Gilmerton Core Sample Collection: Keyworth Transfer Methodology

October 2010

Contents

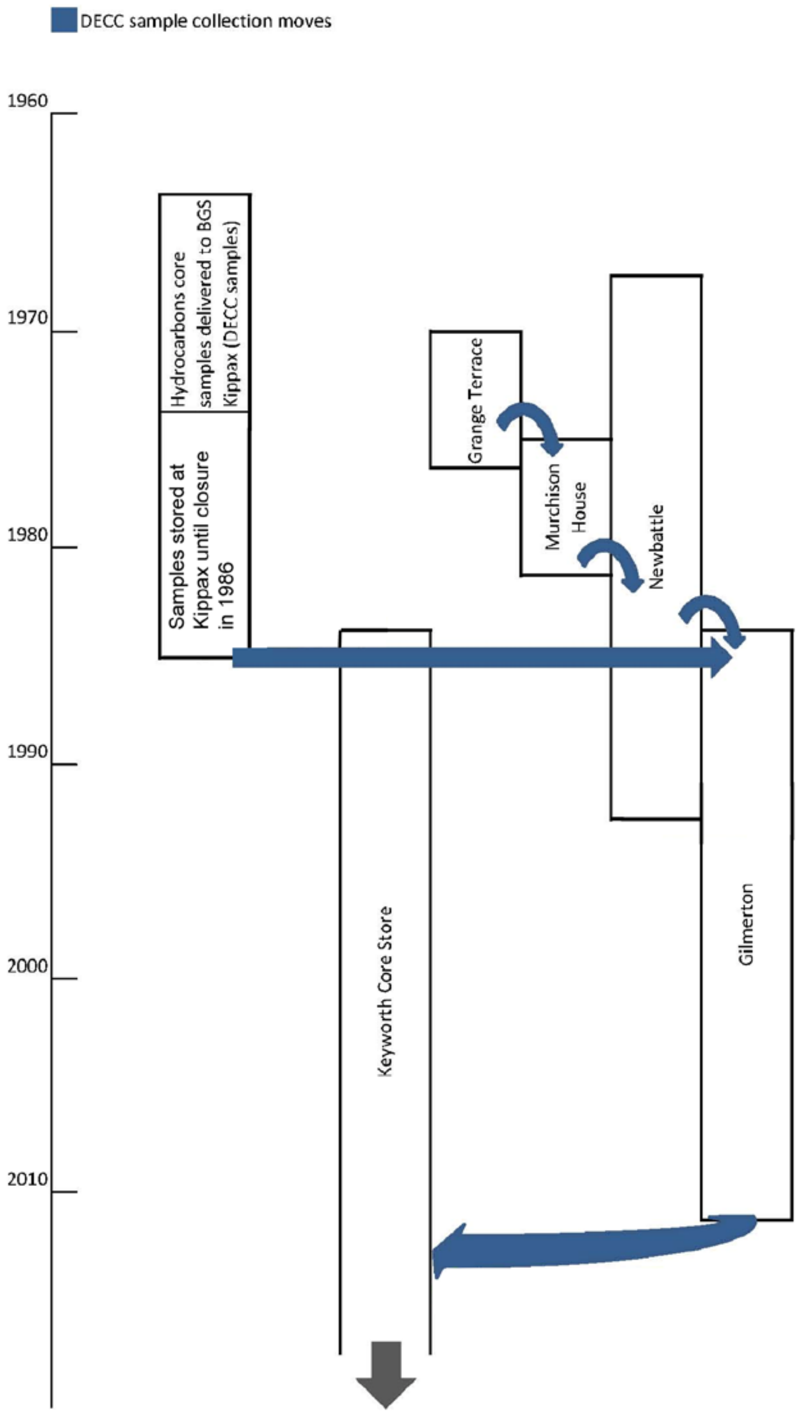
1. Background

This document describes the methodology to be used in the preparation, photography and transportation of the UK Continental Shelf core collections held at Gilmerton by the BGS on behalf of the Department of Energy and Climate Change. The methodology has been developed by the BGS working in partnership with the independently chaired 'Gilmerton Core Advisory Group', comprising members from DECC, from industry (including a representative of the Geological Society of London's Petroleum Group) and from the UK's museum community with specialist skills in conservation of specimens.

The Gilmerton Core Store contains approximately 172,000 boxes of curated core and cuttings (Core = 124,846 boxes; cuttings = 47,119 boxes). Most of these are held in kraft-lined board core boxes 100 x 12.7 x 15.25cm., although some older material is held in a variety of either wooden or plastic trays measuring 52 x 9 x 41 cm. (16,884) or 100 x 10 x 10cm kraft-lined board core boxes (13600).

Over the years the collections have been stored in a number of different locations including the Leeds area and four locations in the Edinburgh area – see Figure 1 for timeline. It should be noted that no special protective measures were in place to mitigate potential damage to core integrity during any previous transportation, including from seaport to store. This, coupled with many years of invasive sampling by users, means that the present condition of many of the core runs is poor.

Figure 1 Timeline for major collections moves



Curation standards at Gilmerton have varied with time, but Figure 2 shows some typical examples of cores. Most boxes include a core support on top to restrict movement (A). Beneath this, the core is sometimes restrained from movement by card supports stapled in place (B), but in many cases (C & D) there are no such supports. Whilst this might have been "fit for purpose" while the core remained at Gilmerton, it is not considered appropriate for core in transit, nor would it have been the practice at Keyworth. All boxes and trays are labelled with a single sequential number – for confidentiality reasons the outsides of the boxes do not carry well details.

Figure 2 Examples of onshore cores transported from Gilmerton to Keyworth

2. METHODOLOGY

2.1 Preliminary operations

2.1.1 Bar-coding

Bar-coding of the trays and boxes has taken place over the past few months, ahead of their removal from the shelves for preparation for transport, and is now complete. The box/tray numbers and material type were extracted from the Gilmerton Sample Information System (SIS) database and checked for multiple entries or errors. The cleaned data was then stored in spreadsheets, ahead of barcode printing.

The barcodes were printed on standard laser self adhesive 63.5mm x 33.9mm labels, 24 labels per sheet, Avery code L7159, using a label printing program, Endlabel™. Each box was bar-coded with a single label stuck in a uniform position on the visible box end and each tray had a barcode stuck in the label holder.

Each label displays:

- British Geological Survey
- BGS logo
- Box number (e.g. S37288)
- Material type (e.g. Core)
- Barcode (Telepen Alpha-Numeric) with text version beneath

Figure 3 Example bar code labels.

2.2.1 Reboxing

Any damaged boxes are being re-boxed early in the project, well before removal from the shelving for photography, stabilisation and transfer. This includes any boxes soaked with diesel or other hydrocarbons (and therefore unlikely to take a self-adhesive label, as well as being weakened and potentially harmful), and any other boxes considered unlikely to protect the core during its transport to Keyworth

All relevant information relating to the material, depths, core numbers etc. is being transferred to the new box which will also be relabelled with the same number on the visible end.

3 Transfer scheduling

3.1 Prioritization

Following discussions with industry representatives, it has been decided to transport samples in order of accession. This is thought to be the quickest method and the one least open to error.

Detailed records of which wells have been relocated to Keyworth and which are in transit will be published.

Should an enquirer wish to view a number of wells, it may be that they are spread between both stores. To assist visitors, wells may be held back or fast-tracked; the Core Store Manager is happy to discuss the preferred solution with #the enquirer.

