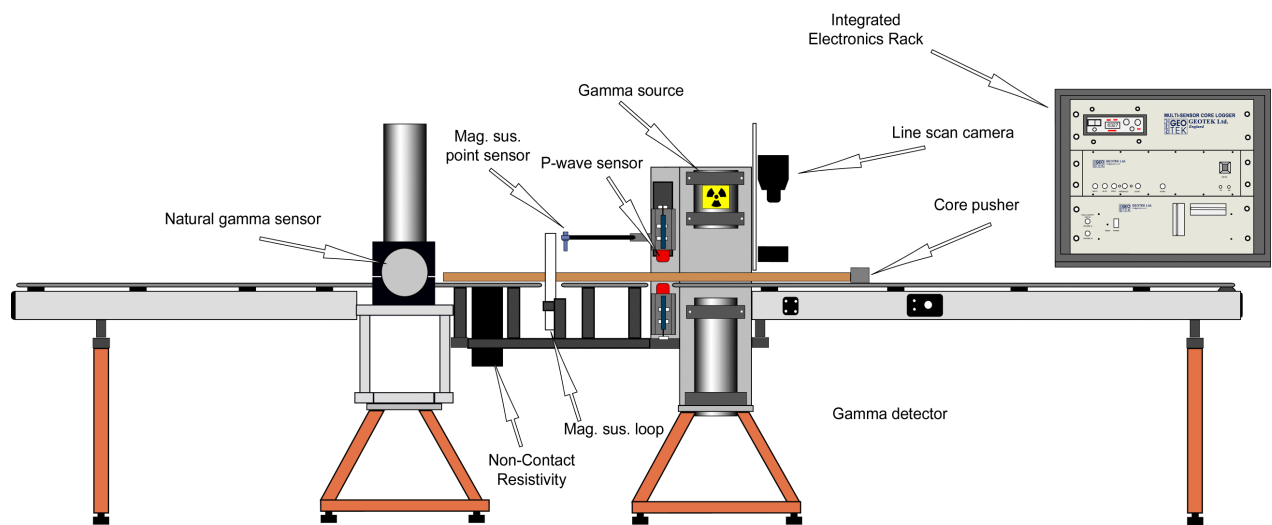


Multi-Sensor Core Logger



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1. Introduction

1.1 Overview

This introduction presents an overview of the capabilities and features of the Multi-Sensor Core Logger (MSCL). It describes the major features of the logging systems and outlines variations that occur between different generations of logging systems. The organisation and use of this manual are described, notational conventions safety symbols and abbreviations are explained.

1.2 The Multi-Sensor Core Logger (MSCL)

The GEOTEK Multi-Sensor Core logger has been built for a range of users since 1989. During that time the logging system has inevitably evolved with significant improvements being made to the simplicity of the mechanical arrangements, the effectiveness of the sensors and in particular with the sophistication of the software. Consequently there are a number of slightly different systems in use. Despite this natural evolution GEOTEK has been conscious of the need to update older systems so that important new features can be incorporated. This is particularly true with the software, which has been designed to function on all systems with only minor modifications to the electronics and hardware. If you find features described in this manual that do not seem to apply to your system then contact GEOTEK directly for an assessment of the upgrade potential.

1.3 Types of Logging Systems

Single Section - Whole Cores - Core Boat

Early versions of the logger moved the core sections through the sensor systems using a core boat in which each whole core section was placed. Each core section was logged individually. Data files were subsequently manually concatenated by the user within a spreadsheet.

Single Section - Whole Cores - Core Pusher - Long Belt

Later versions of the logger did not have a core boat. They moved individual whole core sections through the sensor systems by using a core pusher to push individual core sections (lying on plastic rails) through the system. This was achieved using a long belt that went around the complete length of the track, through the sensor systems and was attached to the core pusher.

Multiple Sections - Whole Cores - Core Pusher - Short Belt

Recent versions of the logger have maintained the core pusher principle but have a short belt which allows the pusher only to move along the right hand section. Cores are passed through the complete sensor array by butting adjacent cores together. In this way a continuous core logging process is achieved with continuous data sets for a complete core.

Multiple Sections - Split Cores - Core Pusher - Short Belt

The most versatile logging system is now the split core logging system that is floor mounted and measures P-Wave Velocity and Gamma Density either horizontally through whole cores or vertically through whole or split cores. It features a moving vertical slide onto which is mounted the upper P wave transducer (either the older type that required water coupling or the new Acoustic Rolling Contact (ARC) type). This automated vertical slide enables the measurements to be performed on horizontally split cores as well as whole rounds. With this system there is a large degree of flexibility that enables other sensor systems to be attached. For example the Digital Imaging GEOSCAN system is fitted simply with 2 bolts to the upright section.

Special systems:

All of the above systems use the moving core/stationary sensor philosophy. However GEOTEK has also built special systems for particular applications where a stationary core/moving sensor philosophy is more appropriate.

Most of this manual refers directly to the recent versions of the split core logging systems that are now most popular. However, where significant operational differences occur specific reference is made to other types of systems.

1.4 General Description

The split core version of the Multi-Sensor Whole Core Logger system enables a number of geophysical measurements to be made on both horizontally split and un-split (whole round) sediment cores encased in cylindrical plastic core liners. Core sections with plastic end caps of up to 150 cm long and from 50 to 150 mm in diameter (maximum including end caps) can be used in a standard system. A schematic diagram of the complete apparatus is shown in Chapter 2.

The system is designed to be operated primarily under computer control, depending on the customer's specific requirements and available peripheral equipment. The simplicity of the core pusher operated tracking system and automated vertical slide arrangement enable additional sensors to be added at a later date to operate on either whole or split cores.

Sensors:

The primary measurement sensors described in this manual are:

- a) Ultrasonic Transducers to measure the velocity of compressional waves in the core.
- b) A Gamma Ray Source and Detector for measuring the attenuation of gamma rays through the core (providing density/porosity values).
- c) A Magnetic Susceptibility Sensor to determine the amount of magnetically susceptible material present in the sediments.
- d) An Electrical Resistivity Sensor to measure the electrical resistivity of the sediments in the core using a non-contacting method.

Two secondary measurement sensors are also described which enable measurements to be corrected for changes in core diameter and temperature:

- e) Core Diameter: The diameter of the core is measured using a pair of displacement transducers connected to the spring loaded compressional wave transducers. This enables the compressional wave velocity and density (from the gamma ray attenuation measurements) to be calculated in addition, allowing for changes in core diameter.
- f) Temperature: A platinum resistance thermometer (PRT) is included. The data is logged and can be used to correct for temperature changes that may occur during the logging process. It should be used particularly to make corrections to the P-Wave velocity.

Additional sensors such as core imaging, electrical resistivity, total and spectral natural gamma can be added to the system in a modular fashion. The track system, electronics and software have been designed to allow upgrades without the need for any major modifications.

1.5 Use of this Manual

This manual is organised into the following chapters:

Chapter 2, Installation

Tells the user how to unpack and assemble the core logger. It discusses safety issues and computer requirements. It provides important information for new users and may also be valuable in the event that the logger is moved to an alternative site.

Chapter 3, Setting Up

Explains what initial procedures should be conducted to set up the tracking system, the sensors and the computer prior to the start of automated core logging.

Chapter 4, Core Logging – Quick Start

This provides a short-form description of the procedures required for operating the MSCL using the automatic logging software. If the user is using these procedures then it is assumed that all set up and calibration procedures have already been performed.

Chapter 5, MSCL Application Software

Describes all the features of the main logging software. It is probably best used as a reference chapter when specific information is required regarding the operation of the software.

Chapter 6, Microprocessor and Utilities Software

The interactions between the logger the microprocessor and the PC are described. It explains the file structure and how to use the Utilities software, both as a set-up tool for the core being logged and as a diagnostic facility.

Chapter 7, Calibration and Operation Protocols

Recommended calibration procedures are described and explained for all sensor systems. Also included are hints on operational protocols. These will help the user in the overall logging operation.

Chapter 8, Trouble Shooting

A number of potential problems are described together with appropriate measures for solving them.

Chapter 9, Natural Gamma Data Acquisition

Describes the measurement, the instrumentation used and the software features that control the instrument.

Chapter 110, Digital Imaging

Explains the specifications of the Geoscan system and the software routines to set up the system and collect images.

1.6 Notation

This manual uses the following notation:

Commands, which must be executed from the PC keyboard, are printed in **bold type**. Keys that are to be pressed simultaneously or in succession are linked with a hyphen. For example, press **CTRL-A**.

Commands, which must be executed by placing the cursor arrow on a software button, or in a specific position on the screen, followed by clicking the mouse button, are shown in **[bold square brackets]** where the name in the bracket is the name of the software button.

1.7 Warning Symbols:

The following warning and safety notation is used:



**Safety warning
regarding
radiation risk**



**Safety warning
regard
risk of electrocution**



**Safety warning
regarding
risk of poisoning**



**Safety warning
regarding personal injury from
heavy weights**

1.8 Acronyms and abbreviations:

The following are abbreviations are used in this manual:

AD	Analogue/Digital
AGC	Automatic Gain Control
CPS	Counts Per Second
DT	Displacement Transducer
GD	Gamma Density
LCD	Liquid Crystal Display
LH	Left Hand
MP	Microprocessor
MS	Magnetic Susceptibility
MSCL	Multi-Sensor Core Logger.
PC	Personal Computer (IBM Compatible)
PRT	Platinum Resistance Thermometer
PWT	P-Wave Transducer
RH	Right Hand

2. Installation

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2.1 Chapter Overview

This chapter familiarises the user with the installation of the Multi-Sensor Core Logger assuming no prior knowledge of the system.

If you are using the gamma attenuation density system it is assumed that you have registered your premises for the handling of the ^{137}Cs source, and that you have planned a code of practice for the safe operation of the system. If you have not done so, do not open the packing case containing the gamma source before completing the preparation of your safety plan.

Unless the user is already familiar with the MSCL then on first installation GEOTEK personnel will normally install, commission and provide instruction on the use of the equipment. Consequently this chapter is not intended to provide a comprehensive set of instructions for the new user but is intended to provide pertinent notes that may prove valuable, especially if the user moves the equipment to a new site or from a land based laboratory to a shipboard laboratory.

2.2 Unpacking

2.2.1 Safety

Before unpacking the MSCL please ensure that you have made adequate preparations with regard to safety. The following general notes can be used as a starting point for your preparations.

Radiation Hazard: If the core logger has a gamma density sensor system then it will have a ^{137}Cs source that has an activity of about 10 milli-curies. This is securely located in a shield that when closed restricts the exposure to less than 3 micro sieverts per hour. The shield has an asymmetric rotating shutter that allows the user to align a narrow collimator, which will allow a narrow beam of gamma rays to pass through the sample for making the gamma density measurements. This shutter can be simply closed and locked in position when it is not in use. (see Chapter 3 for details).



**DO NOT OPEN THE SOURCE
SHUTTER UNLESS SHIELD IS
SECURELY MOUNTED IN
FRAME**

The source is classified as a sealed source and copies of its certificate of manufacture and wipe tests will be provided by GEOTEK.



**Do not open any electrical
component unless supervised by a
qualified electrician**

**Some components contain high voltages
(e.g. gamma detector and P Wave Tx box).**



**The gamma source and detector
shields contain lead.**

After handling the shield ensure hands are cleaned.



**THE LEAD SHIELDS ARE VERY HEAVY:
MIND YOUR BACK!
USE GOOD STRONG HANDS NOT YOUR
FEET!**

Use 2 people to handle and place on soft surfaces - do not drop!

2.2.2 Laboratory requirements

Depending on the system configuration being used the MSCL can either be a free standing device, mounted on legs, or it can be mounted on a bench. In either case it is best situated against a wall.

The electronics rack and controlling PC should be installed on a bench at the RH end of the system, so that water and soil are kept away from the electronics (see below).

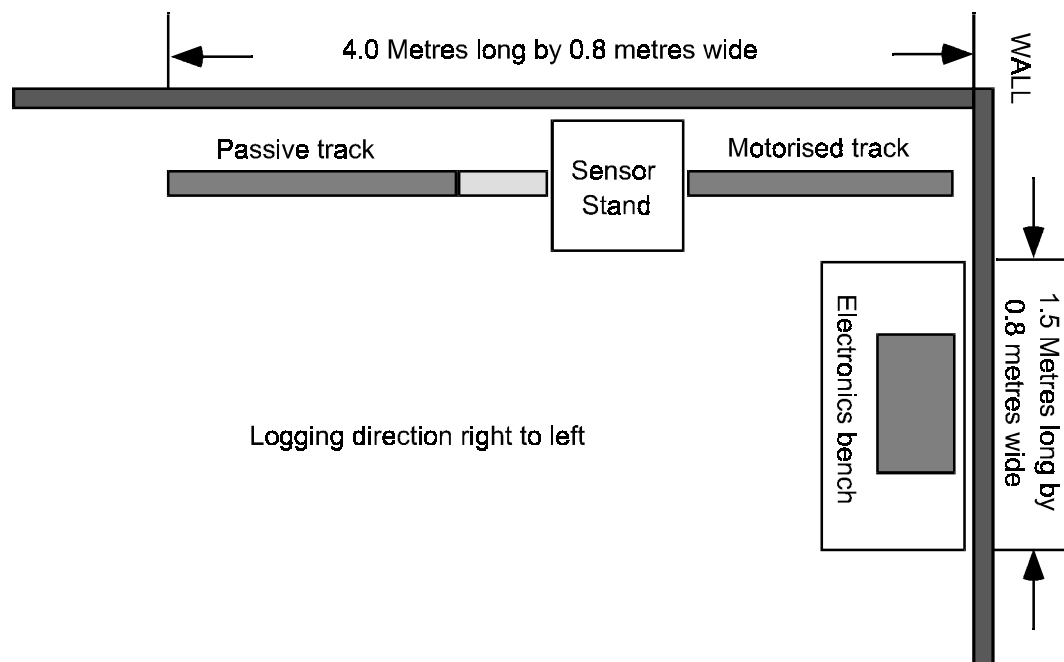


Figure 1. MSCL Laboratory Layout

2.2.3 Computer requirements

The MSCL needs a controlling PC computer. This should be an IBM compatible PC with a Pentium 60MHz or faster microprocessor with at least 8 Mbytes of RAM, a hard disk and a spare serial COMMS port. It must be loaded with Windows 95™ software or higher. Preferably the user should use Windows 95 or 98™.

2.2.4 Re-packing

All of the strong wooden packing cases are designed for re-use. Use ample packaging material to ensure that the equipment is not damaged in transit.

2.3 Assembly

1.1.1 List of parts

Note that this list is generalised as it will vary depending on which options have been purchased.

- **Motorised RH track assembly**
- **Passive LH track assembly**
- **Track support feet (3 off)**

- Main centre Sensor stand
- Magnetic Susceptibility centre assembly
- Main electronics rack with cables and junction boxes
- Stepper motor power supply
- Set of narrow core rails
- Set of wide core rails
- Magnetic susceptibility loop sensor
- Magnetic Susceptibility point sensor
- Gamma detector
- Gamma detector housing
- Gamma source
- Perspex gamma covers
- 2 off P-Wave Transducer and Displacement Transducer assemblies (PWT & DT)
- Cables and power distribution board
- Manuals and documentation
- ‘T’ handled hex keys

2.3.2 Assembly Instructions

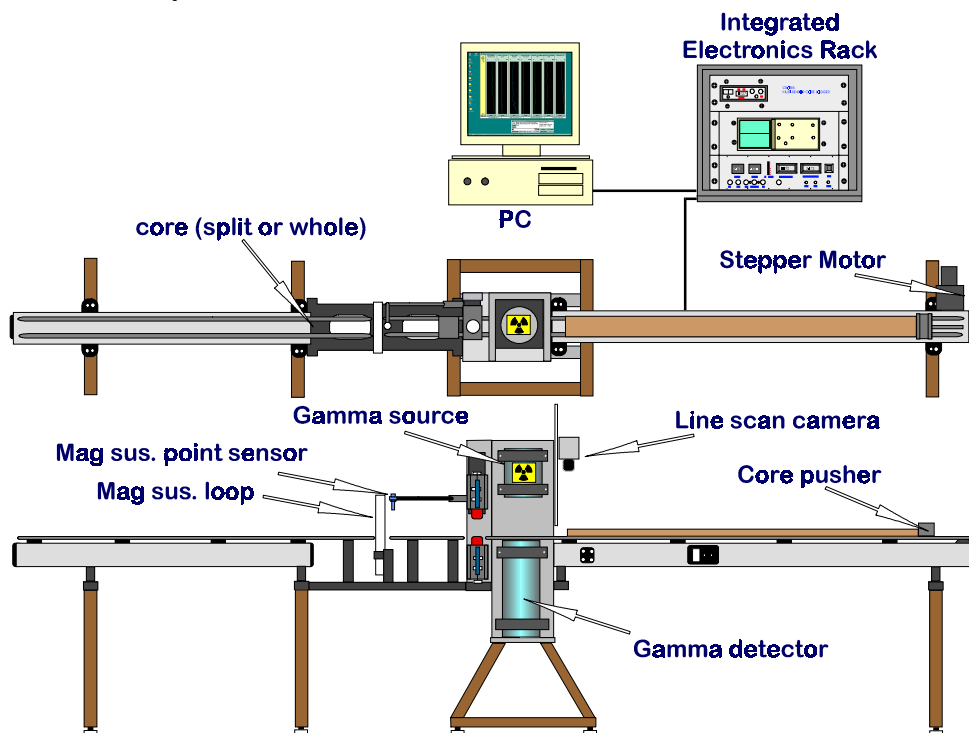


Figure 2. MSCL Schematic Layout (Split Core Logger).

