377	43	100.0%	100.0%		100.0%
6029	1351	43	100.0%	100.0%		100.0%
6040	1315	43	100.0%	100.0%		100.0%
6049	1344	43	100.0%	100.0%		100.0%
6031	1360	43	100.0%	100.0%	2.3% (1)	97.7%
6064	1252	44	22.7%	22.7%		22.7%
6047	1337	44	0.0% <sup>††</sup>	0.0% <sup>††</sup>		0.0% <sup>††</sup>
6051	1340	44	100.0%	100.0%		100.0%
6087	1324	44	100.0%	100.0%	4.5% (1)	95.5%
6089	1320	44	100.0%	100.0%		100.0%
6117	1163	44	100.0%	100.0%		100.0%
6126	1157	44	100.0%	100.0%		100.0%
6137	1333	44	93.2%	100.0%		100.0%
6172	1329	44	100.0%	100.0%		100.0%
6018	1346	45	100.0%	100.0%		100.0%
6057	1356	45	93.3%	93.3%		93.3%
6074	1209	46	100.0%	100.0%	4.3% (2)	95.7%
6011	1366	46	95.7%	100.0%	4.5% (2)	95.5%
6072	1370	46	100.0%	100.0%		100.0%
6099	1373	46	100.0%	100.0%	2.2% (1)	97.8%
6039	1435	48	97.9%	100.0%		100.0%
6045	1394	48	95.8%	100.0%	4.3% (2)	95.7%
6058	1416	48	93.8%	100.0%	4.4% (2)	95.6%
6071	1430	48	0.0%	0.0%		0.0%
6076	1443	48	100.0%	100.0%		100.0%
6118	1403	48	100.0%	100.0%		100.0%
6122	1437	48	100.0%	100.0%		100.0%
6156	1400	48	100.0%	100.0%		89.6%
6110	1384	49	100.0%	100.0%	10.4% (5)	100.0%
6140	1387	49	83.7%	100.0%		100.0%
6078	1062	50	100.0%	100.0%		100.0%
6043	1037	52	98.1%	100.0%		100.0%
6048	1266	52	100.0%	100.0%		100.0%
6116	1042	52	92.3%	100.0%		100.0%
6121	1046	52	88.5%	100.0%		100.0%

Instrument	Site #	Days in Field	Data Recovery (%) <sup>1</sup>	Data recovery accounting for wraparound (%) <sup>2</sup>	GPS Unreliable (%) <sup>3</sup>	Data recovery incl. GPS failure (%) <sup>4</sup>
6024	1008	54	46.3%	46.3%		46.3%
6041	1001	54	100.0%	100.0%		100.0%
6054	1004	54	96.3%	100.0%	1.9% (1)	98.1%
6070	1030	54	94.4%	100.0%		100.0%
6084	1023	54	100.0%	100.0%	1.8% (1)	98.1%
6130	1011	54	13.0%	13.0%		13.0%
6149	1026	54	96.3%	100.0%		100.0%
6010	1125	55	3.6%	3.6%		3.6%
6068	1141	55	85.5%	100.0%		100.0%
6093	1110	55	98.2%	100.0%		100.0%
6136	1101	55	100.0%	100.0%		100.0%
6022	1014	55	78.2%	100.0%		100.0%
6065	1018	55	92.7%	100.0%		100.0%
6014	1151	56	100.0%	100.0%	23.2% (13)	76.8%
6016	1146	56	85.7%	100.0%		100.0%
6028	1138	56	89.3%	100.0%		100.0%
6032	1155	56	96.4%	100.0%		100.0%
6021	1094	56	83.9%	100.0%		100.0%
6105	1097	57	96.5%	100.0%		100.0%
6083	1089	58	86.2%	100.0%		100.0%
6125	1085	58	79.3%	100.0%		100.0%
6131	1058	52	100.0%	100.0%	9.6% (5)	90.4%
6132	1054	50	50.0%	100.0%		100.0%
<b>Total</b>		<b>4191</b>	<b>84.9%</b>	<b>88.1%</b>	<b>1.5% (54)</b>	<b>86.8%</b>

Notes

<sup>1</sup> Data recovery based on number of days data recorded versus number of days in field.