3.2 Scottish Teaching Collection

Discussions with a number of Scottish Universities who use the Gilmerton Core Store regularly for teaching purposes have identified a set of wells that have been regularly used. Discussions are already in hand with the appropriate operators to identify whether they hold additional core slices from these wells that they would be prepared to donate to form a Scottish Teaching Collection. This collection will be housed in Level 1, Murchison House, and plans are being prepared for the installation of core viewing facilities.

Wells used for teaching by Scottish Universities		
14/02-1	21/01-6	47/03b-6A
14/19- 5	21/01-7ST	49/12a-5
14/19-18	21/19-1A	49/21-R1
15/17-6	22/06a-9	49/26-2
15/20a-5	29/05b-6, 6Z	98/06-7
15/22-11	30/16-3	98/06-8
16/07a-8	30/16-6	110/08a-5
16/07a-B11	30/16-T1	211/18-A31
16/08b-A2	44/22-1	211/19-4
16/29a-2X	44/23-9	211/27-10

Core from these wells will be held back at Gilmerton until replacement material is obtained, or until the end of the core and sample transfer.

3.3 Fragile Material

Plans are in hand to link the BGS Gilmerton Sample Information System database to the DECC database of stratigraphic surfaces to help identify core boxes and trays that are likely to include particularly fragile samples, such as unconsolidated Tertiary sands. Gilmerton users are encouraged to suggest other particularly fragile intervals.

Particular care will be paid to these coreboxes: they will be identified with a special sticker and subjected to enhanced QA at Keyworth. BGS has arranged an option for a number of the road transfers to use air suspension vehicles of the type used for the transport of works of art and antiques.

Further details on the special measures to be put in place to safeguard these fragile materials are described in sections 3, 4 and 5.

4 Photography, stabilisation and palletisation at Gilmerton

4.1 General process

Figure 2 shows the flow of core and cutting samples through the photography, stabilisation and palletisation process; each step of the process is described in more detail below.

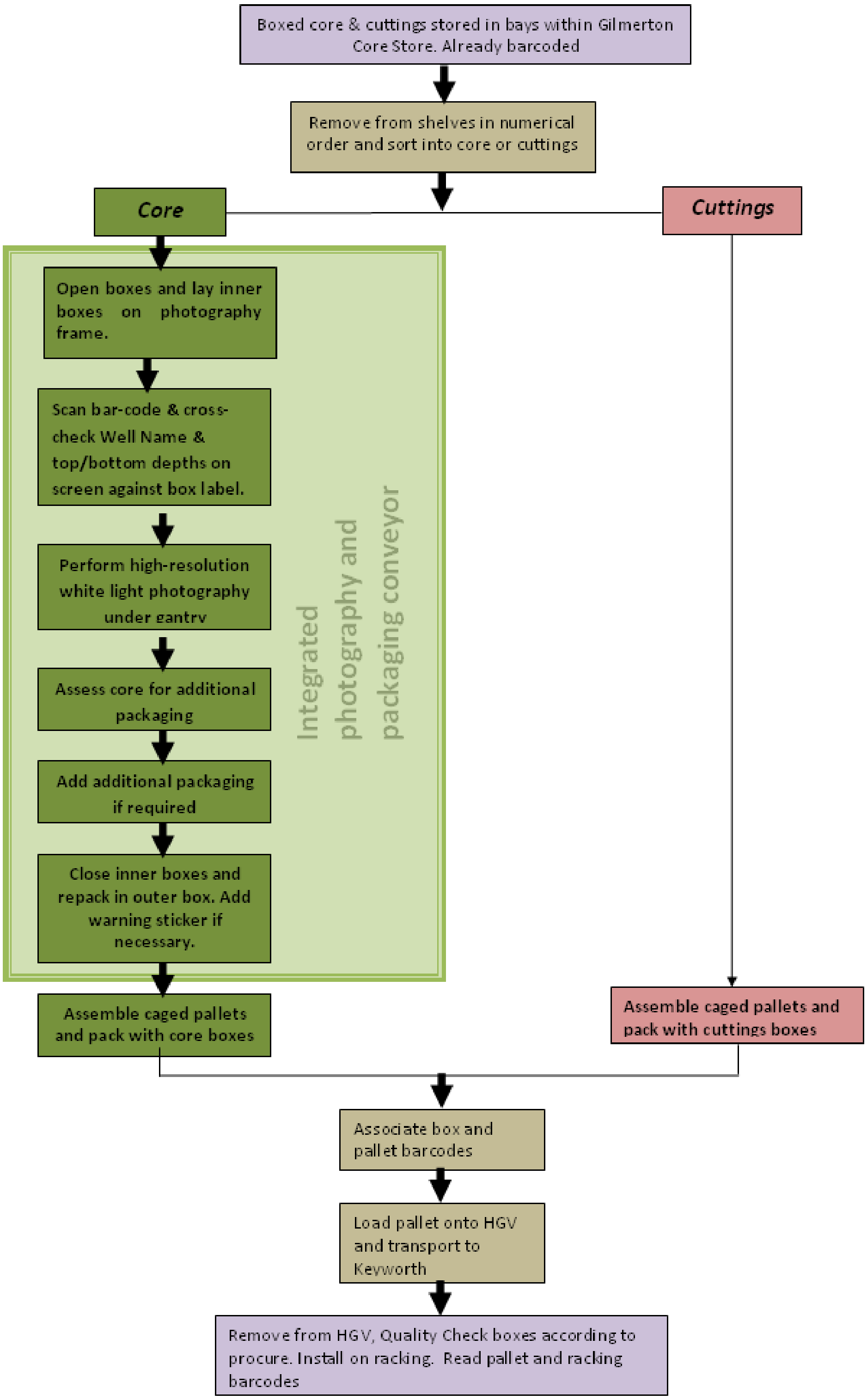


Figure 4. Flow of core and cutting samples through the photography, stabilisation and palletisation process

a. The core and cuttings boxes will be removed from the shelving in numerical order and moved to the work area where they will be sorted into separate flows for core and for cuttings.

b. Cuttings boxes will be loaded directly into caged pallets (these cages have been part of standard procedure at the Keyworth core store for many years, and are therefore tried and tested). The cages hold the boxes extremely securely, obviating the need for shrink wrapping. Space filler boxes may be required as in Figure 4 below where empty boxes have been placed on their side to fill the gap between full boxes and the enclosing cage.

Figure 5 Typical caged pallet: note filler boxes in a perpendicular orientation

c. Core boxes. The outer boxes will be opened, the inner boxes removed, the sleeves slid off and the core trays placed, in order, on a “vac-formed” photographic jig on the gravity feed roller conveyor. Vac-formed items are made by shaping heated plastic sheets to a mould using vacuum conditions. The lids and sleeves will be then placed on the trailing section of the jig and both processed through the photography station. The camera operator will scan the barcode on the core box, and the well details, core numbers and depth intervals will be displayed automatically on a screen within the photographed area. The bar-coded core box number will also be used automatically to name the image file.

d. While being photographed the core will be assessed for condition: unconsolidated, pyrite decay, foil wrapping, etc. Additional labels will be added to the outer box with the main barcode if special conservation or other treatment is required in the future. This supplementary information will also be captured digitally and appropriate additional metadata added to the database.

e. After photography, the core will continue along the conveyor where the trays will be assessed for additional packaging requirements. This may include gap fillers to prevent horizontal or vertical movement: precut Plastazote™ conservation grade foam strips, rolled card or “scrunched” acid-free, conservation-grade tissue paper. It may also be necessary to add a flat strip of card to stop packing material moving whilst the tray is re-inserted into the sleeve. The inner boxes will be replaced into the outer boxes and then into a caged pallet.

f. The contents of each pallet will be digitally associated with the pallet by scanning the pallet barcode.

g. The filled pallets will be temporarily stored indoors prior to loading onto an HGV for transport to Keyworth. One pallet per consignment will include an environmental monitoring array which will record temperature, relative humidity and vibration.

h. On arrival at Keyworth, the pallets will be off-loaded by forklift. The environmental monitoring data will be downloaded, the results evaluated.

i. Core boxes will be selected for Quality Control inspection, following the methodology. The results of QC and environmental data download will be used to constantly inform and improve the process where possible, and a variety of materials will be checked to ensure the packing procedures are sufficiently robust to safeguard the integrity of the core during transit.

j. The pallets will be placed directly onto the racking in the new store by forklift without any manual handling. Each location will be recorded by associating the pallet and racking position barcodes.

k. All core / box / pallet / racking barcode information will be uploaded to the Combined Borehole Database (*ComBo*).