- Place the main centre sensor stand in its correct position in the laboratory. (2 people are needed to carry out this operation).
- Fit the wooden leg to the RH end of the RH motorised track section.
- Bolt the RH track assembly to the main centre section. Two people are required to do this.

- d) Fit the two remaining feet to the LH track section so that it can stand on its own, and place it in line with the RH section and the correct distance away from the sensor stand.
- e) Attach the MS section to the LH box section using both the bolts at the bottom of the MS assembly and the nylon screws that fix the track to the top. You can now let go of the MS section and line its right hand bolts up with the fixing points at the LH side of the main sensor stand. Fix the other end of the MS assembly to the main sensor stand.
- f) Use an empty core liner of the largest size (with end caps) laying on the rails to ensure that it passes freely through the loop when run along the rails. The MS loop sensor can be moved vertically by loosening the clamp.
- g) Check the position and alignment of both sections on the bench and adjust using the adjustment bolts at the top of the feet.
- h) Unpack and place the electronics rack on a table at the right hand end of the logger.
- i) Install the scintillation detector into the housing (if it has been removed). Use the temporary handle on top of the housing to lower it into the sensor stand.
- j) Fit the remaining rail section across the gap in the sensor stand.



**THE LEAD SHIELDS ARE VERY HEAVY:
HANDLE WITH CARE**

- k) Lift the Gamma source shield onto the step in the source support bracket with the shutter lever pointing to the right. (2 people are needed to carry out this operation) **DO NOT LET GO OF THE HANDLE** until the source clamp and bolts are securely in place. Adjust the source until the shutter lever is in the correct position, and can be moved through 180° (loosen the clamps a little to rotate into the correct position). Do not to open the gamma beam shutter on the source at this stage but wait until all other aspects of the system are set up.

**DO NOT PLACE HANDS ARMS
OR ANY OTHER BODY
COMPONENTS BETWEEN THE
SOURCE AND DETECTOR**



**HANDLE AS LITTLE AS
POSSIBLE**

**ENSURE WARNING LABEL IS
ATTACHED AT ALL TIMES**

- l) Fit the perspex guard around the source.
- m) Adjust the position of the lower PWT by placing a core on the rails and holding it down while sliding the PWT up towards the core. The exact position is not crucial but the user should ensure that the lower transducer is always in contact with the core. Tighten and check that the core moves through the spring-loaded assembly without difficulty. Re-adjust if necessary. Tighten only sufficiently to prevent accidental movement. **Do not over-tighten.**
- n) Re-check the positions of all sensors by manually running a core along the complete length of the system.

CAUTION

**TAKE CARE NOT TO RUN THE CORE INTO ANY OF THE SENSORS
OR ANY OTHER OBSTRUCTION.**

**SIGNIFICANT MECHANICAL DAMAGE COULD RESULT.
BE PARTICULARLY CAREFUL OF THE P-WAVE TRANSDUCERS AND THE MAGNETIC
SUSCEPTIBILITY LOOP.**

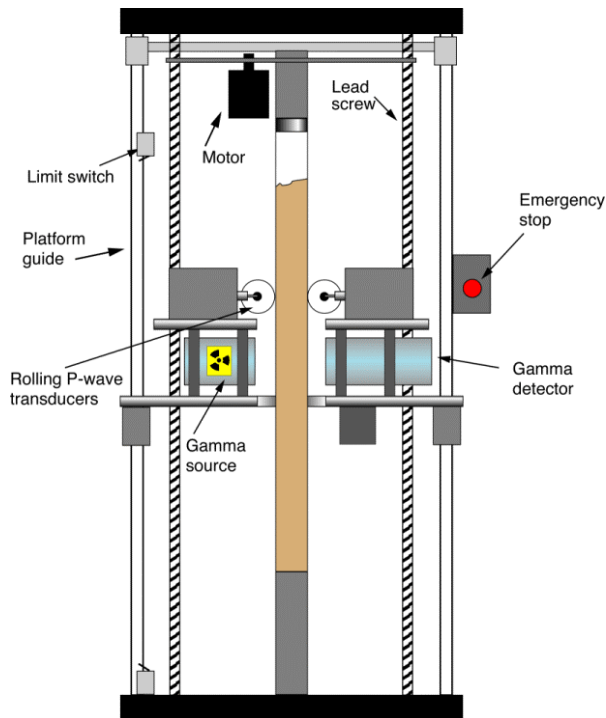


Figure 3. Schematic layout of a vertical moving sensor MSCL.

2.3.3 Special notes for ship-board installation

The MSCL support feet can be anchored to the deck with special plates depending on the type of deck and fixings available. Ideally the mountings should be attached directly to the swivel pads which provide some vibration isolation. Please consult GEOTEK if you have any difficulties.

The MSCL should be assembled while the ship is in port, and should not be disassembled in any way at sea. Some components are very heavy and could cause serious injury if they broke loose on board a moving ship.

Make sure that the complete system is securely bolted to the ship's structure. Check that the structure you have bolted it to is both fixed and is strong enough for the purpose

2.4 Wiring

The electronics for the MSCL system are mounted in a sturdy standard 19" rack. A cable bundle from all the sensors, stepper motor and control box, enables the rack to be positioned at the RH end of the system on a bench.

Position the electronics rack and remove the protective front and back cover panels for access to connectors.

2.4.1 Mains supply

All the mains power for the system is supplied via the mains distribution board from which 2 cables are run:

- a) For the computer.
- b) For the electronics console.
- c) If you have an analogue oscilloscope an extra power lead will be required.

2.4.2 Cable connections

All the cables from the logging system enter to the rear of the electronics rack. Most of the connectors (apart from serial connectors) are different. Figure 4 gives a schematic wiring diagram for the free cables.

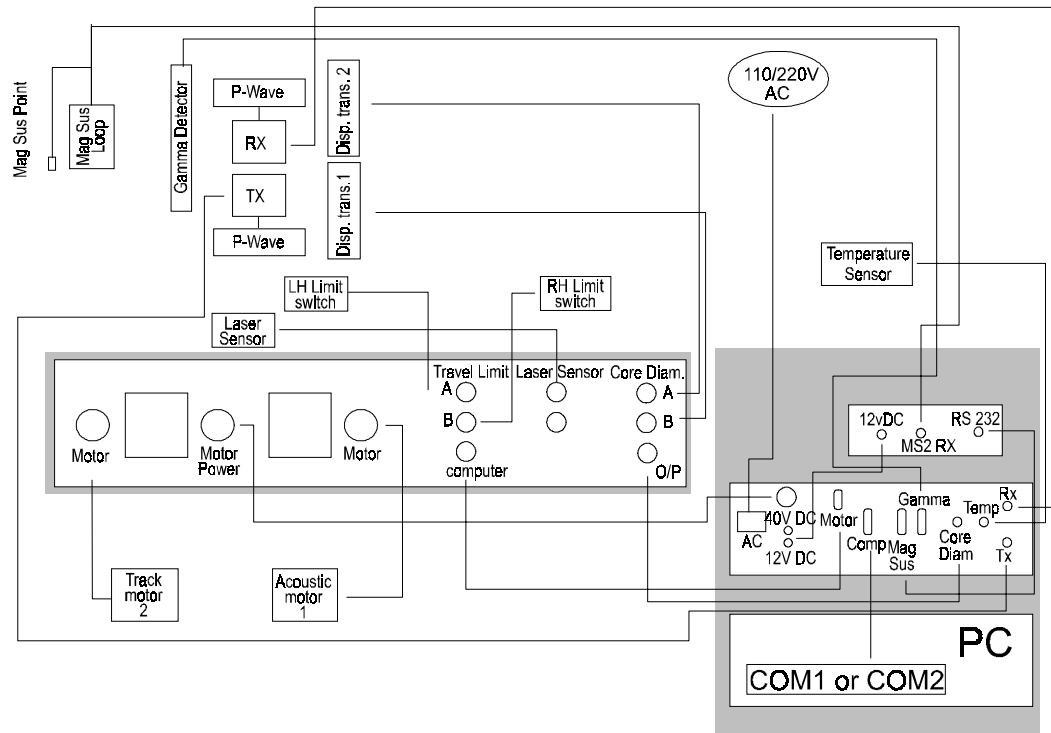


Figure 4. Interconnecting wiring layout.

CAUTION

**ENSURE THAT THE SYSTEM IS SET TO RUN ON THE CORRECT A/C VOLTAGE.
THE VOLTAGE SELECTOR ON THE BACK OF THE COMPUTER MUST BE SET
ACCORDINGLY.**

3. Setting Up

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3.1 Chapter Overview

Once the Multi-Sensor Core Logger has been assembled, this chapter provides the user with a more detailed description of the main components and enables the user to establish that the individual parts of the system are functional. To calibrate the different parts of the system before core logging begins the user should refer to Chapter 6.

3.2 Track Mechanism and Vertical Slide

3.2.1 The track and core pusher

The track mechanism is constructed in two sections referred to as the 'RH section' and the 'LH section' (right and left hand sections). The sections are aligned and mounted on feet end to end (see Chapter 2 on installation). Each section comprises of an aluminium box section base on which parallel, cylindrical plastic rails are mounted on plastic sleepers and along which the plastic core pusher travels.

Two sets of rails and core pushers are provided to accommodate the range of core sizes that may be used. The appropriate rail set for a given core diameter is shown below:

Small rails Core diameters 50 mm to 90 mm
Large rails Core diameters 80 mm to 150 mm

The core pusher is driven from the stepper motor and gearbox assembly mounted on the RH motor section. A 'kevlar' reinforced nylon-toothed belt is attached to the pusher and passes around the driven toothed pulley wheel at the RH end of the motor section. It runs beneath the complete length of the RH section and back over the free running pulley wheel at the LH end of the section to the LH side of the core pusher where it is attached. In this way a complete drive loop is formed enabling the stepper motor to drive the core pusher in either direction.

The stepper motor and gearbox assembly provide the torque required to drive the core along the track at speeds of up to 2.5m/min. The stepper motor will, however, stall if it is started at too high a speed or the core is driven into an obstruction. In practice this means that if the core inadvertently comes up against a solid obstruction then it will stall. However, care is required to ensure that this does not occur as substantial damage could occur if the core is inadvertently driven into any of the sensors. The sensors most at risk after the initial set up are the P-wave transducers because they are adjustable.

There is some backlash (approx. 5 mm) in the drive assembly that can be negated for all practical purposes, by ensuring that the core pusher was last driven to the left prior to automatic logging. When using the Windows™ software this is done automatically.

3.2.2 Changing the belt/rails

To change the rails on the RH box section the belt must be removed first. To remove the belt simply dismantle the clamp on the core pusher and unthread the belt from the RH box section. To change the rails remove all the fixings in the sleepers and replace with the alternative rail set.

Replacing the drive belt. Thread the belt around the motor pulley at the RH end, under the complete system and around the free pulley at the LH end and back to the core pusher. It can be useful to run the motor to help the belt feed around the motor pulley

KEEP FINGERS AWAY FROM THE PULLEYS WHILE THEY ARE MOVING!

Clamp the belt to the LH side of the core pusher so that it is flush with the pushing face. Fix the belt into the bracket at the RH end of the core pusher keeping the tension as tight as practically possible. The core pusher can be clipped into the rails at any position between the sleepers, where the rails will flex apart. The top part of the fixings on the core pusher can be used either way round to obtain the best tension (this provides adjustment of ½ pitch - 2.5 mm).

3.2.3 The Vertical Slide

The upper PWT and DT together with the MS point sensor are fitted to the vertical slide. This slide is driven via a stepper motor (No 1) and rack and pinion assembly. If the slide is driven too high then the pinion gear disengages from the rack preventing any damage. It will re-engage when the slide is driven down again. If the slide is driven too low with the P-Wave transducer and housing in place then a limit

switch will cut the power and prevent any further motion. If the slide disengages because it is too low then the user can re-engage by simply applying a slight upward pressure on the rack while the motor is turning.

3.2.4 Limit Switches

Three limit switches are installed on the system to prevent accidental damage occurring in the event of an error. The user should note that in normal use in the automatic logging mode the switches will not be contacted unless an error occurs and if they do contact then logging should be paused whilst appropriate measures are taken to 'reset' the system.

Two switches are located at either end of the motor track section to prevent damage occurring to the system by cutting the power to the stepper motor should the core pusher (or a damaged core liner) run into them. Note that only the limit switch located at the end towards which the core is travelling is active. This prevents the system from 'locking up' in either of the end positions.

The 3rd limit switch is mounted on the vertical motor to prevent the core from being crushed in the event of an operational error. This limit switch is connected in series with the track switch at the LH end. Consequently it is possible if an operational error occurs to lock the system if both this switch and the RH track switch are closed.

A laser based core detection system is fitted as standard on MSCL systems Serial #39 and higher. The laser 'looks' across the right hand track to the right of the reference position and detects either the LH end of the core section or the pusher depending which part of the logging cycle the system is in. Having a laser detect system achieves several objectives;

- i) The user does not have to align the first section with the reference position before logging begins.
- ii) All core sections are measured and automatically butted against the previous core section without the user having to position the core accurately by hand. This automatic operation enables the process to be achieved more accurately and insensitive to user errors.
- iii) At the end of logging each section the software checks and resets the position of the pusher. If there is a difference in the actual and assumed position of greater than 5mm then this error is reported to the user. The user can decide whether to relog that section or to ignore the error and reset the pusher position. In this way if small errors do occur (for example if the motor stalls briefly) the user does not have to reset the position manually and can continue knowing that the error will not be accumulated into the next or subsequent sections.

3.2.5 Motor Control Panel

There are 2 switches and 1 knob on the control panel located on the face of the RH aluminium box section:-

- **'Auto/manual'**: In the 'Auto' position the stepper motor is under control from the PC through the serial interface on the stepper motor controller. In the 'Manual' position the stepper motor is controlled by the knob on the control panel. In the 'Auto' mode both the speed and direction of movement are controlled from the PC. On MSCL Serial #39 onwards the auto/manual switch has been made into a "smart" switch by linking it to the microprocessor. In this way whenever the software 'assumes' that the switch is in the 'auto' position it can now check and prevent the user proceeding until it is set appropriately. This prevents user errors occurring by starting the logging process when in 'manual' and hence losing reference between the position the computer 'thinks' the pusher is at and the actual pusher position.
- **'Motor 1/Motor 2'**: The 'Motor 1' position is for controlling the height of the vertical (or acoustic motor). This controls the upper PWT height as well as the height of the MS point sensor. The track stepper motor is controlled when the switch is in the 'Motor 2' position. During normal operation this switch should be kept in the 'Motor 2' position to help prevent accidental manual movement of the vertical motor after it has been set.
- **'Speed <---- / ---->'**: This knob controls both the direction and speed of the core pusher system when in the manual mode. It has no effect in the 'Auto' mode. Note that the motor will stall if it is started at too high a speed. The red lights indicate the direction of travel and the centre stop position.

3.2.6 Changing the orientation of the sensor plate.

For high quality cores (where the sediment completely fills the liner) the axis of measurement through the liner does not effect the measurement in any way. However, there are circumstances when the user may wish to log whole cores where the sediment does not completely fill the liner. This can occur with very soft sediments and with cores where the core is cut a little smaller than the ID of the liner. Under these

circumstances it is better to log whole cores with the P Wave and gamma attenuation measurements oriented horizontally. To accommodate this requirement on the split core logger (where the normal measurement orientation is vertical) an adapter sensor plate can be provided which enables the horizontal logging to be made.

To change from a vertical mode to a horizontal mode follow the instructions provided below.

- a) Remove the following parts from the centre sensor section:
 - Gamma Source and delrin bracket
 - Perspex cover
 - Short rail above the gamma detector
 - Short rail to left of P Wave transducers
 - Gamma Detector and delrin brackets
 - Delrin sleeper and support
 - Upper P Wave assembly and vertical drive mechanism
 - Lower P Wave assembly
- b) Remove the two aluminium back plates from the centre section.
- c) Remove the Gamma Source support plate from between the 2 upright side plates.
- d) Fix the 2 long feet with adjusting pillars attached to the side plates
- e) Fit to the sensor plate;
 - the spring loaded rear P Wave assembly
in both cases ensure that the transducers are correctly sprung
 - the front P wave assembly
 - the delrin brackets for holding the gamma source and detector
- f) Lower the horizontal sensor plate into position with the LH side plate through the large slot in the plate. Locate on the delrin pillars.
- g) Adjust the pillars to ensure that the plate is horizontal and the load is spread evenly between all 4 pillars.
- h) Locate the gamma source and gamma detector onto the brackets and secure with the top halves.
- i) Re fit the short rail sections
- j) Adjust the positions of the P Wave transducers to suit the core.
- k) Fit the horizontal perspex cover between the gamma source and detector and check that the core is free to move between the sensors.

3.2.7 Setting up (pre logging checks)

It is valuable at this stage have 1 or 2 lengths of core together with an empty length of similar core liner.

- Ensure that the correct rails are fitted for the size of core to be logged and that they and the core liner are clean.
- Check that the belt is suitably tensioned.
- Use the 'Manual' control to ensure that the core pusher and core section moves freely in both directions with the PWTs and MS point sensor well clear.
- Check that the LH and RH limit switches on the track function correctly when the core is moving by trial and error. Reverse the connections on the rear connector panel if incorrect.
- Use the 'Manual' control to ensure that the vertical slide moves freely in both directions.
- Check that the limit switches on the vertical slide functions correctly when the slide is lowered and the PWT contacts the core.