<sup>2</sup> Percentage takes into account data assumed lost by memory wraparound of CMG-6TD.

<sup>3</sup> Unreliable GPS indicates either no GPS lock or timing offset unacceptably high (> ± 10,000 µs). Number of days given in brackets after percentage. Percentage calculation based on number of days recovered data.

<sup>4</sup> Percentage accounts for data deemed unusable due to timing errors.

<sup>†</sup> Instrument 6085 recorded 12 days data but instrument had lost settings: data recorded at incorrect sample rate and unusable

<sup>††</sup> Instruments could not be downloaded and so may contain useable data – returned to Guralp for further attempts at data recovery.

Data recovery calculations are based on an assumption of continuous recovery between first and last recovered days data, using vertical component data only. Actual recovery may therefore be lower than calculated value of 86.8%.

**EAGLE Phase III Profile 1 CMG-6TD Data Problems**

Instrument	Site #	Deploy Day	Retrieval Day	Data Start	Data End	# Days Data	Known Problem
6023	1310	342	16	342	11	29	E-W dead, autcentre spike on Z & N-S
6044	1306	342	16	342	1	19	
6057	1356	338	18	338	15	37	Solar panel cable disconnected
6024	1008	329	18	329	354	25	
6010	1125	327	17	327	329	2	Suspect solar panel #0387
6085	1381	337	15	361	12	16	Data cable disconnected from 6TD, instrument lost settings
6064	1252	336	15	5	15	10	
6130	1011	329	18	11	18	7	Instrument had lost settings
6111	1189	342	16	---	---	0	Palm not working on deployment but was checked next day
6124	1114	340	16	340	341	1	Cable cut
6042	1195	341	15	---	---	0	Could not download
6047	1337	338	17	---	---	0	Could not download
6112	1270	341	16	---	---	0	Could not download
6071	1430	333	16	333	333	<1	No gps sync on deployment
6036	1238	345	15	345	15		Auto centre spike all channels
6075	1081	345	18	345	18		N-S dead
6203	1274	342	16	342	16		E-W dead
6190	1290	342	16	342	16		N-S dead

**EAGLE Phase III Profile 1 CMG-6TD Data Memory Overwritten**

Instrument	Site #	Deploy Day	Retrieval Day	Data Start	Data End	# Days Data	Data "loss"
6135	1219	341	15	347	15	28	6
6123	1120	340	17	345	17	32	5
6141	1235	337	15	342	15	33	5
6137	1333	338	17	341	17	36	3
6140	1387	332	16	340	16	36	8
6077	1226	337	15	338	15	37	1
6022	1014	328	18	340	18	38	12
6011	1366	337	18	339	18	39	2
6058	1416	333	16	336	16	40	3
6045	1394	333	16	335	16	41	2
6121	1046	330	17	336	17	41	6
6125	1085	325	18	337	18	41	12
6039	1435	333	16	334	16	42	1
6068	1141	327	17	335	17	42	8
6021	1094	327	18	336	18	42	9
6116	1042	330	17	334	17	43	4
6016	1146	326	17	334	17	43	8
6028	1138	326	17	332	17	45	6
6083	1089	325	18	333	18	45	8
6043	1037	330	17	331	17	46	1
6070	1030	329	18	332	18	46	3
6065	1018	328	18	332	18	46	4
6054	1004	329	18	331	18	47	2
6149	1026	329	18	331	18	47	2
6093	1110	327	17	328	17	49	1
6032	1155	326	17	328	17	49	2
6105	1097	325	17	327	17	50	2
6132	1054	330	15	355	15	25	25
<b>Total</b>							<b>151 (3.6%)</b>