4.2 Core photography procedures

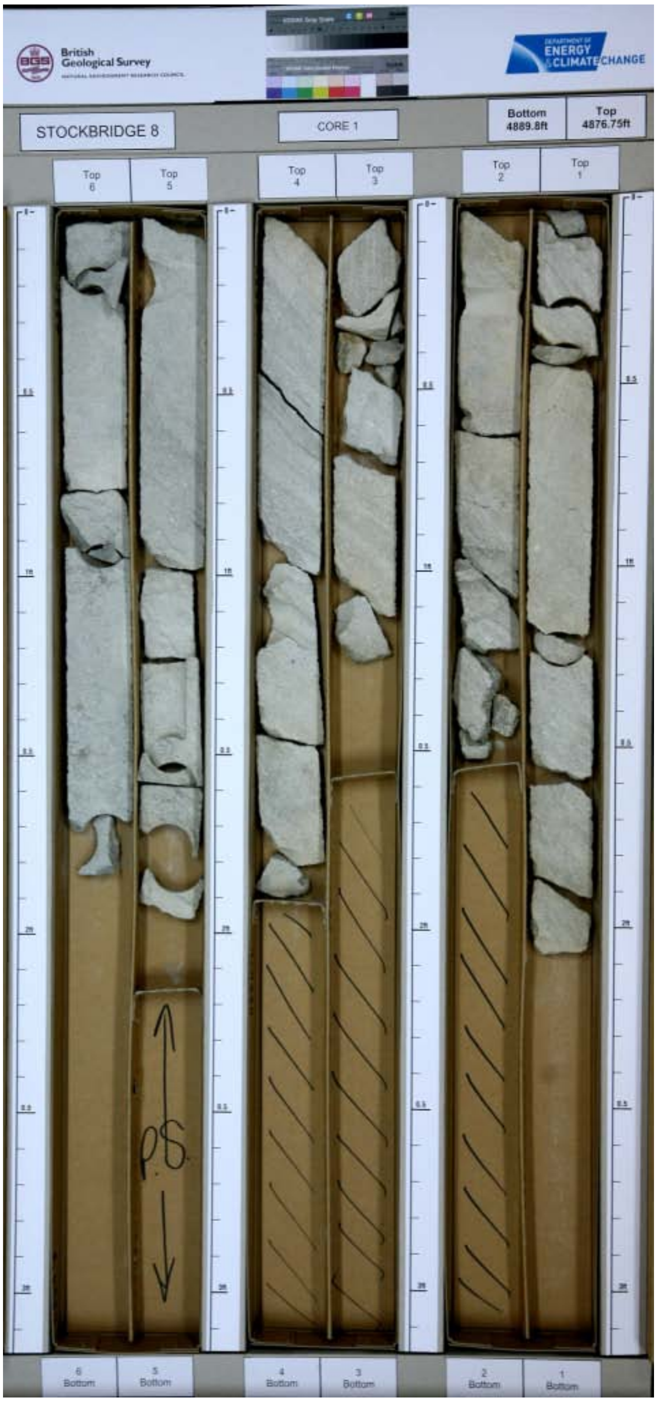


Figure 6 Indicative "mock-up" of core layout for photography. The holding jig will be vacformed grey plastic, and the well information will be displayed on a fixed digital screen included in the photograph.

Introduction

It is widely accepted that photographs of well sampled "A-cut" archival core, possibly 20 – 40 years old, are unlikely to equal the quality of photographs of clean slabs of core from recent wells. Nevertheless, a full set of high resolution core photographs documenting its present condition under standard photographic settings will be a major asset. BGS intends to make these freely available for web download. The photographs will also form a key part of the project QA process, and will assist BGS in monitoring visitor use in the future and reducing invasive sampling.

To eliminate potential degradation at this stage of the process no attempt will be made to clean the core (this decision has been taken after discussions with commercial core repository experts). Core sealed in plastic will be photographed as is and not opened, as this will provide additional protection during transport. These cores will be re-photographed when opened for a visitor.

Photography procedure

a. The core boxes or trays will be selected from the shelves according to the transfer schedule and moved by trolley to the photography/stabilisation station. A pool of loaded trolleys will provide a buffer at the start of the process.

b. Where core boxes contain inner boxes, the outer box will be opened, and the inner boxes removed, opened and placed in order on the photographic jig at the start of the conveyor. The outer box and lid, plus sleeves, will be placed on the trailing section of the jig. Where core boxes or trays do not contain inner boxes, the box will be placed on the jig and opened and the lid will be placed on the trailing section. There are two sizes of jig – one to accommodate trays and the other to accommodate core boxes. The jigs are vacformed in grey plastic. There will be a dozen of each size, all with interchangeable imperial and metric rulers, attached by magnets.

c. The camera operator will scan the barcode on the box end, which will allow the well number, core number(s) and top and bottom depths and core box number (taken from the existing SIS database) to be displayed on a small horizontal flat screen forming part of a fixed panel adjacent to the conveyor and fixed to the camera/lighting array. This fixed panel will also include a Q-13 Kodak Colour Separation Guide and Gray Scale. The core box number is included for QA purposes and for confidentiality reasons may be cropped out before the images are delivered on the web.

d. The jigs will be stopped in the same position under the photographic gantry and against the data panel, where they will be imaged with a Phase One P45+ camera: an ultra high resolution camera (7216 x 5412 pixels, i.e. ca. 200 dpi at 100% size for a 1 metre x 0.6 metre core tray) achieving 1 frame per second. The camera is linked to and controlled by a high specification PC. The image files will be written to the PC in RAW format and automatically post-processed to jp2 format and renamed with the core box number. They will then be automatically backed up to a BGS server off-site at least twice every day. The position of the frames is important to allow automated image cropping to remove white space and the core box number.

e. The Phase One camera forms part of an *ICAM Guardian System*™ as used by a number of archives around the world.

f. The images will be processed and linked to the ComBo database for easy viewing.

4.3 Core stabilization procedures – mitigation of problems

a. Cuttings

No photography or additional packaging is planned for boxes of cuttings.

b. Core in sleeving

Where core is still protected in its original plastic sleeve, it will not normally be removed. The core will be photographed as is and re-photographed as and when the sleeving is removed for inspection.

c. Spaces in boxes

Significant gaps in the core or voids at the end of the boxes will be filled with plastazote foam, cut to length from pre-cut strips of different widths and thicknesses to allow for differing thicknesses of core.

d. Breaks in core

Fragile breaks in the core should be protected by thin sections of plastazote (e.g. plastazote skin) to reduce or remove abrasion between pieces during the transport phase and later handling of boxes.

e. Air-gap between core and lid

Any significant void between the core and the top of the box will be filled with a pre-cut foam strip or "scrunched-up" acid-free tissue. If the foam or tissue is expected to "ruck-up" while the box is reinserted in its sleeve, a card strip should be added on top to hold it down. Care must be taken that the addition of any filler will not cause pressure to be applied to fragile core pieces.

f. **Fragmented or variable height core**:

If the core is fragmentary and/or varies in height, a layer of folded acid-free tissue will be added, followed by "scrunched-up" tissue and a card cover to reduce any vertical movement.

g. Fragile core

If the core is particularly fragile (e.g. unconsolidated sand), folded tissue should be placed on top, followed by foam or scrunched tissue as appropriate. A sticker to indicate this type of core will be placed on the box front and the information captured and associated with the box at the photography stage.