3.3 Gamma density

3.3.1 Operating principle

A gamma ray source and detector are mounted across the core on a sensor stand that aligns them with the centre of the core. A narrow beam of gamma rays is emitted from a Caesium-137 source with energies principally at 0.662 MeV. These photons pass through the core and are detected on the other side. At this energy level the primary mechanism for the attenuation of gamma rays is by Compton scattering. The incident photons are scattered by the electrons in the core with a partial energy loss. The attenuation, therefore, is directly related to the number of electrons in the gamma ray beam (core thickness and electron

density). By measuring the number of unscattered gamma photons that pass through the core unattenuated the density of the core material can be determined.

To differentiate between scattered and unscattered photons the gamma detector system only counts those photons that have the same principal energy of the source. To do this a counting window is set which spans the region of interest around 0.662 MeV.

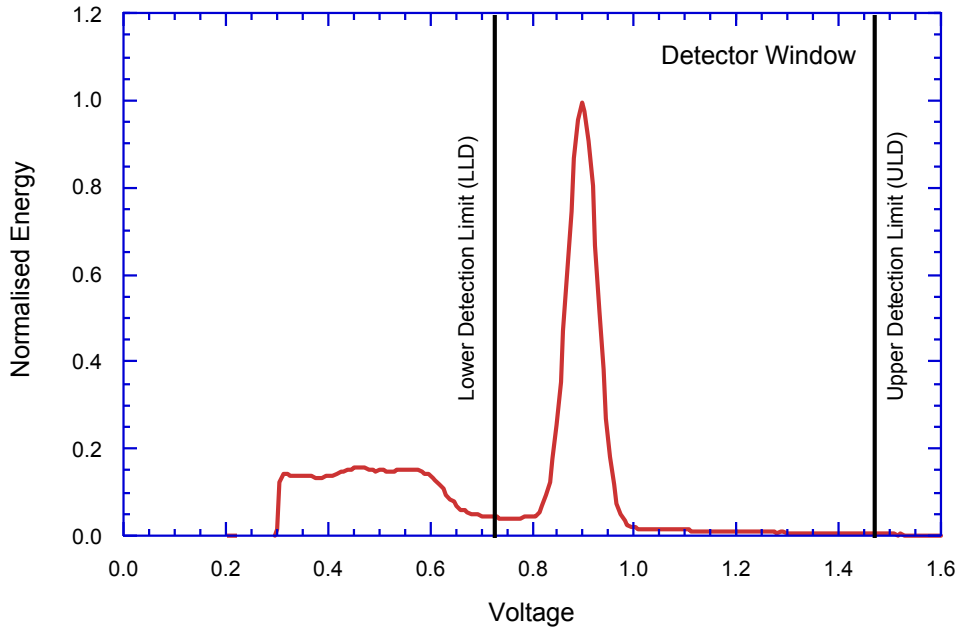


Figure 5. Gamma spectrum showing the ^{137}Cs peak and the detector counting window.

3.3.2 Gamma Ray Source

A 10 milli-curie Caesium-137 capsule (active element CsCl) is used as the gamma ray source. ^{137}Cs has a half-life of 30.2 years and emits gamma energy principally at 0.662 MeV.

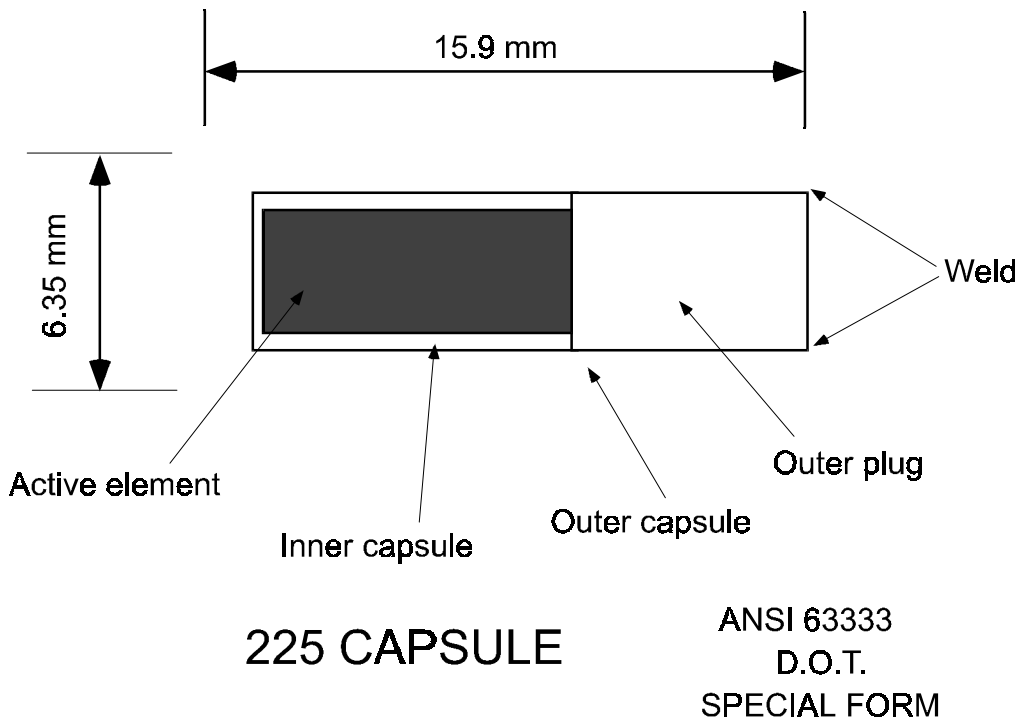


Figure 6. Caesium Source Capsule.

The small Caesium capsule is securely housed inside a 150 mm diameter lead filled, 3 mm wall stainless steel container. The design restricts the radiation at the surface of the container to less than 7.5 $\mu\text{Sv/h}$.

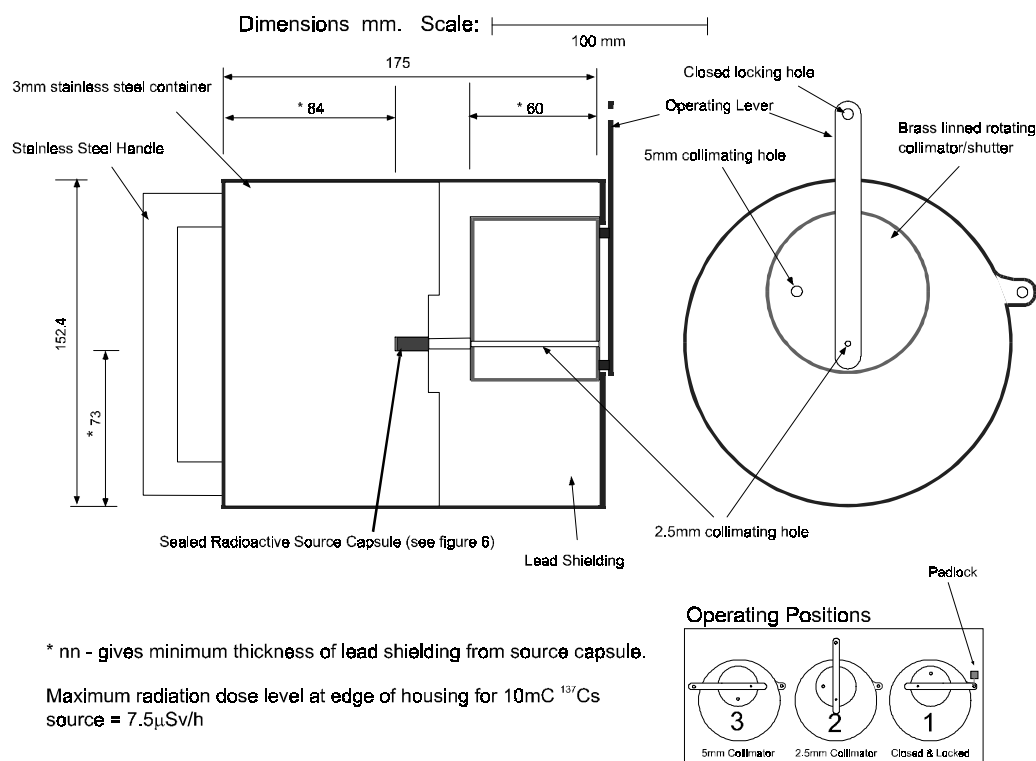


Figure 7. Gamma Source Shield.

The gamma beam is collimated through a choice of 2 collimators (5 and 2.5mm diameter) in the rotating shutter at the front of the housing. The shutter has three operating positions; 2 for the use of different diameter collimators and 1 which closes the beam.

- Position 1. Source closed.**
- Position 2. 2.5 mm collimator open**
- Position 3. 5.0 mm collimator open**

In position 1 a padlock can be inserted for security purposes when the equipment is not in use or is being transported.

The collimating holes permit a narrow beam of gamma rays to be emitted from the source, through the core sample to the detector opposite. The source should always be closed and locked when not in use and when being removed or installed in the apparatus.

Unless a spatial resolution of less than 5 mm is required then the 5 mm collimating hole should be used to minimise the counting time needed to obtain accurate data.

3.3.3 Gamma Ray Detector

The gamma ray detector comprises a scintillator (a 2" diameter and 2" thick NaI(Tl) crystal). and integral photo-multiplier tube. The tube also contains the internal high voltage supply and electronics to window the primary gamma rays (0.662 MeV). Pulses from the detector unit are sent continuously to a counter board in the main electronics rack. The count period and count rate are determined through the software control and the internal microprocessor.

The whole detector unit is mounted inside a 150 mm diameter stainless steel housing. Internally this consists of lead shielding at the front, a central nylon tube that holds the detector and a lead back-plate through which the connecting cable passes. The lead shielding around the detector is designed to attenuate scattered gamma photons and reduce the radiation level around the equipment to very safe levels.

It is recommended that the detector is always kept in its housing (even during shipping) as the housing provides mechanical and thermal protection to the sensitive components. If the detector has to be removed from the housing then the following procedure should be followed:

- Remove the short rail above the detector and fix the handle to the top of the housing. Remove the upper clamp and lift the complete assembly clear of the centre section taking care to ensure that the cable is free.
- Lay the housing on a padded bench (be careful to ensure that it can not roll) and remove the locating screw at the rear in the side of the housing and loosen the opposite screw (located in the slot).
- Carefully withdraw the rear lead back-plate and nylon tube revealing the PMT that can then be disconnected and removed.



To install the detector into the housing, reverse the above procedure.

3.3.4 Gamma System Testing

The gamma counting electronics can only be tested when the utilities software is running (see Chapter 6). Set the gamma count time to 1 second and check the count rate with the gamma source shutter in all 3 positions through air. Depending on the system the following (very approximate) count rates should be obtained.

Position 1.	Source closed.	Approx. 50-200 CPS
Position 2.	2.5 mm collimator	Approx. 5000-10000 CPS
Position 3.	5.0 mm collimator	Approx. 25000-35000 CPS

The detector should not be exposed to very high count rates, for example when the 5 mm collimator is open and no sediment core or calibration piece is in the path of the gamma beam. Exposure of the detector to very high count rates will increase the slight drift of count rate that occurs with time and temperature and this should be avoided to ensure high quality data.

3.4 P-Wave Velocity System

The Ultrasonic P-wave system measures the P wave velocity through the core. The P-Wave Transducers (PWTs) are mounted on the centre sensor stand with the gamma system. The upper PWT can be mounted on the vertical slide which is raised or lowered by the 'Motor 1' stepper motor. When logging whole cores the position of the slide can be fixed during the logging process. When logging split cores the upper PWT is lowered onto the split core surface to take a measurement and raised prior to the core moving to the next increment along the track. This operation is carried out automatically by the PC once the displacement transducer calibration exercise has been carried out (see Chapter 7). When logging whole cores both PWTs are spring loaded against the core liner.

3.4.1 The P-Wave Transducers

There are two types of P-Wave Transducers available with the GEOTEK MSCL:

- 1) Old style stainless steel 'Piston' transducers
- 2) New style oil filled Acoustic Rolling Contact (ARC) transducers

'Piston' Transducers

The two PWTs are similar, apart from the mountings. The receiver is normally mounted on the lower bracket, and the transmitter is mounted on the upper vertical slide. Connection between the rear of each transducer is made to the transmitter and receiver electronics modules (Tx and Rx) at the rear of the sensor stand.

The active element of each PWT is a thickness mode 500 kHz or 250 kHz piezo-electric crystal, which is mounted in epoxy resin and housed in a stainless steel cylinder. Each PWT acts as a spring-loaded piston within a bronze sleeve. This arrangement is mounted within the plastic housing. Using these transducers in the horizontal mode both PWTs should be sprung so that they press against the core. To avoid any

disturbance to the core surface during split core logging the spring must be removed from the upper transducer housing when in the vertical mode.

ARC Transducers

These transducers have been designed so that they can be used on older bench mounted systems and so are interchangeable with the old style piston transducer housings. The active element is a piezo-electric crystal, mounted on the central spindle of the rolling transducer, surrounded by oil and encapsulated in a soft epoxy sheath. The PWTs are mounted on spring loaded linear slides in a plastic housing. The main advantage of these transducers is vastly improved acoustic coupling characteristics. Also, a new active element has been incorporated to enhance the frequency content of the transmitted pulse. Connection to the Tx and Rx boxes, located at the rear of the main sensor stand, is made at the top of the central spindle.

Waveform Storage

Using a 'virtual' oscilloscope (see section 3.4.7) waveforms from the PWTs can be stored or printed. If waveforms are to be stored for subsequent analysis (e.g. spectral analysis) then the raw signal should be recorded and not the amplified signal that is used by the microprocessor for calculating P Wave travel times. Therefore, it is recommended that for logging P Wave velocity the amplified signal should be used, i.e. through the Rx box and the main electronics rack. For waveform storage, however, the raw signal should be used, and no P Wave velocity logging conducted. To do this a separate lead will be required to connect the receiving transducer directly to the virtual scope inputs on the left hand side of the rack mounted PC. In this mode the amplifier and microprocessor are bypassed precluding P Wave travel time logging.

3.4.2 Operating principle

A short P-wave pulse is produced at the transmitter. The length and repetition rate of this pulse can be adjusted to suit the type of the transducer elements supplied (see Chapter 3 Appendix). This pulse propagates through the core and is detected by the receiver. Pulse timing circuitry is used to measure the travel time of the pulse with a resolution of 50 ns. The distance travelled is measured as the outside core diameter with an accuracy of 0.1 mm. After suitable calibration procedures have been followed (see Chapter 7) the P-wave velocity can be calculated with a resolution of about 1.5 ms^{-1} . The accuracy of the measurements will largely depend on any variations in liner wall thickness. However, experience has shown that an absolute accuracy of $\pm 3 \text{ ms}^{-1}$ is normally achievable with some care.

3.4.3 Acoustic Coupling

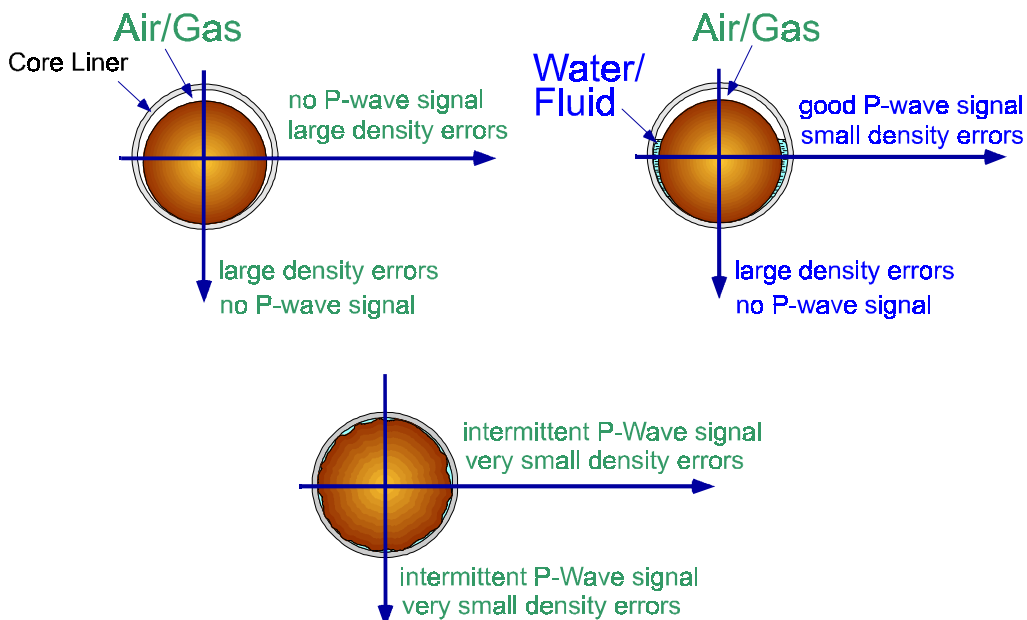


Figure 8. Horizontal vs. Vertical acoustic coupling.

It is essential to maintain a good acoustic coupling between the transducer faces and the core liner. This is achieved by wiping the core liner with a wet sponge prior to logging and dropping a few drops of distilled water onto the contact points. A very small amount of detergent in the water can sometimes help the wetting characteristics, which depends on the core liner material. When using the ARC transducers there is no need to wet the core liner as the acoustic coupling is greatly improved. This normally provides a good acoustic

contact for the complete traverse of the core section. It should be noted that a good acoustic coupling is also required between the sediment and the liner. Consequently, when logging whole cores, only high quality cores where the liner is full of sediment will provide consistently good data. Figure 8 illustrates this problem and associated problems caused in density logging.