As described above, plans are in hand to link the BGS SIS database of Gilmerton core and samples to the DECC database of stratigraphic surfaces to help identify core boxes and trays that are likely to include particularly fragile samples, such as unconsolidated Tertiary sands. Gilmerton users are encouraged to suggest other particularly fragile intervals.

h. Conservation issues

It has been noted that some cores are wrapped in non-conservation grade materials, for example aluminium foil, or have pyrite decay. Any cores found with these problems will be noted electronically, using a barcode, and will form the basis of a conservation works database for future work at Keyworth.

5 Transport arrangements

5.1 Loading procedures

Pallets will be temporarily stored in a holding area within the Gilmerton store before being loaded onto the lorry trailer. Each will be identified and loaded in such a way as to preserve the order as closely as possible, mindful that some wells may have been retained for enquirers.

The pallets will be positioned on the trailer with the open end to the centre. This will ensure none are displaced during the road journey.

As noted above, for particularly fragile cores there is an option to use air suspension vehicles of the type used for the transport of works of art and antiques.

5.2 Vibration & environmental monitoring

One pallet in each consignment will include a set of digital monitors. Two *Tiny Tag*™ vibration monitors, positioned in different planes to measure the vertical and forward motion, will be installed in a dummy core box, together with a *Digitron Monolog*™ datalogger to measure variations in temperature and relative humidity. The dummy core box will be placed in a marked pallet and the driver informed.

The monitors will be downloaded on arrival at Keyworth. The results will be considered during the QC process, when selected boxes will be examined for any sign of disturbance. A typical graph is included as Figure 7. In this case, the average while the vehicle was moving was 6.8 mm s^{-1}. Vibration sensors measure either acceleration, velocity or displacement; velocity was chosen because it provides a measure of vibration more independent of frequency.

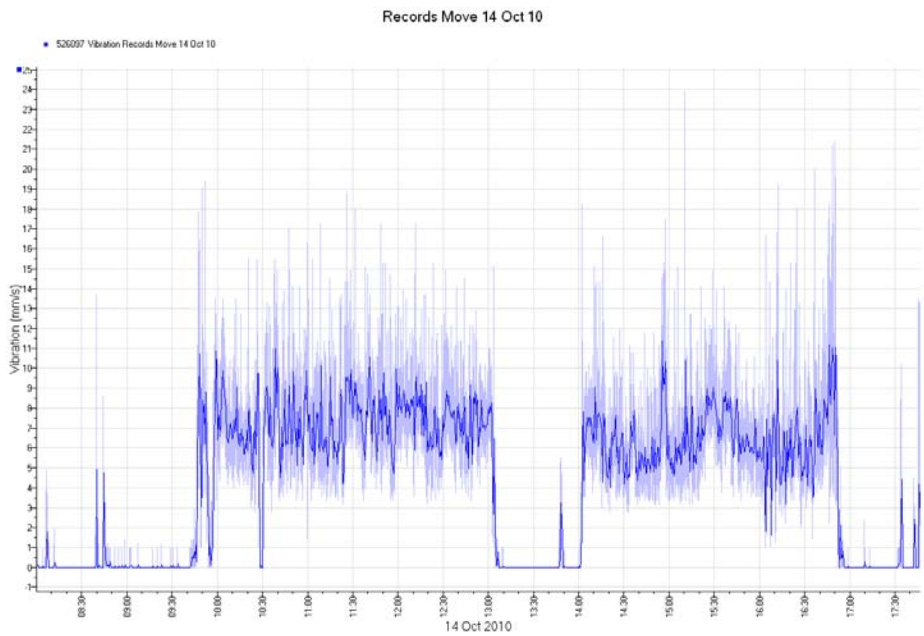


Figure 7 – Tiny tag vibration monitor graph for vertical vibration during a typical HGV journey from Gilmerton to Keyworth.

There are no generally agreed standards of acceptable vibration for geological samples. Thickett (2002) in a study of the British Museum galleries, noted that day-to-day activities such as visitor circulation yielded average accelerations of between 0.006 g – 0.15 g. Values typically above 0.2g – 0.5g produced some minor damage to fragile objects, such as the flaking of blistered paint or the opening of cracks in plaster frames of wall paintings. Converting these acceleration figures to velocity figures is not possible without making assumptions about frequencies.

The project approach is to build up a QC database of maximum and average vibration levels for each load. This information would then underpin any decision to use air cushioned vehicles for the transport of particularly fragile material.

5.3 Vibration mitigation

Trials have been carried out to determine whether the addition of a layer of foam between boxes and pallets reduced vibration. No significant improvement was observed. Advice has also been sought on the possible provision of shock absorbing mats on HGV trailers.

As noted above, air cushioned HGVs may be used to transport particularly fragile cores. This would require such cores to be grouped together and portions may be delivered out of phase with the remainder of the well, temporarily causing a well to be housed at two locations.

Following vibration data analysis and box examination, consideration may be given to modifying the route selection or additional packing if necessary.

The stabilisation methods for unconsolidated or loosely consolidated materials are described above and in Appendix 1. Transportation trials have already been carried out using loose sand in core-boxes as a proxy for poorly consolidated sand cores, with vibration monitors. The initial trials were undertaken using Ford Ranger vehicles. However, it is essential that the final trial test conditions exactly replicate those that will be used during transportation. For this reason further trials will be undertaken in the very near future by placing loose sand analogues in core boxes loaded onto HGVs transporting the Gilmerton paper archives to Keyworth. The results of these final trials will be used to finesse the stabilisation measures applied to these materials, and will be added as an appendix to this report.

6 Quality Control

6.1 Quality Control principles

The QC system will consist of three parts:

- the objective recording of the extremes and averages of vibration, humidity and temperature,
- the recording of any potentially harmful “incidents”, and
- a regular system of visual inspection, representative post travel photography and comparison of “before” and “after” images.

6.2 Vibration and environmental monitoring

On arrival at Keyworth, the *Tiny Tag*™ vibration monitors and *Digitron Monolog*™ datalogger will be recovered and downloaded, and the results analysed, compared to previous data, and extreme and average values databased.

It is expected that these comparisons will allow best routes, vehicles and possibly drivers to be determined. It will also provide the basis for box inspection: if a load has been subject to particularly harsh movement additional checks will be made.

6.3 Incident reporting

A “no blame” culture will operate throughout. Staff will be required to report any relevant incidents, which will be recorded against the core box and made available to future viewers of the specific box.

6.4 Manual quality checks:

Four levels of quality control sampling will be operated: routine (1), extended (2), thorough (3) and total (4).

Levels of Quality Control Sampling			
Level	Pallets inspected per consignment (ca. 50)	Boxes inspected per pallet (ca 18)	Appropriate when
Routine (1)	2	5	Routine transfer, >1 quality issues detected
Extended (2)	4 Pallets containing boxes flagged for special care to be selected first.	5 3 boxes flagged for special care to be selected first, but a couple of other random boxes to be selected as well.	Early transfers OR transfers containing boxes flagged for special care OR when a routine (1) examination was carried out and 2 or more quality issues were detected OR when recorded vibration levels exceeded the safety threshold.
Thorough (3)	10 Pallets containing boxes flagged for special care to be selected first.	10 5 boxes flagged for special care to be selected first, 5 other random boxes to be selected as well.	The first two transfers OR When an extended (2) examination was carried out and 5 or more quality issues were detected
Total (4)	50	18	Exceptional circumstances only.