This problem can be partially overcome by reorienting the P Wave and gamma sensor systems into a horizontal orientation, (see Chapter 2).

For horizontally split cores it is necessary for the upper PWT to be lowered onto the split surface at each measurement increment. To avoid contamination along the core in soft sediments it is normal to cover the split surface with a layer of thin plastic film ('clingfilm', 'gladwrap' etc.). A few drops of water spread along the surface of this film will provide the acoustic contact necessary. With rock cores water is needed both on the top surface of the material and in the bottom of the liner to maintain good acoustic contact.

3.4.4 Pulse Timing

The accuracy of the measurement system revolves around the principle by which the pulse timing circuitry operates. Although a manual system can use the first break to time the onset of the signal, an automated system needs a more electronically definitive technique for consistently good measurement resolutions. Consequently, the automated P-wave measuring system uses an easily identifiable zero crossing to measure the travel time of the pulse. In this way the timing is very insensitive to signal amplitude which can vary by as much as 60 dB depending on the sediment type.

A threshold detector determines the first negative-going excursion on the received pulse. The pulse timing is achieved by measuring the time to the first zero crossing after threshold. In this way the travel time measured is approximately one wavelength after the start of onset of the pulse but is measured without any errors caused by signal amplitude. Obviously a good calibration technique is required to ensure and maintain accuracy (see Chapter 7).

The transmitter pulse is sent to the transmitter transducer that generates an ultrasonic compressional pulse at 250 kHz or 500 kHz. This pulse propagates through the core and is detected by the receiver and is amplified by the AGC (automatic gain control) producing the received signal. A delay pulse is generated by the system after the transmit pulse has been sent. The delay time is set by the thumb-wheel switch and should be a few microseconds less than the travel time for the beginning of the received pulse. The negative-going edge of the delay pulse 'Delay' should be used to trigger the oscilloscope. A gate pulse is generated (set by the thumb-wheel switch) after the set delay time, during which period a peak detector measures the amplitude of the incoming signal. The AGC operates from this peak detector. A threshold detector detects any negative excursions below a set threshold level and can be monitored through the 'Threshold' output. A zero crossing detector detects all zero crossings and can be monitored through the 'Zero Crossings' output. The count pulse, which is the signal required, is triggered as the 1st zero crossing after the threshold has been exceeded. In practice, it is necessary to check that the 'Count' pulse consistently aligns itself with the designated part of the received pulse.

On MSCL systems Serial #0-38 thumbwheel switches 'Delay' and 'Gate', for controlling the P-Wave velocity measuring system, were incorporated into the main electronics panel enabling the user to set these parameters manually. In MSCL Serial #39 onwards these thumbwheel switches have been removed and replaced with software selectable settings. The settings for Delay and Gate can be set in the 'Settings file' and can be changed at any time during logging by accessing the 'Advanced Panel' when logging is paused (see section 5.5). It should also be noted that at the same time as removing the thumbwheel switches the LCD displays for 'Travel Time' and 'Core Diameter Deviation' have also been removed. These values are now accessible through the software only. The routine for setting up the core diameter deviation has also been simplified and is applicable to all logging systems (see section 5.4.1).

3.4.5 Setting up Signal levels

Check that the transducers move freely in their housings against the spring pressure.

- a) Position a water filled test core between the 2 PWTs and adjust the position of each transducer. If the PWTs are mounted horizontally (on a whole core logger) then the transducers should be positioned so that they are about in their mid travel position.
- b) Wipe the core liner with a wet sponge or cloth and drop a little water onto the contacts between the transducer faces and the core liner to provide a good acoustic coupling (not necessary with ARC transducers). Do not over-wet the system, it does not help!

- c) Connect the dual beam oscilloscope or the virtual scope to the front panel of the P-wave electronics using BNC cables provided. With the dual beam oscilloscope use 'Delay' as the negative trigger pulse, 'Signal' on channel 1 and 'Count' on channel 2. Set the Delay to 0 and set up the oscilloscope to clearly display the received signals. A large pulse should be clearly visible on channel 1. If the user is unfamiliar with the use of the dual beam oscilloscope then see section 3.4.6. When using the virtual oscilloscope swap the BNC cable from 'Delay' to 'Count' (see section 3.4.7) and miss out the next step.
- d) Increase the delay time (for the dual beam oscilloscope) and adjust the time base on the oscilloscope until the direct pulse is expanded and clearly visible on the screen. The bar graph amplitude display should read >7 across a water core (Serial # 0-38).

Signal and Pulse Timing

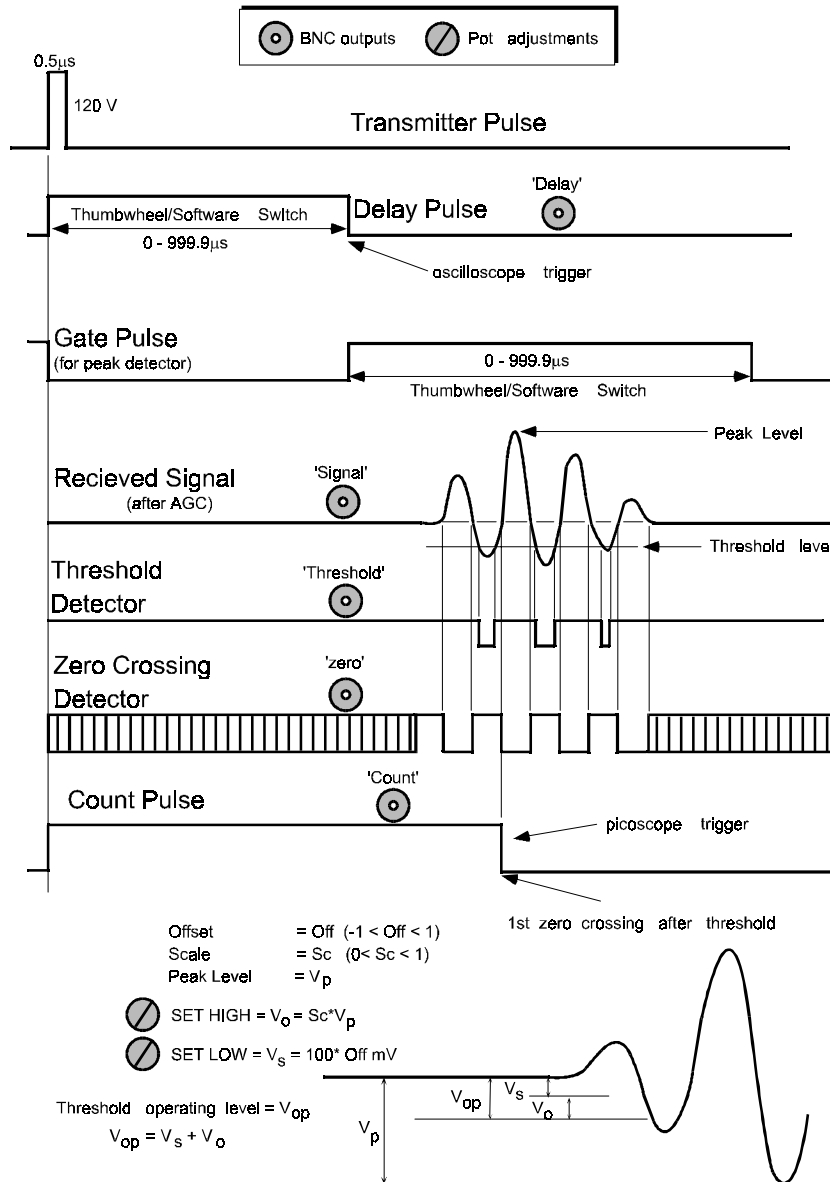


Figure 9. Signal and Pulse timing diagram for the P Wave system.

- e) Check that the count pulse occurs at the zero crossing following the first negative excursion (see Figure 9). If not, the 'scale' and 'offset' adjustments for the threshold detector need resetting. Note that the threshold and zero crossing pulses can be monitored directly from the front panel.
- f) Remove the water core and observe the transmission through air. Check that the count pulse occurs at the zero crossing following the first negative excursion (see Figure 9). If not, the 'scale' and 'offset' adjustments for the threshold detector need resetting.

- g) Check that the travel time shown on the LCD (Serial # <39) or in the MSCL Utilities software (Serial # >38) is in approximate agreement with the travel time shown on the oscilloscope.
- h) Use the test panel in the MSCL Utilities software (see Chapter 6) to check that the travel time is in agreement with the LCD (Serial # <39). Small differences can occur but it should be noted that the computer value is more accurate (0.05µs) than the LCD display (0.1µs).

Adjusting Threshold Voltage Level

The threshold voltage level has been adjusted prior to delivery. However the following should be used as a guide to reset or adjust the threshold voltage level (should it become necessary) using the 'scale' and 'offset' pots (refer to Signal Timing Diagram). The purpose of these adjustments is to ensure that the threshold operating level V_{op} consistently picks first -negative excursion over as wide an amplitude range as possible.

With a large signal (through water or preferably a mud core) adjust the 'Set High' so that the threshold operates just on the first -negative peak.

With a very small signal (through air with the transducers at their closest position) adjust the threshold operating voltage using 'Set Low' such that the threshold operates above the noise level but detects the first real negative excursion. Repeat this procedure until the threshold operates correctly over the entire range of signal levels.

- i) Check that the signals remain fairly constant whilst the core is moving right to left past the transducers (remember to wipe the core liner with a wet sponge or drop a little water on the transducer faces, not required for ARC transducers).

3.4.6 Using the Dual Beam Oscilloscope

If the dual beam oscilloscope is unfamiliar to the user then the following notes will help to get started.

- Connect the P-wave electronics to the oscilloscope using the 'BNC' cables provided.
 - Connect 'Delay' to the external trigger input.
 - Connect 'Signal' to Channel 1 input
 - Connect 'Count' on Channel 2 input
- Set the following on the P-Wave electronics thumbwheel switches/in the MSCL Utilities software;
 - SET DELAY to 0000
 - SET GATE to 5000
- Set the following on the oscilloscope;
 - TIME/DIV 5 ms/DIV
 - CH1 VOLTS/DIV 0.5V
 - CH2 VOLTS/DIV 0.5V
 - CH1 AC GND DC DC
 - CH2 AC GND DC DC
 - MODE ALT
 - TRIG MODE NORM
 - TRIG SOURCE EXT
 - LEVEL PULL -SLOPE
- Adjust the trigger level so that 2 traces are seen on the screen
- Adjust horizontal and vertical position of traces.
- Set intensity, focus and illumination controls.
- Expand the time base (TIME/DIV) to allow the details of the pulse to be seen clearly (5 µs/DIV)
- Increase the DELAY to move the pulse to the left side of the display if necessary.
- Adjust CH1 VOLTS/DIV as necessary.

3.4.7 Using the 'Virtual' Oscilloscope

The 'virtual' oscilloscope is mounted within the electronics rack, at the side of the rack mounted PC. Software is used to control the functions of the scope and the traces are displayed on screen. To start the program click on [**Start-Programs-Pico Technology-Picoscope for Windows**]. Once the program has started an oscilloscope window will appear on the screen within the program window. You should adjust the size of the program window so that you can view the oscilloscope traces whilst you are logging your cores (i.e. whilst the MSCL Core Logging Software or MSCL Utilities is operating).

Whilst you are logging cores with the MSCL Core Logging Software you will only need to use the Picoscope in one of two modes.

- 1) As an observational tool to ensure the logger is receiving high quality signals as with the dual beam oscilloscopes supplied with older loggers.
- 2) In a recording mode where the signals can be observed and recorded to disk at the users command.

For more comprehensive set of information on the virtual oscilloscope and the Picoscope software use the online software help (Help menu item).

The Picoscope software will run whilst either of the MSCL applications are running so simultaneous monitoring of logger activity and signal quality can be conducted.

- Connect the P-wave electronics to the oscilloscope using the 'BNC' cables provided.
 - Connect 'Count' to the Channel 2 input.
 - Connect 'Signal' to Channel 1 input
- Set the following on the P-Wave electronics thumbwheel switches/in the MSCL Utilities software;
 - SET DELAY to 0000
 - SET GATE to 5000
- Set the following in the software interface. The timebase (x) and y scale options are displayed at the top of the screen and the trigger setup is displayed at the bottom of the scope window;
 - X-scale 20 μ s/DIV
 - Ch A scale \pm 1 V and x1
 - Ch B scale \pm 500 mV and x1
 - TRIG MODE AUTO
 - TRIG SOURCE Ch B
 - LEVEL 120 mV and Falling
- Adjust Channel A and B scales as necessary.
- Channels A and B are displayed in blue and red respectively.
- Adjust the timebase on the virtual oscilloscope as required
- Adjust the +/- display button to show any signal before the trigger point.
- Adjust the vertical position of traces using the scroll bars.

To view part of the trace before the trigger point: at the far right of the trigger setup options is a box indicating the percentage of the screen displayed before the trigger point, adjust as necessary.

Other signals can be viewed by swapping the 'COUNT' BNC plug to the relevant BNC socket, e.g. THRESHOLD or DELAY. Ideally, during logging the user will use the Picoscope for monitoring the signal quality and the count integrity so the best setup then would be to trigger using the COUNT. To view the ZERO signal (where the p-wave signal crosses the zero line) use the p-wave signal to trigger off; trigger source =Ch A and level = 50mV Rising.

Recording Signal Data to Disk

To save the signal to disk click on [**File-Save as**]. A dialogue box will appear into which a file name must be typed. There is a choice of file formats as follows:

- *.PSD The applications own data format. Saves signal and spectrum traces.
- *.TXT An ASCII output of the signal data. Saves signal data only.

*.PSS The applications settings file that records all the trigger and scale settings.

The data displayed on screen is saved to the specified file. There are 2500 data points in each trace. If two traces are displayed both will be saved. The *.TXT format saves two columns of data, channel A first then channel B.

Note: If triggering off the falling side of the delay pulse and the DELAY thumbwheels are set to greater than 0000 then the user must make a note of the value and use it to adjust the recorded signal in any subsequent analysis.

Spectral Analysis

A limited spectral analysis is available within the oscilloscope control software. The signal data are reduced to 1024 points for spectral analysis. The setup options for the Spectrum window appears at the top of the screen when the Spectrum window is active. To eliminate any aliasing effects it is advisable to set the frequency scale to the smallest possible range (1.5 MHz is suitable for most applications). The scales for channels A and B set the amplitude window that is analysed, if set to Auto (recommended) the entire signal is analysed. If a range is selected that is smaller than the signal amplitude then the analysis will clip the extremes of the signal giving an erroneous spectrum. Both channels can be analysed simultaneously.

3.5 Core Thickness Measurements

3.5.1 The Transducers

The thickness or diameter of the core is measured as the distance between the active faces of the two PWTs. This is achieved by mounting a rectilinear displacement transducer (DT) on each of the PWT mountings. Each DT is coupled to the moving PWT via a bracket at the rear end of each transducer. In this way each DT precisely follows the movement of each PWT. In practice the core thickness is measured with reference to a known thickness and it is the deviation from that reference thickness that is recorded.

The 2 DTs are wired together in such a way that equal movements in the same direction produce no change in reading. Only real changes in total offset are recorded. The total travel of each transducer is only 20 mm, hence they must be mounted so that the travel matches that of the PWT.

3.5.2 Setting up

The upper P-wave transducer is free to move approximately 25 mm in the motor driven housing. The movement in the housing is measured using the upper displacement transducer. The lower P-wave transducer is spring loaded in the lower housing and is free to move approximately 15 mm which is measured by the lower displacement transducer. The output of the two displacement transducers provides the core diameter deviation LCD reading on the MSCL front panel (Serial #0-38) and in the MSCL Utilities software. The actual core diameter (thickness) is a function of both the core thickness deviation and the position of the upper motor housing.

During the automated logging procedure the user will be prompted to insert a reference piece between the transducers. It is important to make up reference pieces (from aluminium or plastic) which closely correspond to the size of core being logged.

For Whole cores:

Make a round bar, approximately equal in diameter (within 1mm) to the nominal (outside) core liner diameter.

Split cores:

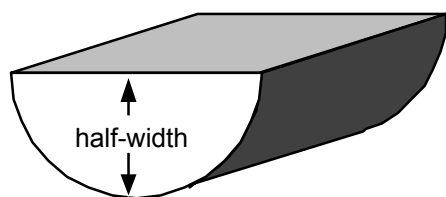


Figure 10. Core half width.

Make a semi-cylindrical piece to simulate the sediment or rock with the nominal or anticipated average core half-width. Fit this piece into a short length of split core liner.

Split core logging (vertically arranged transducers)

In this logging mode the vertical motor moves up and down between successive measurements. To ensure that the automated zeroing and measurement procedure works correctly during logging it is essential to carefully follow the set up procedure described below (in version 4.2 of the MSCL Software the user is prompted through this procedure for both split and whole cores).

- a) Put the “Auto/Manual” switch to “Manual” and the motor select switch to “Motor 1”. Using the manual motor control raise the upper transducer to ensure that it is clear of the reference piece.
- b) Place the appropriate reference piece on the rails between the P-wave transducers. The reference piece must have a precisely known thickness. This thickness is entered in the “Processed Data Display” as the “Reference Core Thickness” value in order to accurately compute core thickness.
- c) Manually adjust the lower transducer housing so that the spring-loaded P-Wave transducer is touching the lower part of the reference piece and is approximately mid-way in its travel. This can be confirmed by watching the LCD core diameter deviation display (Serial # <39), observe the maximum and minimum readings and adjust so that the reading is approximately mid-way.
- d) Raise the motor so that it is well clear of the core

Whole core logging

- a) With the reference piece in place, manually adjust the position of both P-Wave housings transducer so that the P Wave transducer is approximately mid-way in its travel
- b) Secure the position of the housings and leave in this position.