The inspection process will consist of a series of checks for each box

- Is the box in good condition and dry?
- Is the barcode correctly attached?
- Has the appropriate packaging material been added?
- Are the warning stickers appropriate and correctly entered on the database
- Do the displayed metadata on the image agree with any markings in the boxes?
- Are the boxes in the correct order on the jigs?
- Has the correct core header been used?

- § Have the correct rulers been used?
- § Is there any visible damage when compared to the image?
- § If so, describe the damage.

The core will then be photographed to record its condition on arrival.

Quality inspection results for each delivery will be circulated to key Gilmerton and Keyworth personnel immediately upon completion of inspection. Results for the early runs or when a particular concern is noted, will be reviewed immediately by the appropriate personnel and any procedural improvements recorded and implemented. Routine results will be reviewed at regular weekly management teleconferences.

Regular quality reports, complete with illustrative photographs, will be posted on the BGS website.

It is expected the route may necessarily vary over time due to road conditions or works. In these instances we will be informed of any changes to the agreed route and additional checks made on arrival at Keyworth.

Procedures for packing will be adjusted as necessary as will possible route selection and load stacking.

7. Laboratory visits during the move

7.1 Laboratory visits

The Gilmerton store will remain “open for business” throughout the move, and procedures are being established to ensure any disruption is kept to a minimum. To assist Core Store staff to schedule a visit, possibly requiring the priority transfer of material, reasonable notice will be required. Staff will be happy to advise potential visitors on the current location of the core and samples they wish to view and the planned transfer date for material still at Gilmerton. They will also advise whether fast-tracking or delaying transfers could assist the visitor to view all the material at a single site.

7.2 Timetable Publication

Potential visitors may also assess the current and future location of cores and samples themselves. A full list of the relocation status of wells will be established and published on the BGS website; this list will indicate all transferred wells and the expected date of transfer and availability of others.

In addition, both three month indicative transfer lists and more precise monthly lists will be included and updated regularly.

BGS is also in discussion with UKDEAL to explore the feasibility of adding a location “tag” to the UKDEAL core and sample catalogue, combined with regular updates.

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Appendix 1: Mitigation of Potential Problems: Examples

Wet Cuttings

Recommended cuttings stabilization procedure						
Stage of process	Plastic cover	Wet box				
1	Do not open plastic		.			
2		Re-box cuttings & add plastic lining if required				

Incomplete Tray: multi rows

Recommended core stabilization procedure						
Stage of process	Thin foam separators	Folded acid-free tissue	Scrunched-up acid free tissue	Precut foam block, trimmed to size	Precut foam sheet	Cardboard rectangle
1	Fill small gaps, protect vulnerable pieces					
2				Remove straw and folded card. Replace with two foam blocks		
3			Pack level with scrunched tissue			

Complete Tray: multi rows

Recommended core stabilization procedure						
Stage of process	Thin foam separators	Folded acid-free tissue	Scrunched-up acid free tissue	Precut foam block, trimmed to size	Precut foam sheet	Cardboard rectangle
1			Pack level with scrunched tissue			

Complete Tray: multi rows, overlapping

Recommended core stabilization procedure						
Stage of process	Thin foam separators	Folded acid-free tissue	Scrunched-up acid free tissue	Precut foam block, trimmed to size	Precut foam sheet	Cardboard rectangle
1	Protect vulnerable pieces					
2				Pack empty end spaces with short pieces of precut block		
3		Layer of flat tissue				
4			Pack with scrunched tissue			
5						Cover to retain tissue

Single Run: loose core in card box

Recommended core stabilization procedure						
Stage of process	Thin foam separators	Folded acid-free tissue	Scrunched-up acid free tissue	Precut foam block, trimmed to size	Precut foam sheet	Cardboard rectangle
1	Protect vulnerable pieces					
2				Fill end voids with lengths cut from precut blocks		
3					Fill box with precut foam sheet	

Double Level Runs: incomplete core in card box

Recommended core stabilization procedure						
Stage of process	Thin foam separators	Folded acid-free tissue	Scrunched-up acid free tissue	Precut foam block, trimmed to size	Precut foam sheet	Cardboard rectangle
1	Protect vulnerable pieces					
2				Fill end voids with lengths cut from precut blocks		
3		Add layer of folded tissue				
4			Fill with scrunched tissue			
5	Note box number and mark box with high visibility label for subsequent removal of aluminium foil at Keyworth					

Double “Inner”: loosely- or un-consolidated core

Recommended core stabilization procedure						
Stage of process	Thin foam separators	Folded acid-free tissue	Scrunched-up acid free tissue	Precut foam block, trimmed to size	Precut foam sheet	Cardboard rectangle
1				Fill end void with length cut from precut blocks		
2		Cover with folded tissue				
3			Fill with scrunched tissue			
4						Cover to retain tissue if required

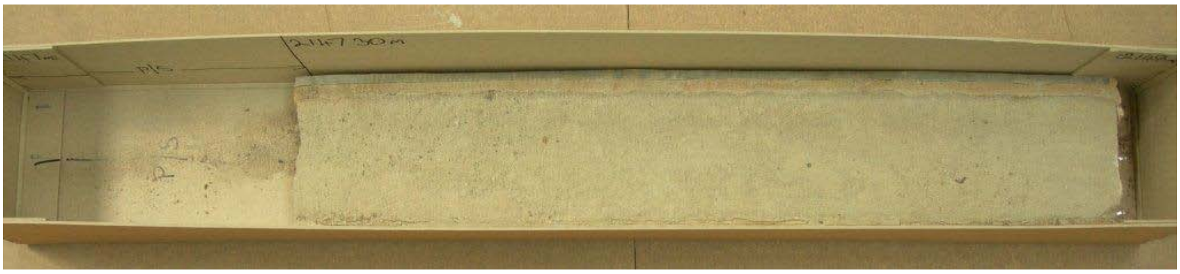
Double "Inner": incomplete runs.

Recommended core stabilization procedure						
Stage of process	Thin foam separators	Folded acid-free tissue	Scrunched-up acid free tissue	Precut foam block, trimmed to size	Precut foam sheet	Cardboard rectangle
1	Protect vulnerable pieces					
2				Fill end voids with lengths cut from precut blocks		
3			Fill with precut foam sheets or scrunched up tissue		Fill with precut foam sheets or scrunched up tissue	

3 “Inner” Boxes: incomplete runs and fractured core

Recommended core stabilization procedure						
Stage of process	Thin foam separators	Folded acid-free tissue	Scrunched-up acid free tissue	Precut foam block, trimmed to size	Precut foam sheet	Cardboard rectangle
1	Protect vulnerable pieces					
2				Remove cardboard, fill gaps with lengths cut from precut blocks		
3		Cover with folded tissue				
4			Fill box with thin foam sheet or scrunched tissue		Fill box with thin foam sheet or scrunched tissue	
5						Cover to retain tissue if required

Short Resinated Core



Recommended core stabilization procedure						
Stage of process	Thin foam separators	Folded acid-free tissue	Scrunched-up acid free tissue	Precut foam block, trimmed to size	Precut foam sheet	Cardboard rectangle
1				Fill end void with length cut from precut blocks		
2		Cover with folded tissue				
3					Fill box with foam	

Appendix 2: Summary Risk Assessment

RISK ASSESSMENT FOR PREPARATION, PHOTOGRAPHY AND TRANSPORT OF GILMERTON UKCS CORE AND CUTTINGS COLLECTIONS

This risk log identifies a set of risks specific to the relocation of the Gilmerton collections. The Gilmerton relocation is part of a £17M Keyworth estates redevelopment project being managed to Prince 2 methodologies, which has its own risk register.