Use the test panel in the Utilities software (see Chapter 6) to check that the core thickness recorded is in agreement with the LCD (Serial # <39). Small differences can occur but it should be noted that the computer value is more accurate.

3.6 Magnetic Susceptibility

Two sensors are available, a point sensor for split cores only and a loop sensor for whole or split cores. Ordinarily only one sensor may be used at a time.

Loop Sensor: The Bartington loop sensor (MS2C), ruggedised for GEOTEK applications, is used for magnetic susceptibility measurements on whole cores. It is available in a range of internal diameters and is mounted between the two main box sections in such a way that no magnetic or metallic components come close to the sensor. For maximum resolution of magnetic susceptibility the loop-diameter/core-diameter ratio should be as small as possible. Hence for small diameter cores some data degradation may occur and a smaller magnetic susceptibility loop may be desirable. A wide range of internal diameters can be substituted to optimise the core diameter to loop size, please contact GEOTEK if you wish to obtain additional loops.

Point Sensor: The Bartington point sensor (MS2E) is mounted on an arm suspended from the upper PWT housing. This allows the sensor to be placed on the core surface for each measurement. It uses the same electronics as the loop sensor. Note that the original point sensor (MS2F) required an interface box that is placed in the line from the sensor to the MS2 electronics. This sensor can only be used at a sampling rate of 1.0 Hz (1 s period).

The point sensor gives much higher spatial resolution but is less sensitive. Its field of influence is about 1 cm in diameter and so it cannot be used on whole cores. It is also more sensitive to temperature fluctuations, so care must be taken to stabilise the temperature of the system and core before logging.

3.6.1 Operating principle

An oscillator circuit in the sensor produces a low intensity (approx. 80 A/m RMS) non-saturating, alternating magnetic field (0.565 kHz). Any material in the near vicinity of the sensor, that has a magnetic susceptibility, will cause a change in the oscillator frequency. The electronics convert this pulsed frequency information into magnetic susceptibility values. For further details refer to manufacturer’s documentation.

3.6.2 Setting up

- Ensure that the MS sensor does not obstruct the core.

- Switch the MS meter on at least 5 min. before testing. The system needs to warm up to minimise drift.
- Without a core present choose either the 0.1 Hz or 1.0 Hz sampling rate and zero the meter. This can be done either with the push buttons for a single reading, or by using the toggle switch for a continuous cycle mode (see MS manual).
- Run an empty core liner using the core pusher through the MS sensor with the MS meter on cycle mode. No significant change in readings should occur as there are no moving magnetic parts.
- **Note:** When making MS measurements ensure that no magnetically susceptible materials are near the sensor (including wrist watches!).
- **Note:** Because of the potential drift in the MS sensor and electronics, zero readings should be taken at the start and finish of each core section and appropriate calibrations made to the data.
- Use the test panel in the Utilities software (see Chapter 6) to check that MS value recorded is in agreement with the MS2 meter display.

3.7 Temperature Measurement

A standard PRT (platinum resistance thermometer) probe is used to measure temperature. The probe is connected to a long flying lead that can be most conveniently inserted into the end of each core section as it is loaded onto the RH section. It is most important for accurate velocity measurements in sediments because velocity changes by approximately $3 \text{ ms}^{-1} \text{ } ^\circ\text{C}^{-1}$.

To test the thermometer place it in a beaker of water at a known temperature and use the test panel in the Utilities software (see Chapter 6) to check that the reading is accurate.

3.8 Logging Computer

3.8.1 Rack Mounted Computer

On more recent loggers a rack mounted PC has been installed with a virtual oscilloscope, replacing the dual beam oscilloscope in the electronics rack. The front panel houses the on/off switch and reset button and gives access to the 3.5" disk drive and CD-ROM drive. The user should connect the peripherals to the ports on the rear of the PC.

The two inputs for the 'virtual' oscilloscope are found at the rear of the PC.

3.8.2 Loading the MSCL Software

To operate the MSCL under the WindowsTM environment the user must set up the computer using the 'MSCL for WindowsTM installation' disk provided. The MSCL software runs under Windows 95/98/2000TM.

Windows 95/98/2000TM

Insert the 'MSCL for WindowsTM installation' disk provided into drive d:

Choose RUN from the START menu and type **d:\install\setup**.

Note: d is the drive letter of your CD-ROM.

The install procedure will now take place ensuring that all the appropriate files are created. Note that if any of the files are already present they will automatically be overwritten.

The installation procedure creates a directory: C:\GEOTEK\ where the main application (*.exe) programmes and associated files are stored.

3.8.3 The MSCL Software File Structure

The installation disk should include the following files:

- 1) **Files for installing the software:**
SETUP.EXE (run this file to start the installation)
- 2) **Visual Basic Support Files** - these are necessary for the software to run:
CTLHPUSHERSLIDE.OCX
CTLVPUSHERSLIDE.OCX

TABCTL32.OCX
MSFLXGRD.OCX
DBLIST32.OCX
DBGRID32.OCX
COMDLG32.OCX
COMCTL32.OCX
COMCT232.OCX
MSINET.OCX
RICHTX32.OCX
RICHE32.DLL
MSCHART.OCX
MSWINSCK.OCX
MSMAPI32.OCX
MCI32.OCX
PICCLP32.OCX
SYSINFO.OCX
MSCOMM32.OCX
MSMASK32.OCX
LTTWN12N.DLL
LFBMP12N.DLL
LFCMP12N.DLL
LTDIS12N.DLL
LTEFX12N.DLL
LTFIL12N.DLL
LTIMG12N.DLL
LTKRN12N.DLL
LTOCX12N.OCX

- 3) **MSCL application files.** One or more of the following files will be included on the disk. The installation program will install all the files that it finds on the disk. Thus if you do not wish to install one of these files, e.g. the DEMO program, then simply remove it from the installation disk.

MSCL6_0.EXE - the main logger program.
UTIL6_0.EXE - the utility program.
MSCLD6_0.EXE - the demo logger program.
MSCL6_0.SET - the logger settings file.
MSCL6_0.I52 - the I52 program.
CAM6_0.EXE – the digital imaging program.

Digital Imaging support files

RAWRGB.EXE
ACQIMG.EXE
WHICAL.EXE
DCCON.EXE
CAM5_2.INI
WHICAL.PIF
RAWRGB.PIF
ACQIMG.PIF
DCCON.PIF

The installation procedure overwrites, without prompting, any of the above files already residing on the PC. The main application programmes uses the following files.

- 1) **mscl6_0.set.** is located in the C:\Geotek directory and contains the settings information (track length, sensor offsets, etc.) for a specific logger. It also contains other general operational settings such as serial port for communication with logger.
- 2) **msclwin6_0.ini** is located in the C:\Geotek directory and contains the logging configuration settings, e.g. sampling interval; processing parameter values; and default graph settings of the last core logged. Logging parameters are those for the last section logged. It is used to provide the new default values when a new core is logged and is updated when logging ends.

3.8.4 Installing the Picoscope Virtual Oscilloscope Software

To operate the Picoscope 'virtual' oscilloscope under the WindowsTM environment the user must set up the computer using the Picoscope installation disk provided. The Picoscope software runs under both Windows 3.1TM and Windows 95/98/2000TM.

Windows 3.1™

- a) Run the Windows 3.1™ application: **C:\Win**
- b) Insert the Picoscope installation disk provided into drive D:
- c) Using the file manager find and double click on **[setup.exe]** in the picoscope directory.

The install procedure will now take place ensuring that all the appropriate files are created. Note that if any of the files are already present they will automatically be overwritten.

Windows 95/98/2000™

- a) Insert the Picoscope installation disk provided into drive D:
- b) Choose RUN from the START menu and type **d:\picoscope\setup**.

The install procedure will now take place ensuring that all the appropriate files are created. Note that if any of the files are already present they will automatically be overwritten.

The use of this software in conjunction with the GEOTEK MSCL logger is described in section 3.4.7. The online help describes the use of the Picoscope in detail. Updates for the Picoscope software are available from their website (<http://www.picotech.com/download.html>).

4. Core Logging - Quick Start

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4.1 Chapter Overview

The purpose of this Chapter is to provide the user with a short-form guide to automated core logging. It first describes the principles and numbering conventions used in automated core logging together with notes on the variations between different types of systems. This is followed by a short-form guide providing step-by-step instructions of how to perform automated logging using the main application software. It is aimed at the new user who needs simple operational instructions on how to operate the system in an automated fashion. For a detailed description of all the software facilities available the user is referred to Chapter 5. To calibrate the various sensor systems the user should refer to Chapter 7.

The MSCL operating software is Windows™ based. It is a user-friendly application that both acquires raw data and processes the data in real time. It presents the data graphically but also enables the user to view a table of data. The same application can also be used to view and process previously collected data (old data).

In addition to the main operating and processing application there is an associated utilities programme. This enables the user to run tests of individual sensor systems and to set important configuration parameters specific to the users system. Within this utilities application there is also a terminal mode option that enables the advanced user to edit/modify the software in the microprocessor. Details of this application can be found in Chapter 6.

4.2 Numbering and Depth Conventions

It is necessary when logging core material in a “continuous” fashion to follow a numbering convention. The most commonly used convention has been adopted for the MSCL software. A “core” consists of a number of adjacent “sections”. Section 1 is deemed to be at the top of the core and all subsequent sections (2,3,4 etc.) are assumed to be adjacent to each other. There is no limit to the number of sections that make up a core and each section can be any length although they are normally cut into nominal section lengths (normally 1.0 m or 1.5 m). Initially (as raw data is collected) the sub bottom depth is calculated assuming that the top of section 1 has a sub bottom depth of zero. All other sub bottom depths are automatically calculated assuming that all other sections are sequentially logged and adjacent to each other. In the processed data the sub bottom depth can be recalculated by assigning a value to the top of section 1 (sub bottom depth offset) and by assigning a butt error distance. The butt error distance is the increase in length caused by the addition of end-caps that are normally placed around the end of the core liners on each section. This is described in more detail in Chapter 5.

4.3 General Logging Principles

Whilst most logging principles are common between the different generation and types of core loggers there are some subtle differences that occur depending on which track type is being used. The track types fall into 4 categories as described in the Introduction:

Standard: Multiple Sections - Whole Cores/Split Cores- Core Pusher - Short Belt

Unrestricted pusher: Multiple Section - Whole Cores - Core Pusher - Long Belt

Boat: Single Section - Whole Cores - Core Boat

Moving Sensors: Single Section - Whole Cores - Moving Sensors

Vertical Moving Sensors: Single Section - Whole Cores - Moving Sensors

In the sections below the general logging principles are described for the Standard system and any variations that exist for the alternative types of track systems are discussed separately. Note that the 5 types of track are defined in the ‘settings file’ as ‘track type’.

4.3.1 Standard system

Ensure that the ‘track type’ is set to 1 in the ‘settings file’ and that the right and left-hand limits are set correctly (see Chapter 5). A core is automatically logged by sequentially loading core sections onto the RH track with the top of each section on the left. The logging process is started by loading the first section

(which can either be a calibration/control section or section 1) onto the RH end of the track with the top to the left and clear of the laser detect system and the reference position. The reference position is the position on the track from which the positions of all the sensor systems are defined. The reference position normally remains constant but can be changed by the user for special circumstances if needed (see Chapter 5 for further information). The MSCL automatically measures the core section and starts logging.

The core pusher is positioned against the RH end of the first section before the logging begins. The user defines through the use of a configuration panel which sensors are active for the section about to be logged and at what spatial intervals data must be collected from each sensor. Logging begins automatically by pushing the core along the track until the top of the first section is at the first active sensor. The first measurement is made and then the core is pushed until the next measurement position is beneath the appropriate sensor. Measurements are performed incrementally in this way at locations down the core section as defined by the configuration panel.

Measurements continue in this incremental fashion until the pusher reaches the reference point. At this stage the pusher automatically checks its position using the laser detect system and moves back along the track by a distance 2 cm greater than the nominal section length, allowing the user to insert the next section onto the RH track. The user must simply ensure that the next core section is positioned on the RH track and to the right of the laser detect system then continue logging. The MSCL automatically measures the core section and butts it up against the previous section and continues logging.

The process continues, this time with the pusher moving both core sections along the track. When the pusher again reaches the reference position it returns and the user loads the 3rd section and the whole process continues again. Sections continue to be loaded in this fashion until all the core sections have been logged. The user must ensure that core sections from the LH part of the track are removed once they have passed the last active sensor (normally the magnetic susceptibility loop or point sensor). Normally a core section can be removed each time a new section is added.

To end the logging process a dummy core section/s must be used which is at least as long as the distance between the reference position and last active sensor. Normally this dummy is the length of a nominal section. No measurements are made on the dummy section if the sensors are turned off in the configuration panel. Consequently this dummy sections can be lengths of real core.

4.3.2 Unrestricted pusher system

Ensure that the 'track type' is set to 2 in the 'settings file' and that the right and left hand limits are set correctly (see Chapter 5). The only difference between the standard system and the unrestricted pusher system is that the pusher can move all the way through the sensors. Consequently at the end of core logging the user simply has to click [**last section**] and the pusher will go through to the last sensor. The user must ensure that the 'left limit' of pusher movement' is set greater than the position of the last sensor.

4.3.3 Boat system

The main disadvantage with the boat system compared with the core pusher systems is that each section has to be logged individually which: a) takes more time and b) introduces end effects with some measurement parameters (e.g. MS measurements with the loop sensor).

Ensure that the 'track type' is set to 3 in the 'settings file' and that the right and left hand limits are set correctly (see Chapter 5). With a core boat system the core is always placed in the boat in the same way with the RH end of the core butted against the far RH end of the core boat. In this way the reference point still refers to the RH end of the core (not the outside end of the core boat). RH limit should be set to slightly less than the RH extent of the track and the LH limit must be set to a point beyond the last sensor on the system. For example, if your track extends 200 cm to the right of your reference point the RH limit should be set at 195 cm. If the last sensor (usually the Magnetic Susceptibility sensor on GEOTEK MSCL systems) is 70 cm to the left of the reference point you should set the LH limit to 80 cm. See Figure 11.

The system is now ready to start logging a core.

When the user wants to start logging the messages in the logger control panel are slightly different as explained below.

Setting the Left and Right Hand Limits

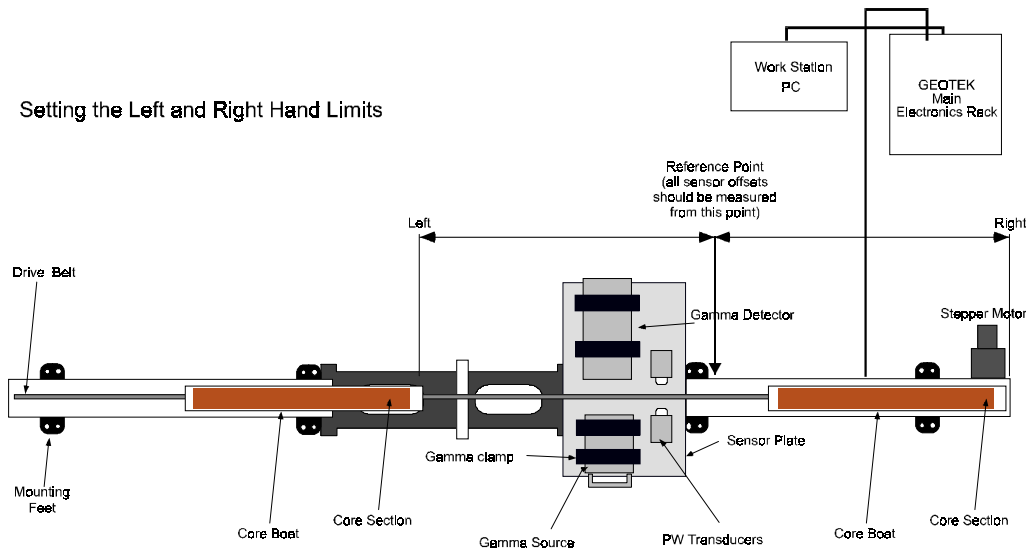


Figure 11. Setting LH and RH limits for the core boat system.

1) Once the configuration panel is completed the Logger Control Panel will appear as shown below.

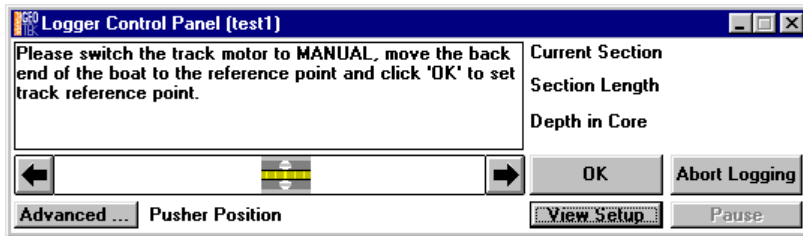


Figure 12. Logger Control Panel (Set Ref Point - boat system).

The user is being prompted to move the back end of the boat to the reference point and click [OK]. This effectively tells the microprocessor where your reference point is. The back end of the core boat is the point at which the end of the core section lies in the core boat (see below).

Setting the Reference Point for the Microprocessor

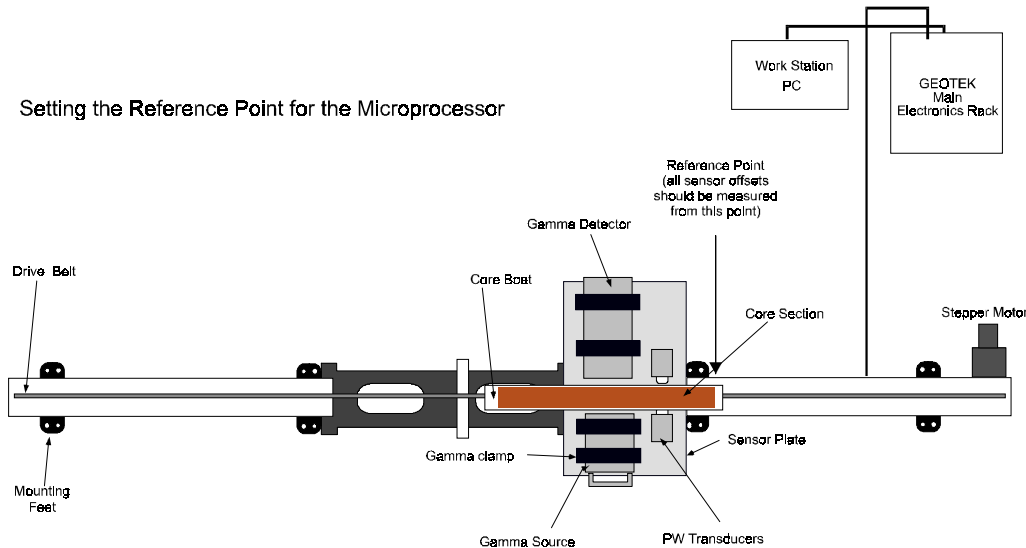


Figure 13. Setting the Reference point (boat system).

2) Once Set Ref. is clicked the user will be prompted to move the boat back to allow the first section to be loaded. Load the core into the boat ensuring that it is butted up against the RH end (i.e. the place the reference point was aligned with). Use the logger control scroll bar and nudge controls to align the LH end of the core with the reference point as instructed (see Figure 14).

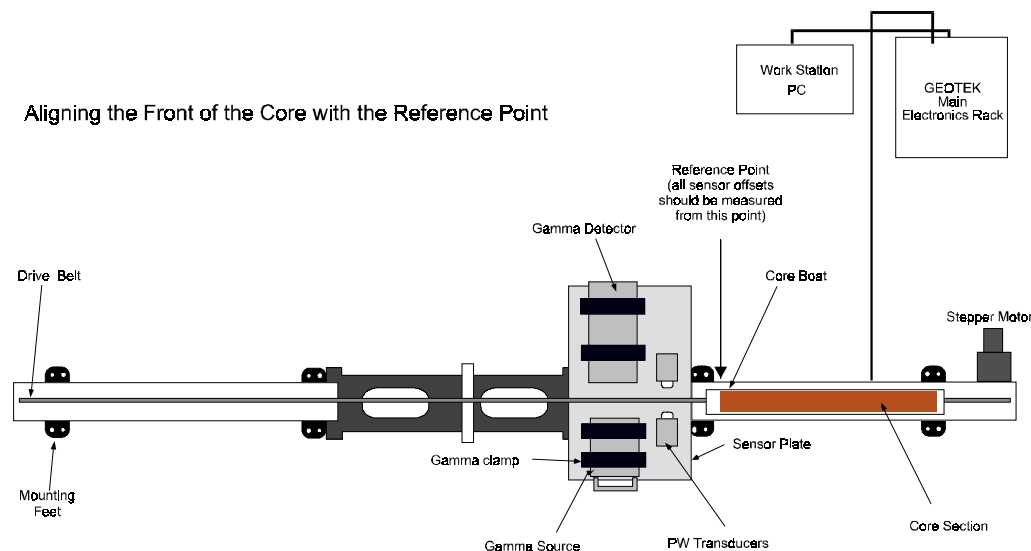


Figure 14. Aligning the front of the core with the reference point (boat system).

- 3) When the core and core boat are in the correct position click [**Begin Logging**]. When the core section has been logged the core boat will be returned to the right hand side of the track ready to load the next section. Repeat step 3 above and resume logging.
- 4) When the last section has been logged simply click [**Abort Logging**] in the control panel.

4.3.4 Moving Sensor System

The principle of operation of the moving sensor system is similar to that of the boat system except that the mechanics are arranged so that the sensors move past a single section of core on a linear slide. The main disadvantage with the moving sensor system compared with the core pusher systems is that each section has to be logged individually which will take more time.

Ensure that the ‘track type’ is set to 4 in the ‘settings file’ and that the right and left hand limits are set correctly (see Chapter 5). With a moving sensor system the core is always placed on the track in the same way with the bottom of the section butted against the reference point, at the LH side of the track. The RH limit should be set to slightly less than the RH extent of the track and the LH limit must be set to the point of the last sensor on the system.

The system is ready to start logging cores.

When the user wants to start logging the messages in the logger control panel are slightly different as explained below.

- 1) Once the configuration panel is completed the Logger Control Panel will appear as shown below.

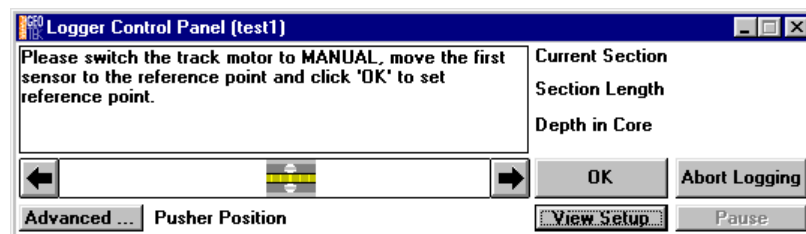


Figure 15. Logger control panel at startup when using a moving sensor system.

The user is being prompted to move the first sensor to the reference point and click [**OK**]. This effectively tells the microprocessor where your reference point is.

- 2) Once the reference point is set the user will be prompted to move the sensors back to allow the first section to be loaded. Load the core onto the track ensuring that it is butted up against the Reference Point. Use the logger control scroll bar and nudge controls to align first sensor with the top of the core section.

- 3) When the core and the sensors are in the correct position click [**Begin Logging**]. When the core section has been logged the sensors will be returned to the right hand side of the track ready to load the next section. Ensure the sensors are in the correct position and click [**Continue**].
- 4) When the last section has been logged simply click [**Abort Logging**] in the control panel.

4.3.5 Vertical Moving Sensor System

The principle of operation of the moving sensor system is similar to that of the boat system except that the mechanics are arranged so that the sensors move vertically past a single section of core. The main disadvantage with the moving sensor system compared with the core pusher systems is that each section has to be logged individually which will take more time.

Ensure that the 'track type' is set to 5 in the 'settings file' and that the upper and lower limits are set correctly (see Chapter 5). With a vertical moving sensor system the core is always placed in the frame with the bottom of the section butted against the reference point, at the bottom of the frame. The upper limit should be set to slightly less than the highest point of the sensor platform movement and the lower limit must be set to 2 cm beyond the last sensor on the system.

The system is ready to start logging cores.

When the user wants to start logging the messages in the modified logger control panel are slightly different as explained below.

- 1) Once the configuration panel is completed the Logger Control Panel will appear as shown below. The user is being prompted to set the reference core thickness RCT for the core diameter sensors. The p-wave sensors must be adjusted such that there is sufficient movement to account for the deviations in the diameter of the core liner, including endcaps. Click [**OK**] to set the RCT. If the user skips this phase using Ctrl-S then use the advance panel to correct this.

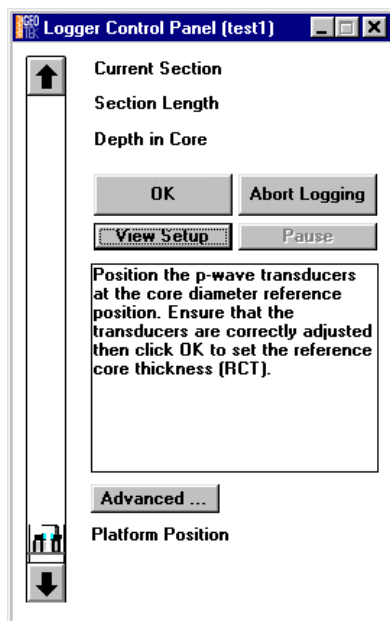


Figure 16. Logger control panel at startup when using a vertical moving sensor system.

- 2) The user is then prompted to move the first sensor to the reference point and click [**OK**]. This effectively tells the microprocessor where your reference point is.
- 3) Once the reference point has been set the user will be prompted to move the sensors back r. Use the logger control scroll bar and nudge controls to align first sensor with the top of the core section.
- 4) When the core and the sensors are in the correct position click [**Begin Logging**]. When the core section has been logged the sensors will remain at the bottom of the frame ready to load the next section. Move the sensor platform to the top of the section and click [**Continue**].
- 5) When the last section has been logged simply click [**Abort Logging**] in the control panel.

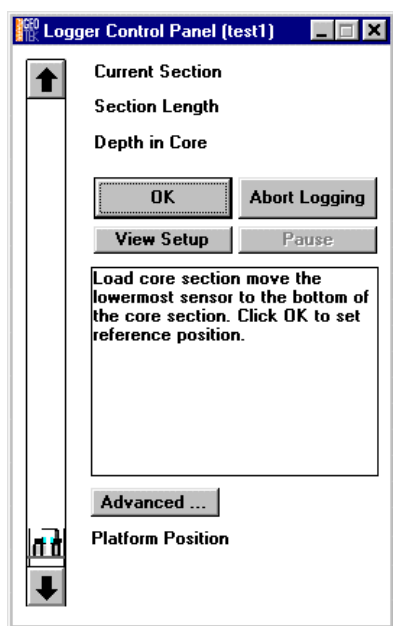


Figure 17. Logger control panel after setting the RCT when using a vertical moving sensor system.

4.4 Logging a New Core

In the short-form instructions below it is assumed that all pre-checks have been carried out (see Chapter 2) and all sensor systems are properly calibrated (see Chapter 7). Note that in the process of logging a core the user is prompted to perform most of the normal necessary actions by messages that appear in the control panel on the screen. For more detailed information the user is referred to Chapter 5 which explains all the options in detail. The instructions assume you are using a standard track system (see Chapter 1).

- 1) From the main menu:

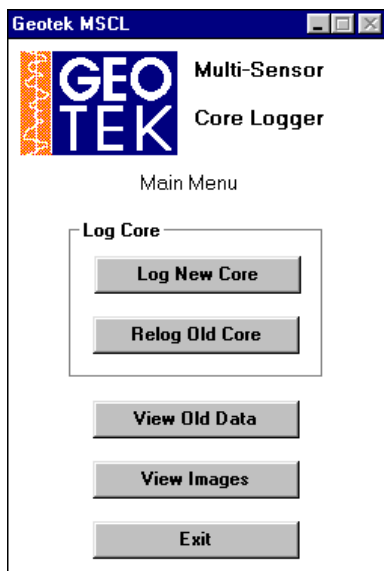


Figure 18. Main Menu panel.

- 2) Click [**Log New Core**] from the Main Menu.
- 3) Enter New Core name in the 'Enter New Filename' Panel and choose the directory in which the data is to be stored. Click [**OK**] when ready.

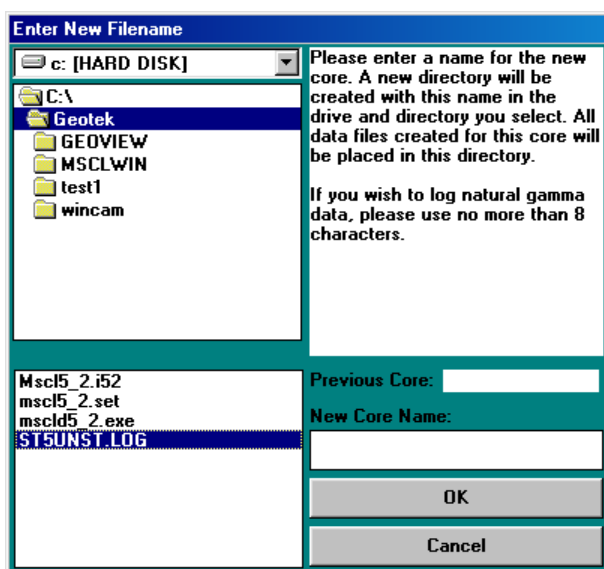


Figure 19. Enter New Filename panel.

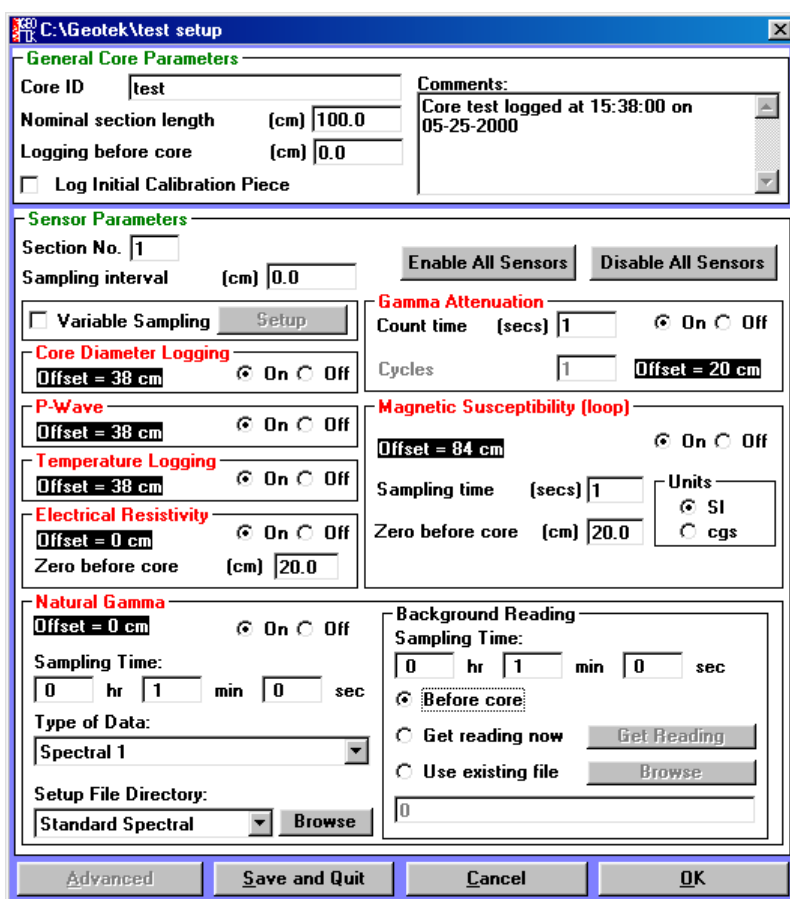


Figure 20. Configuration panel.

4) Complete the configuration panel.

Remember that the sensor parameters refer only to the next section to be logged and can be changed for subsequent sections if desired. Click **[OK]** when ready.

5) Place the reference thickness piece for the core being logged between the acoustic transducers then manually move the acoustic motor down into a position that allows enough movement of the PWTs and click **[OK]**. The Excursion Distance control panel will then be displayed.

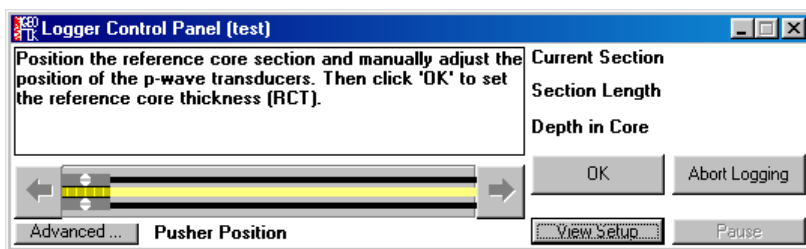


Figure 21. Logger control panel (pusher system – set reference core thickness).

- 6) Enter the vertical excursion distance for the acoustic motor and Click **[OK]** when ready.

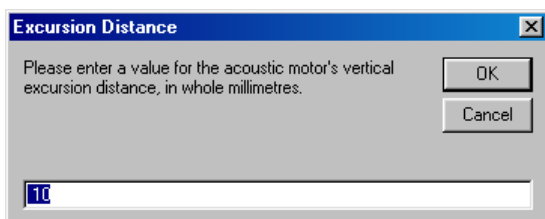


Figure 22. Excursion Distance panel.

Note that this distance must be sufficient for the acoustic transducer to clear the core when it moves and a sufficient distance for the MS point sensor (if used) to obtain valid ‘zero’ readings when in its uppermost rest position. If logging a whole core with the vertical slide then this excursion distance can be set to zero. The normal excursion distance may be 30-40 mm.

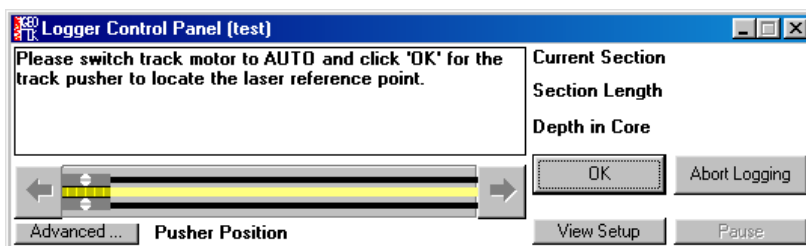


Figure 23. Logger control panel (pusher system - set Reference Point).

- 7) Switch track to ‘Auto’ and click **[OK]** in the Logger Control Panel. The logger automatically finds the position of the pusher using the laser detect system.