BGS has standard health and safety procedures for routine practises such as Manual Handling, Contractor Induction, Fire Safety, Risk Assessment, Incident Reporting, Personal Protective Equipment *etc*. which are not repeated here. These procedures will be implemented at all times in accordance with BGS's ISO 9000 Quality Management System.

Specific risk	Control mechanisms
Damage to collections from vibration, shock, movement *etc*. at all stages of the process including at the Keyworth end	· Core suitably packaged, photographed, vibration levels monitored and controlled, in line with the detailed procedures described in the methodology document · Trial moves for testing of methodologies · QC and rapid feedback to continually improve procedures · Use of air cushioned trucks for fragile collections if required · Contractor follows routes known from monitoring to create minimal vibration levels
Road traffic incident resulting in shift of load or damage to collections	· Transport contractor operates in complete accordance with industry and Department of Transport safety guidelines and legislation at all times · Transport contractor instructed on delicate nature of loads
Disruption to availability of core during transfer	· Core moved in sequence, information published on monthly and three-monthly schedules, collections tracked with bar-codes and linked digital databases · Holding and fast-tracking of collections on request · Liaison with DECC to ensure maximum availability of collections at business critical times
Disrupting core integrity of individual boxes when removing from shelves or returning	· Use of fork lifts and mechanical handling devices to keep core boxes level at all times · Staff instructed accordingly
Back/muscle injury and strain through lifting and operating equipment, loading/ unloading vehicle	· Standard procedures for manual handling operations to be observed and enforced at all times · All staff to undergo task-specific training as required · Mechanical manual handling aids/trolleys/forklifts used at all possible opportunities · Staff to advise supervisor of any problems that may affect

	their ability to carry out manual handling tasks · Staff rotated to spread manual handling
Disrupting core integrity during visitor examination	· Complete photographic record to assist in re-instatement · Staff instructed accordingly · Prohibition on invasive sampling
Risk to cores from extremely cold temperatures during winters	· No transportation of cores when day-time maximum temperatures are forecast to be lower than 0C
Risk to cores from water ingress during transportation	· Ensure all possibilities of water ingress to vehicles are eliminated by thorough, appropriate inspections prior to and during journeys

Appendix 3: Transport trial results

Background

Over the past thirty years, BGS has transported core from approximately 750 onshore wells from Gilmerton to Keyworth, without incident. Over the same period, BGS has also transported numerous onshore Scottish boreholes from Murchison House and Loanhead to Keyworth, as well as offshore boreholes from Keyworth to Loanhead, also without incident. BGS has also collected numerous boreholes from contractors and drilling sites and transported them to Keyworth or Loanhead, again without any evidence of transport related damage. This track record, coupled with the additional packaging that will be added as part of the stabilisation process, makes us confident that the more indurated cores will travel without disruption. In the unlikely event that minor movement of core pieces should happen, the QC procedures outlined in the transfer methodology, coupled with the photography and vibration monitoring, will detect it quickly and allow for modifications to the process.

Specific trials have been conducted In view of the concerns over the transport of poorly consolidated sediments such as the Forties Sandstone. This formation is well known to be soft and friable. Of the 129,671 boxes of core at Gilmerton, 13,733 contain Tertiary core. The Forties Sandstone, and equivalent units elsewhere, including west of Britain, account for significantly less than 10% of all boxes.

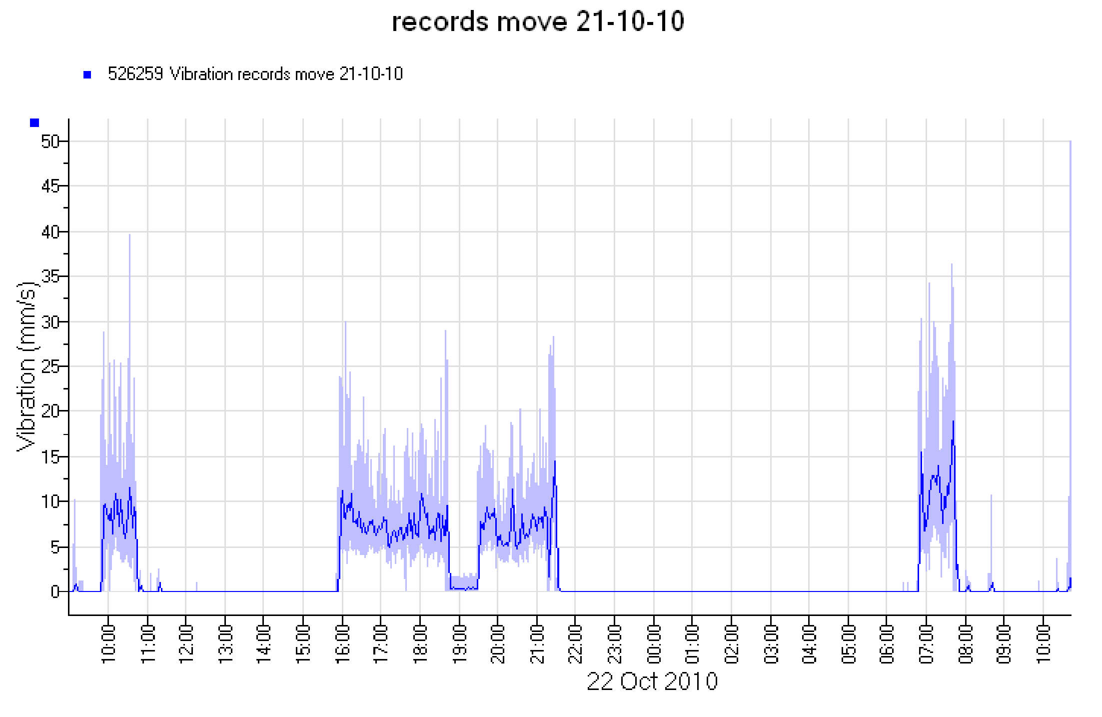
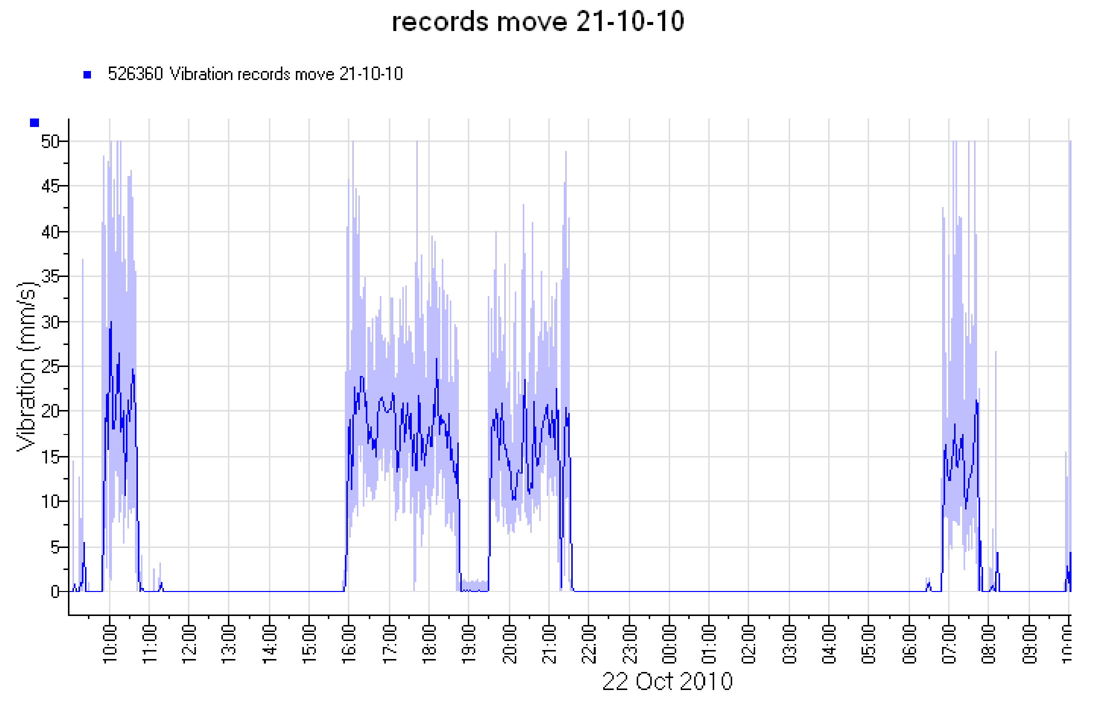
Trials

Trials have been undertaken by loading test core boxes, complete with vibration and environmental monitors, onto the HGVs that are currently transporting the Gilmerton paper well records to Keyworth. These HGVs are of the type that will be used for core transport (unless air-cushioned transportation is chosen for particularly friable materials).

The extreme case of poorly consolidated Forties sand has been modelled using loose sand in a section of guttering (to represent the section of core tubing usually used). The sand has been mixed with light oil (400ml of WD40 per 14.5kg sand), and a number of pieces of white gravel have been added to highlight any sand movement. The trace of oil was intended to model the slight consolidation and hydrocarbon impregnation of the sandstone. The test sample is considered significantly more prone to damage than actual examples of Forties sand.

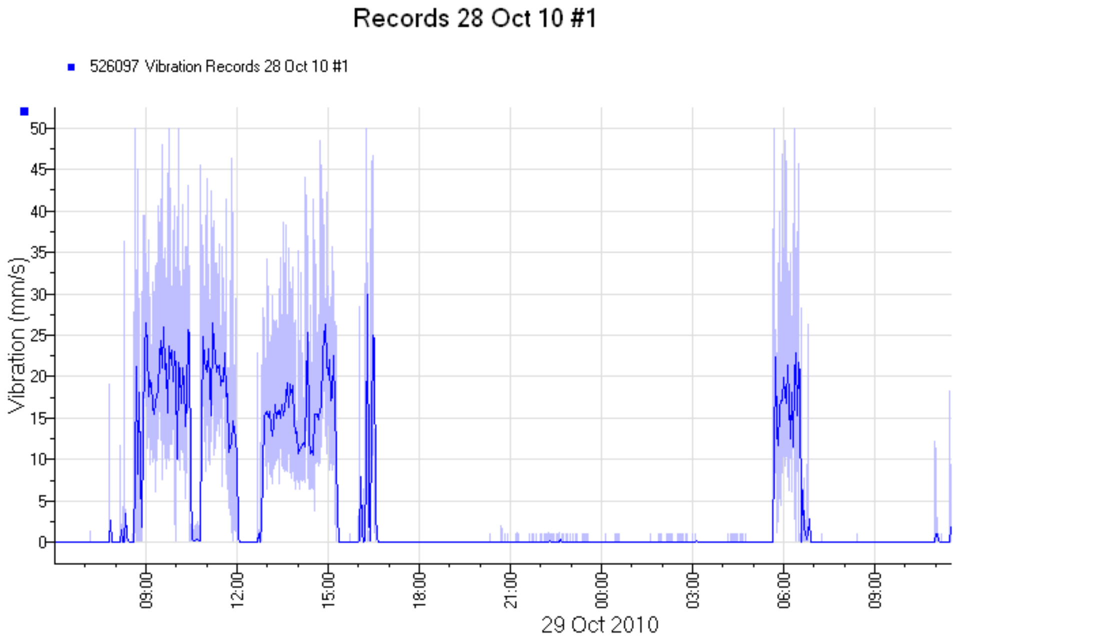
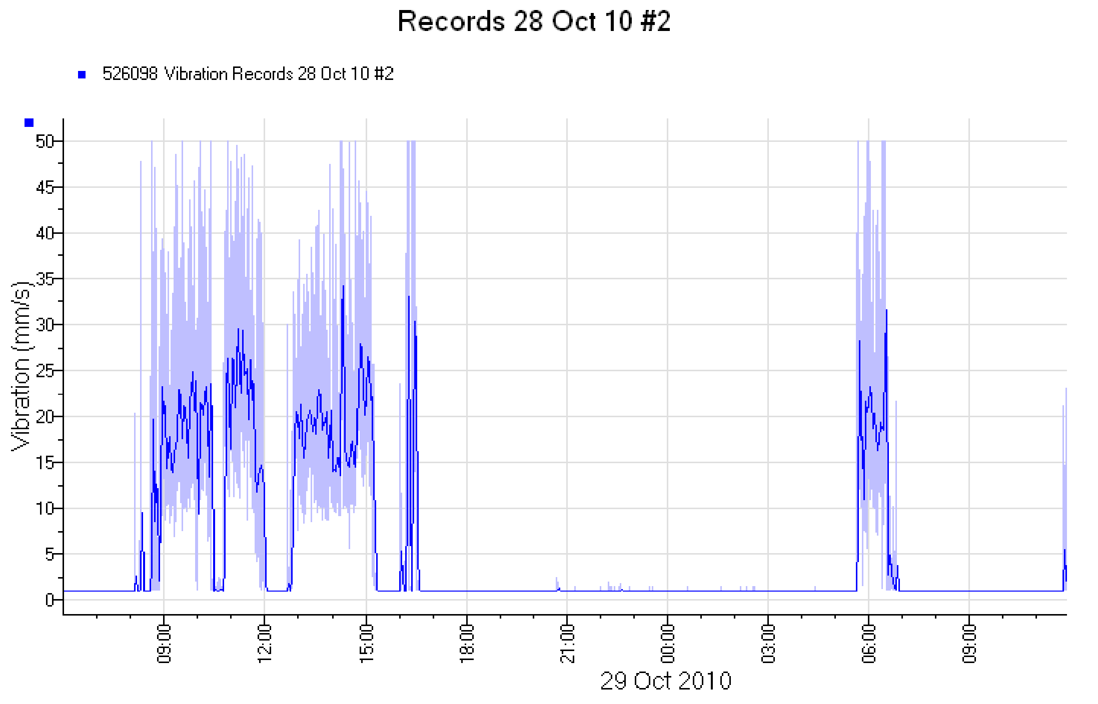
Two sets of trials were run – one with the addition of the prescribed stabilisation packaging, and the other without. The results clearly show that without the packaging some movement occurs, whereas with the packaging, excellent results are obtained.