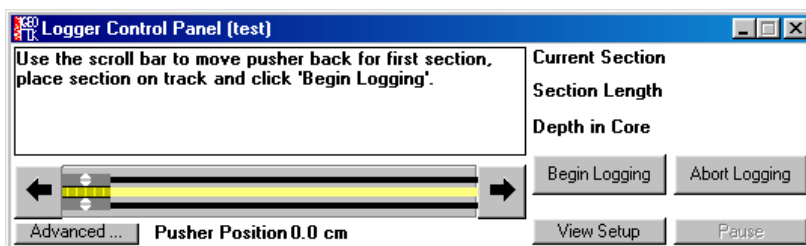


Figure 24. Logger control panel (pusher system - begin logging).

- 8) Using the scroll bar in the Logger Control Panel move the pusher to a position on track which is just greater than the length of the first section to be logged (either section 1 or a calibration section). If a mistake is made the user can press the ESCAPE key while the mouse button is still pressed down and the pusher will stay in its original position.
- 9) Place the first section on the track with the top of the section on the left and not obstructing the laser detect system. It is often valuable to have an empty core section to the left of the reference position. In this way the user ensures that the core will not come across any obstructions (especially the PWTs) as it moves through the sensors.
- 10) Click **[Begin Logging]**.
- 11) The configuration panel will be displayed again. Check (and edit if necessary) and click **[OK]** when ready. This is the point where the automated core logging starts.

Ensure whilst the core section moves to its first measurement position that there are no obstructions to its movement.

Data will be collected from the different sensors according to the information entered into the configuration panel. The logger control panel remains active and informs the user on the current status. It also displays the values of the last data set obtained.

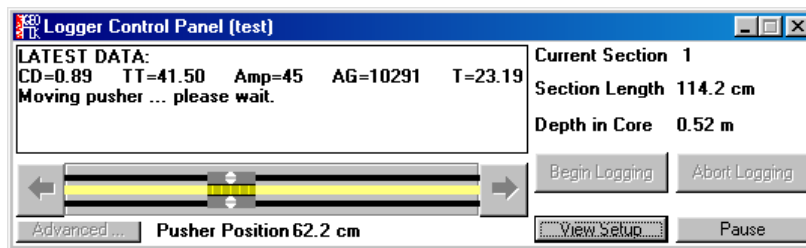


Figure 25. Logger control panel (pusher system - Latest Data).

While it is doing this the user can observe the raw data being collected in the Raw Data Display Panel which appears automatically and can be formatted as desired (see Chapter 5).

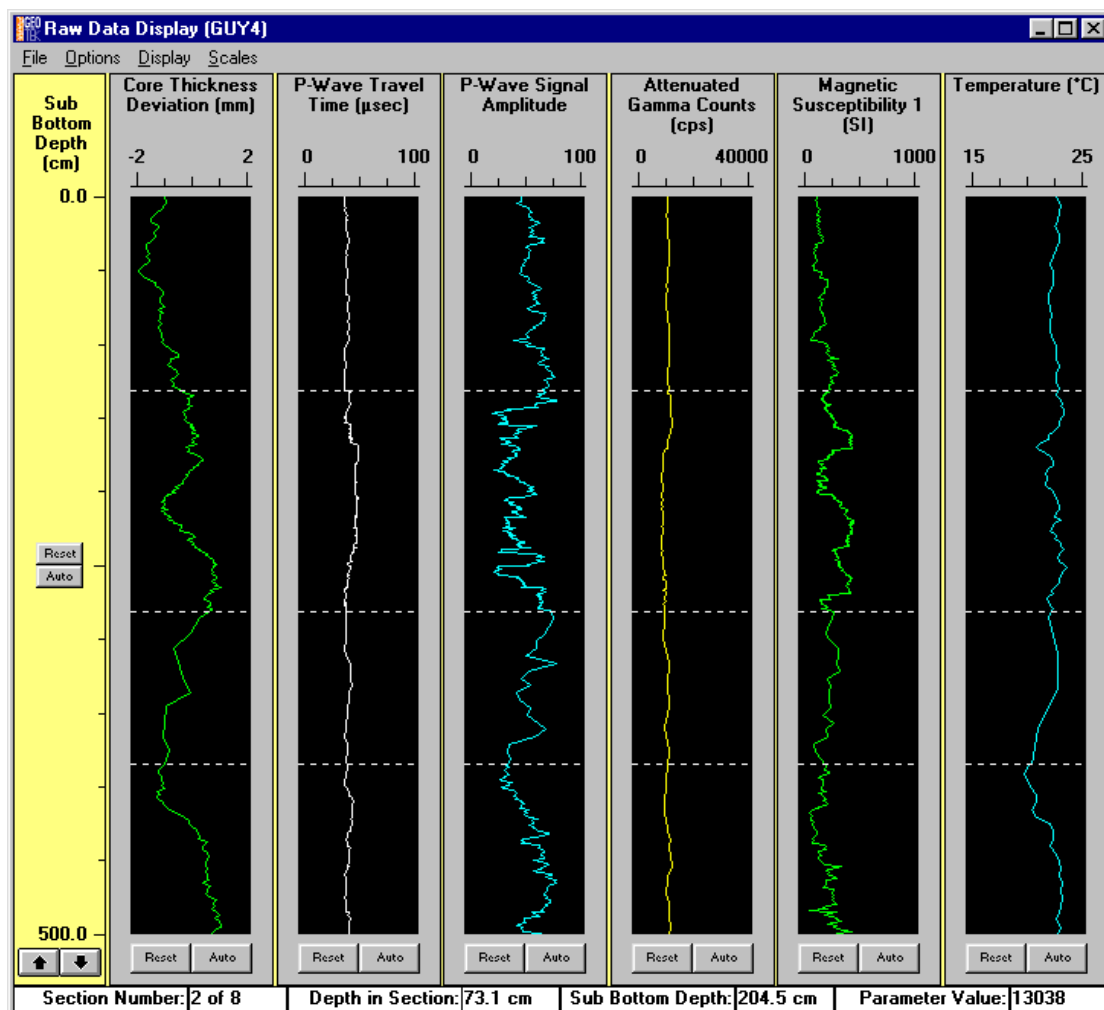


Figure 26. Raw Data Display panel.

- 12) The user can also observe and process the data by selecting the processed data display (see Chapter 5 for details).
- 13) In the event that something is wrong the user should click [**Pause**] in the Logger Control Panel and assess the situation before continuing.

- 14) The logging process will continue until the core pusher reaches the reference position. The pusher will then move back and check its position using the laser detect system, notify the user of any error and move along the track by the nominal core length entered in the configuration panel.
- 15) Place the second section on the track with the top of the section clear of the laser detect system. Click **[Continue]** in the Logger Control Panel.
- 16) Edit the configuration panel as required for the new section and click **[OK]**

Both core sections will be pushed through the sensor systems and will be logged incrementally according to the configuration set-up for each section.

The process is continued until the last core section has been placed on the track.

- 17) There are 2 ways to finish the core logging process.
 - The simplest method is to place a final dummy section on the track that is the nominal section length and turn off all sensors in the configuration panel. This will enable the last core section to finish the logging process past the last section.
 - The more complex method enables the MSCL to be left unattended while logging finishes at the earliest opportunity. The user should click **[Last Section]** in the logger control panel. This can be done either when the last section is loaded or by clicking **[Pause]** and then **[Last Section]** while the last section is being logged. The user will be prompted to load a dummy section/s of an appropriate length/s.
- 18) When the logging process is complete click **[Exit]** or **[Abort Logging]** in the Logger Control Panel and close all active windows which will return the user to the main menu ready for logging another core.

4.5 Reelog Old Core

In the event that core logging is interrupted during the normal process of 'Log New Core' it can sometime be desirable to start the core logging process again where the logging was previously aborted. In this way new data can be appended to the existing data file. This can sometimes happen due to operator error (for example placing the wrong section on the track or placing a section on the track round the wrong way). To relog an old core follow the instructions below noting that the user will be prompted to perform these actions by messages that will appear in the logger control panel.

1. Click **[Relog Old Core]** from the Main Menu. The select data file box will be shown.

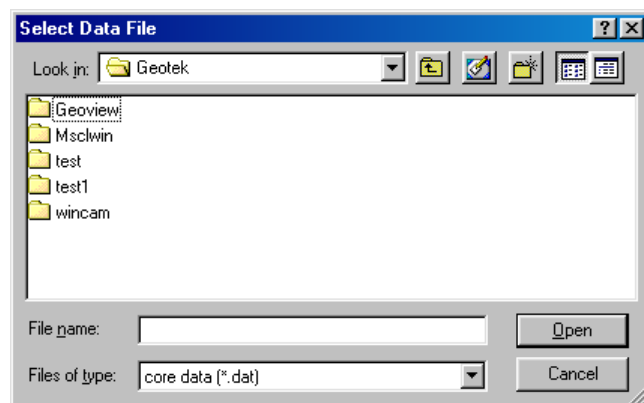


Figure 27. Select Data File panel (relog old core).

Select the appropriate file and click **[OK]**. The raw data of the core selected will be displayed together with a dialog box with information pertinent to the data set.

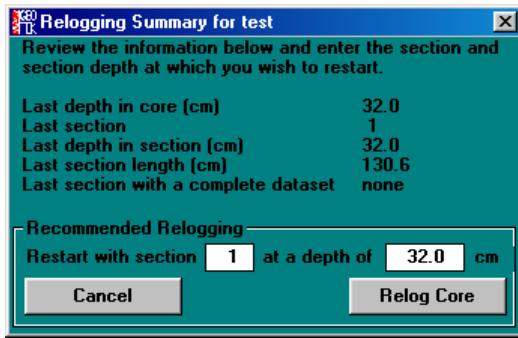


Figure 28. Relog core panel.

The user should decide at what point (at the reference position) he/she wishes to relog the core and enter the values in the boxes [**Restart with section**] and [**at a depth of**] and click [**Relog Core**] when ready (see Figure 28). All data below this point will be deleted.

The user will be asked to reset the reference position and zero the acoustic motor if necessary before being asked to place the appropriate core section on the track.

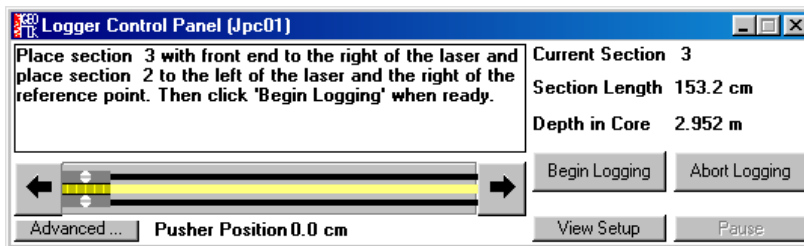


Figure 29. Logger control panel (relog old core).

It is most important that the length of the section should match exactly the value as recorded previously. If in any doubt the user can look up the previously recorded by core length by using the [**View Set-up**] button in the Logger Control Panel.

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5.1 Chapter Overview

This chapter provides detailed information on the different aspect of the main application programme for the MSCL. It is aimed at the new and regular user who requires further detailed information on how the software operates.

The MSCL operating software is Windows™ based. It is a user-friendly application that can be configured to operate with all GEOTEK logging systems. If you are still using an older version then contact GEOTEK with regards an upgrade. It controls the data acquisition process, stores and presents the raw data graphically in real time. The user can also view and edit graphical processed data in real time and change the processing algorithms if required. Although data is normally presented graphically on the screen, tables of raw and processed data can be viewed and exported to other applications for further processing and for presentational purposes.

The same application can also be used to view and process previously collected data (old data).

In addition to the main operating and processing application there is an associated utilities programme which is described in detail in Chapter 6. This enables the user to run tests of individual sensor systems and to set important configuration parameters specific to the users system. There is also a terminal mode option that enables the advanced user to edit/modify the software in the microprocessor.

The descriptions of the software in this chapter relate to the latest version of MSCL hardware so users without the latest hardware modifications should be aware of the protocols to be followed specific to any system. The most notable differences to the procedures described here are those relating to the laser detect system and how that affects the setting of the reference position. A set of release notes is appended to this chapter that outlines the most recent developments in software and hardware impacting on software protocols.

5.2 Main Menu

5.2.1 Running the program

- Click on [Start], [Programs], [Geotek MSCL 5.2], [Geotek MSCL 5.2]
- The Main Menu will appear as below providing the five menu items:

- [Log New Core] (see section 5.2.2)
- [Relog Old Core] (see section 5.2.3)
- [View Old Data] (see section 5.2.4)
- [View Images] (see section 5.2.5)
- [Exit] (exit from application)

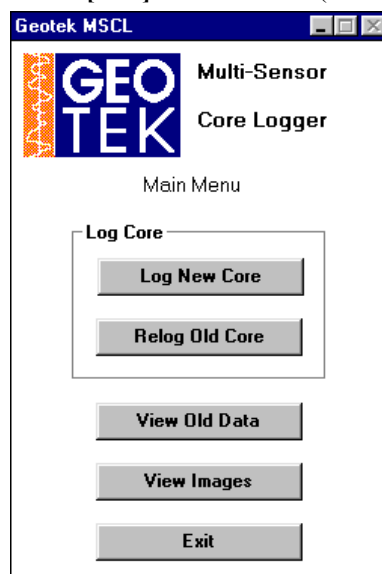


Figure 30. Main Menu panel.

5.2.2 Log New Core

This is the normal starting position from the main menu when the user begins to log a core for the first time.

Enter new filename: The “Enter New Filename” panel will then be displayed. This prompts the user to enter the new core name and select the destination for the data to be logged. The last core logged is shown as a guide.

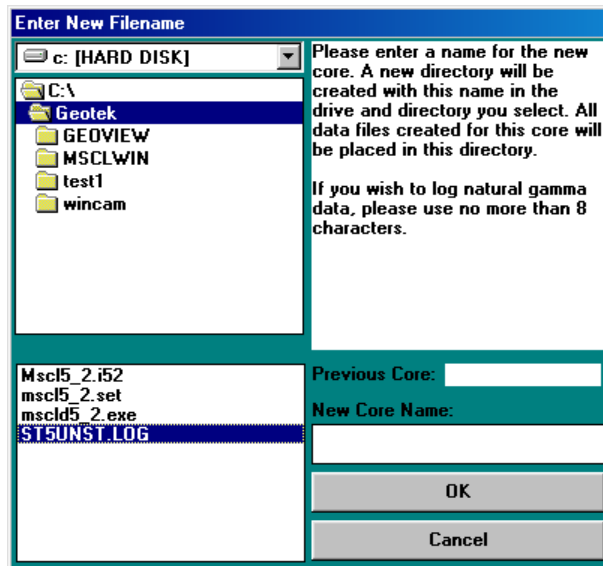


Figure 31. Enter new filename panel.

It is suggested that the user uses the following file structure:

C:\geotek\coredata\filename

This is the directory in which all data relating to this core will be stored. Note that raw data is stored in a binary format and has the extension **.dat** after the filename. These data files can only be read by the application program. ASCII data files (which can be exported to other applications) of both raw and processed data can be created as described later.

Once selected the user should click **[OK]**.

If the filename you have chosen already exists you will be warned that the filename is already in use and that if you continue the old data will be deleted.

Once the file name has been chosen the user will be presented with the configuration panel (see section 0).

5.2.3 Relog Old Core

This option should be chosen from the main menu if the programme had to be stopped for any reason whilst a core was in the process of being logged but had not been completed. This option may be required under the following circumstances.

- Logging was aborted because of an operator error: e.g. a core section was logged out of order or the wrong way around.
- The user wishes to use a different logging configuration.
- A power failure or computer error occurred during logging.

After selecting **[Relog Old Core]** from the main menu the “Select Data File name” panel will be displayed. The user should select the file relating to the old core and click **[OK]**.

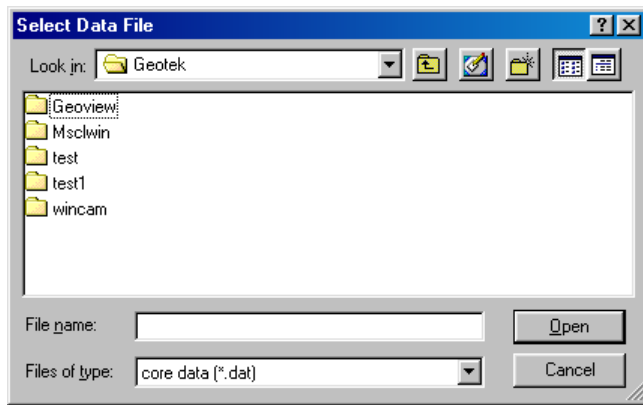


Figure 32. Select Data File (relog old core).

The “Raw Data Display” will then appear together with an information panel relating to the selected core that will help the user to select which section he/she wishes to restart the re-logging process.

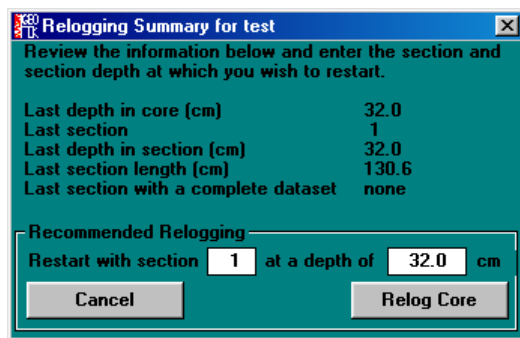


Figure 33. Relog old core panel.

The user should decide at which core section and at what depth in that section that logging should begin and enter these values in the boxes provided. Click [Relog Core] when ready.

WARNING

.....
NEW DATA WILL OVERWRITE ANY DATA FROM CORE SECTIONS AFTER AND INCLUDING THE SECTION BEING STARTED FROM

Logging will then resume in the normal manner.