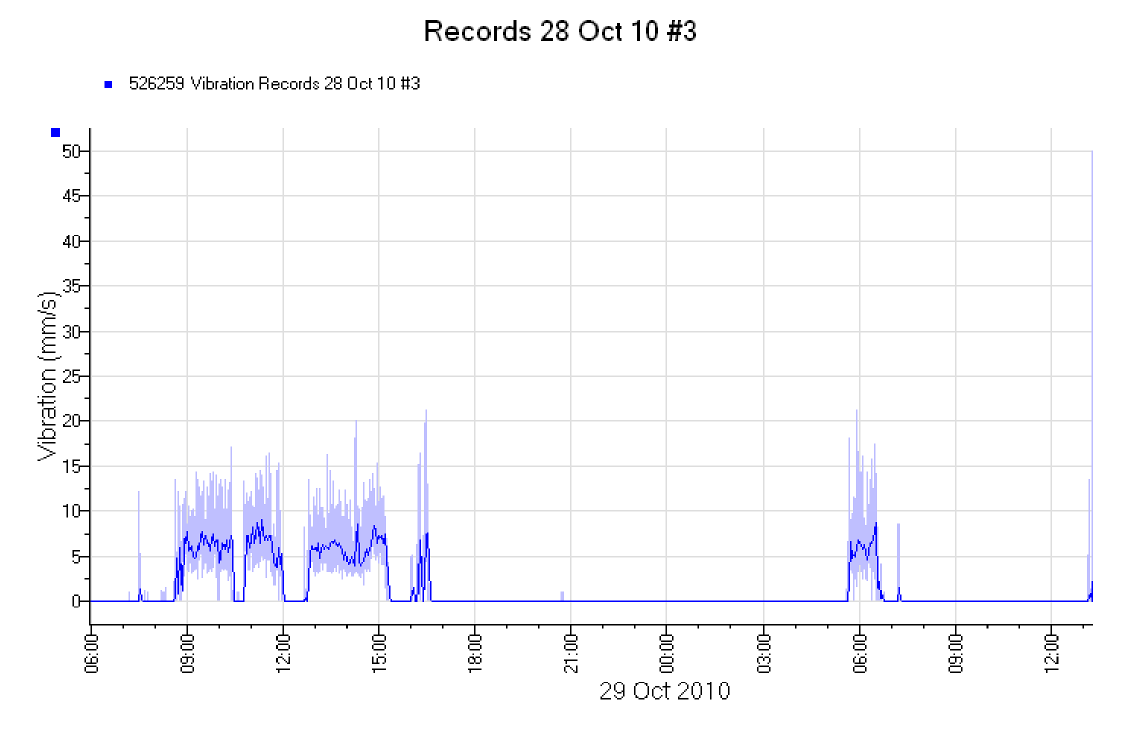
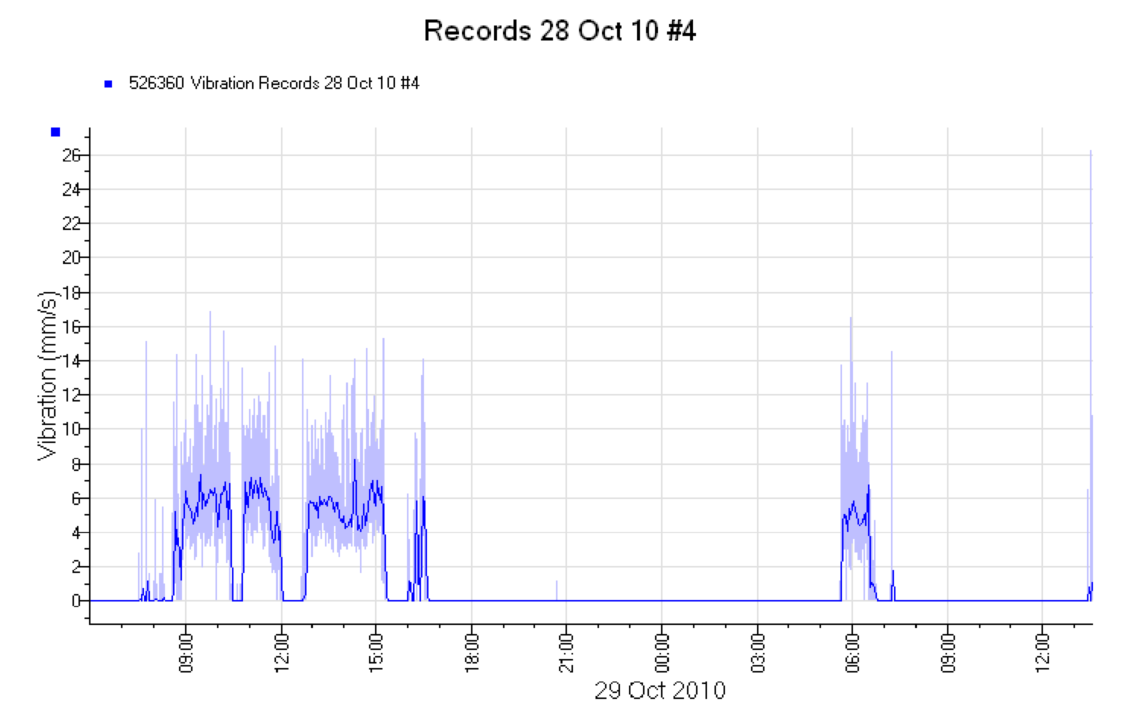
Trial 1 – Without the addition of packaging for stabilisation.

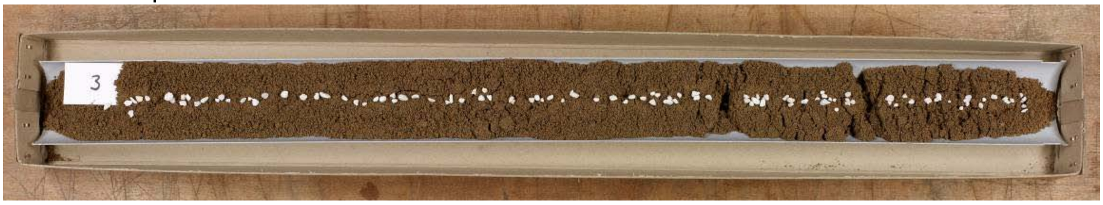
TRIAL RESULTS WITHOUT STABILISATION PACKAGING	
Vibration levels, side to side, lower deck, Max = 39.6 mm/s Av = 8.1 mm/s	
Vibration levels, up and down, lower deck, offside Max = >50 mm/s Av = 17.0 mm/s	

Lower deck, sample 1 NO STABILISATION PACKAGING	Before transport:  After transport: 
Lower deck, sample 2 NO STABILISATION PACKAGING	Before transport:  After transport: 

Trial 2 – With the addition of packaging for stabilisation.

TRIAL RESULTS WITH STABILISATION PACKAGING	
Vibration levels, up & down, lower deck, offside Max = >50 mm/s Av = 17.2 mm/s	
Vibration levels, up and down, upper deck, offside Max = >50 mm/s Av = 18.6 mm/s	

Vibration levels, side to side, lower deck, nearside Max = >50 mm/s Av = 6.1 mm/s	
Vibration levels, side to side, upper deck, nearside Max = 26.3 mm/s Av = 5.4 mm/s	

Lower deck, offside	Before transport:  After transport: 
Upper deck, offside	Before transport:  After transport: 
Lower deck, nearside	Before transport:  After transport: 
Upper deck, nearside	Before transport:  After transport: 

Conclusions

1. Loose sand with a light oil coating acts a cautious analogue (i.e. more fragile) than the sand of the Forties type, which is often slightly consolidated and with traces of heavier oil.
2. Trials with the addition of extra packaging for stabilisation show negligible or no movement within the core tube.
3. The comparison of 'before' and 'after' photographs as part of the QC process will provide an important tool for refining the stabilisation and transport processes as the transfer proceeds. Should deterioration of the more fragile cores be detected, then their transport will be stopped and alternative forms of transport used, such as air-cushioned vehicles designed for the transport of fragile art and antiques.