The user will be asked to reset the reference position and zero the acoustic motor if necessary before being asked to place the appropriate core section on the track.

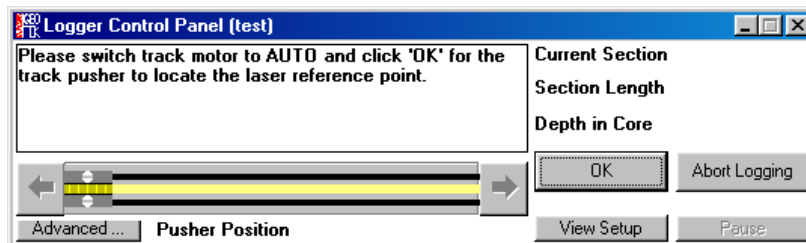


Figure 34. Logger control panel (set ref. point).

It is most important that the length of the section should match exactly the value as recorded previously. If in any doubt the user can look up the previously recorded by core length by using the [View Setup] button in the Logger Control Panel.

Logging will then continue in the normal manner.

5.2.4 View Old Data

This option enables the user to view data sets collected and to process/reprocess the data. It enables data files to be created for export to other applications for either further processing or for presentation.

All the user must do is to choose from the Filename panel the core that he wishes to view. The raw data for that core will then be displayed.

5.2.5 View Images

This option enables the user to view image data that has been collected using the Geotek GEOSCAN imaging system (see Chapter 10). From these images the individual colour reflectance data can be extracted and so profiles of Red, Green and Blue can be displayed.

Once the images have been loaded into the software the user can scroll up and down the core through the images. The images can be viewed in full resolution (as imaged in short lengths) or as a thumbnail, a decimated image of an entire core section. By default the software automatically selects the resolution but the user can override this using the **[Image_Auto Resolution]** menu item.

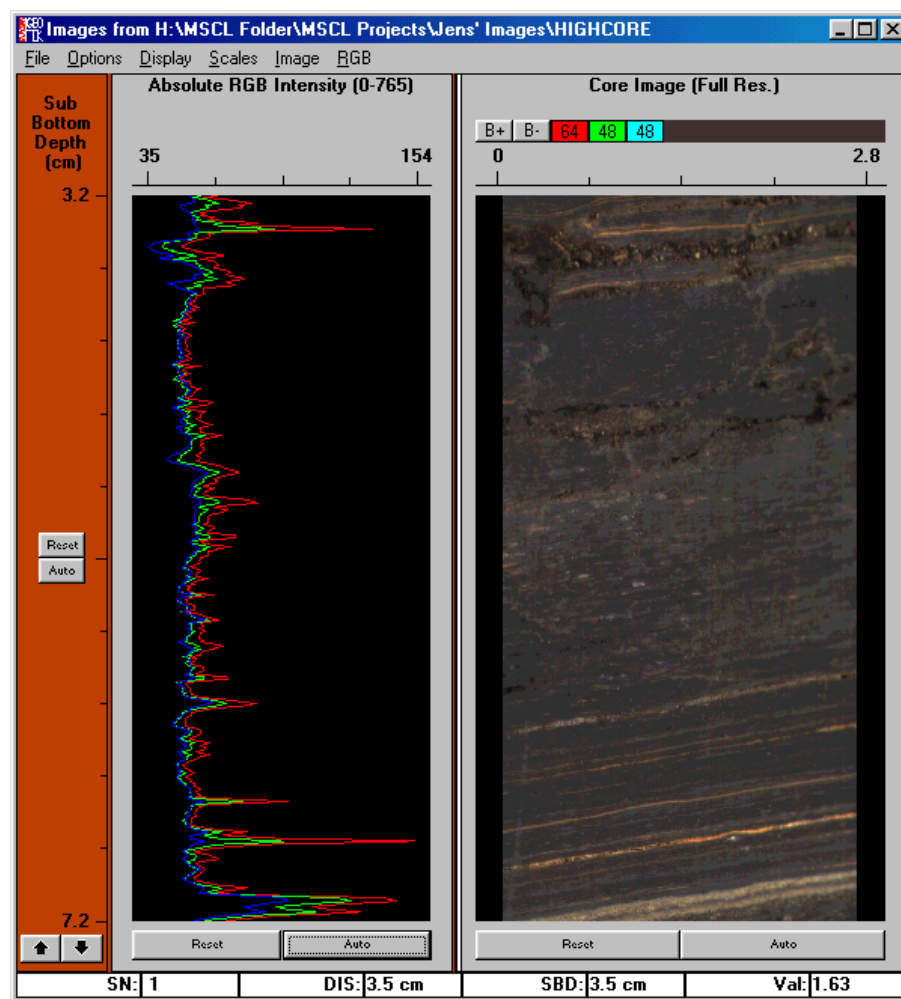


Figure 35. Image display.

The user zoom in on an area of the image by drawing a box around the area of interest and clicking inside it.

To extract the red green and blue reflectance data from the image the user must again draw a box around the area of interest and right click in the box. The user must select Create RGB from the pop up menu. A dialogue box will appear and the user can more accurately define the area of interest and also the depth resolution at which the data should be extracted (see Figure 36). The data can be extracted from each line of the data and averaged over the width of the box (**[Sample]** radio button) or averaged with depth and over the width if the box (**[Average]** radio button). The latter option will take more time because of the increased number of calculations involved.

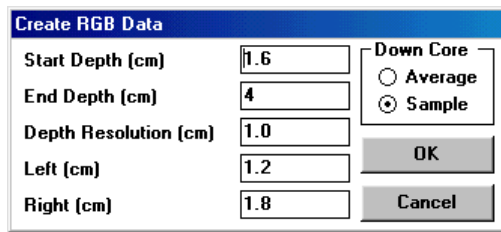


Figure 36. RGB data dialogue box specifying the area of interest and the resolution.

The user can also display the ratios of red/green, red/blue and green/blue by using the [RGB_RGB Ratios] menu item and a new graph will be displayed. These data will also be exported to the ASCII file as with any other data.

5.3 Configuration Panel

The configuration panel appears between sections during the course of logging cores or when viewed by the user when [View Setup] on the logger control panel is clicked.

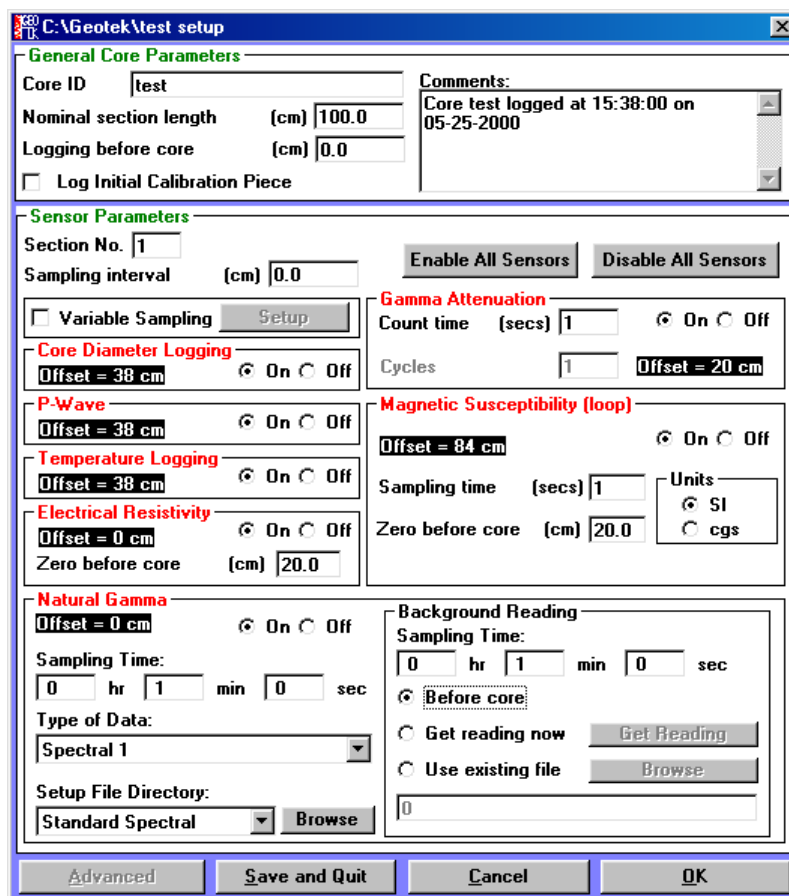


Figure 37. Configuration panel.

It enables the user to define exactly how each core section should be logged and when viewing old data enables the user to determine how the logging process was carried out. Within the panel the user can define which parameters are logged and at what spatial intervals. Note that different parameters can be logged at different spatial intervals. Below is a description of each box available to the user.

The configuration panel is split into 2 sections:

General Core Parameters: which refer to the complete core and

Sensor Parameters: which refer to the individual sensors and can only be edited between sections.

5.3.1 General Core Parameters

Core ID: This is the core identification label. As a default it is set as the same as the filename that the user chooses in the filename panel. However, DOS limits the filename to 8 characters and the user may wish to enter a more complete core name. The core ID also acts as a security check because this name is written inside all the data files and hence if the filename is accidentally changed then its identification can still be established.

Comments: This is a simple text box in which the user can enter or edit comments regarding the core being logged at almost any time during the logging process. It enables notes to be kept regarding the core that is being logged which can be viewed when the data is being viewed at a later date.

Nominal section length: Each core section is pushed through the sensors to the left. When the core pusher reaches the reference position it automatically moves to the right enabling the user to insert the next section. The distance that the pusher moves to the right is set by the 'nominal section length'. Normally this can be set as 150 or 100 cm (depending on what length the core sections are normally cut). However, if the sections are of variable length then this parameter can be changed each time a new section is loaded. When the pusher moves to the right, to enable the next core section to be loaded, it moves the nominal section length plus 2 cm to provide room to load the section easily and to allow for the fact that each section may not be cut to the exact length.

Logging before core: This parameter sets the distance before the beginning of the first section that logging begins (this could be the calibration piece; see below). Under normal circumstances this parameter is set to zero. The data obtained before the beginning of the first section is assigned a negative sub bottom depth and is distinguished on the graphical display by the use of a different colour.

Log Initial Calibration Piece: The protocols for calibration are discussed in a separate section. However, it may often be desirable to use a calibration piece to check that the sensor systems are functioning correctly at the beginning of each core. If the box is clicked then the software assumes that the first section placed on the track is a calibration section. Note that its length is determined automatically (see below). As with the "logging before core" facility (see above) the data obtained from the calibration section is assigned a negative sub bottom depth and is distinguished on the graphical display by the use of a different colour.

5.3.2 Sensor Parameters

Section No.: The number of the next section to be loaded onto the track is displayed in this box. If a calibration section is to be logged first then it will read 'cal'. Note that the software always assumes that core sections are logged in order starting with section 1 (see section 4.2).

Sampling Interval: This number is set by the user and determines the distance between successive sampling points along the core. If variable sampling has not been selected (see below) then all selected parameters will be measured at this sampling interval. The number can be set to within 1 mm. However, the user should note that some sampling intervals are much more time efficient than others because of the spacing of the sensor systems. The sensors are normally spaced at multiples of 2 cm apart from each other. Consequently it is advisable to use the following sampling intervals for maximum time efficiency; 0.1, 0.2, 0.5, 1.0 or 2.0 cm.

Variable Sampling: If this box is selected the user can choose different sampling intervals for each sensor selected. This is a valuable facility when the user is balancing the time taken to log a core with the resolution required from different sensors. The set-up button is activated when variable sampling is selected and when clicked the Variable Sampling Set-up panel is displayed (Figure 38).

The "sample zones" section at the top of the panel allows the user to select areas of the core in which no data are to be collected or discrete points for data collection. The section length is set as the nominal section length by default but this can be changed using the **[Set Section Length]** button. It is best to set the section length greater than the actual section length. To define a skip zone click the mouse at the start or end position using the numeric display for a position guide and release the mouse button at the other end. To set the skipzone the user must then click in the brown coloured area. A dialogue box will appear prompting the user for precise start and end points. After clicking **[OK]** the skip sample zone will be set and become white in colour. Alternatively the user can select discrete points at which to take readings. The user must click approximately where a sample should be taken and a dialogue box will appear prompting for an accurate position. Click **[OK]** and a red cross will appear at the selected position.

To define a skip zone at the end of the section then the user should set the section length longer than the section itself and define a skipzone from the start point required all the way to the end the section. The software will then set the skipzone to the end of the section as measured by the logger.

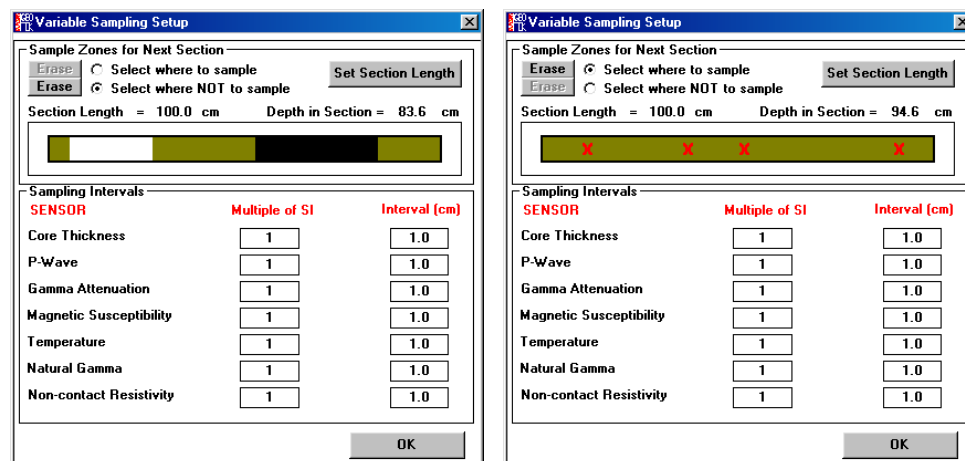


Figure 38. Variable sampling Setup panel.

The lower sampling intervals area shows the sensors that are available and have been selected.

When variable sampling is selected the sampling interval (SI) set in the configuration panel becomes the minimum sampling interval available for any sensor. All other sampling intervals are multiples of this minimum sampling interval. In this way the time efficiency for the logging process is optimised. The sampling interval for any sensor is set either by selecting and editing the “Multiple of SI” or selecting and editing the “Interval (cm)”. If the interval chosen is not an exact multiple the nearest exact multiple will be substituted. When the selection is complete click **[OK]**.

Sensor Selection: The remainder of the panel shows the sensors available. The available sensors are defined by the logger settings facility (see Chapter 6). Available sensors are shown in red with the offset from the reference position shown beneath. If a sensor is unavailable then it is shown in grey and that part of the panel is inactive. Any available sensor can be turned on or off simply by clicking on the adjacent buttons. Some sensors also require further settings information and the user can define these sensor specific parameters in the boxes provided as described below. Note that the settings used are applicable to the ‘Section No’ displayed and can be changed for other sections if required.

Gamma attenuation “**Count Time**” is the time in seconds for which gamma photons are counted at each sampling point. Note that the precision with which gamma density is measured improves with longer count times but the overall logging time increases. A compromise value must be chosen which is described in greater detail elsewhere. A sensible minimum practical count period for most applications is probably 4 seconds.

In the Magnetic Susceptibility panel either a point sensor or a loop sensor can be used (as set in the settings file). The “**Sampling Time**” should be set the same as the setting on the Bartington MS2 meter. Note that on the Bartington meter the sampling interval is given in Hz; so 1 Hz is equivalent to 1 s and 0.1 Hz is equivalent to 10 s. The user should also set the units used (SI or cgs) to be the same as set on the Bartington meter. If the sensor is a loop then the user should also set the distance before the core that the loop is zeroed. Typically this should be about 10 cm.

Once the user has completely defined how the first section is to be logged by editing the configuration panel then under normal circumstances he should click **[OK]**. However, if it is required to save the set-up, but to quit the application, then click **[Save Changes + Quit]**. The filename and configuration parameters will appear as defaults the next time the application is opened. If **[Cancel]** is chosen then all changes will be lost. Note that this configuration panel can be viewed at any time during the logging process to enter comments in the text box or simply to review the information that has been entered.

5.4 Logger Control Panel

This panel is used to control the logging process once the configuration panel has been completed. Within this panel the user is informed about the current status of the system and is prompted to perform actions by

messages in the central panel. When it is first activated communications are established with the microprocessor. The user is prompted by messages to start the logging process.

5.4.1 Zeroing the Vertical Slide/Acoustic Motor

It is necessary at the beginning of logging a new core to ensure that the computer 'knows' the position of both the main core pusher and the vertical 'acoustic' motor. The first message to appear is shown in Figure 39.

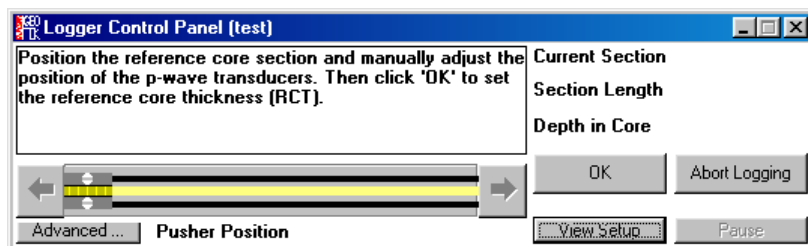


Figure 39. Logger control panel (zero vertical motor).

Assuming that the displacement transducers have already been calibrated (see Chapter 7) then all the user should do is place the reference piece between the correctly positioned transducers and click on the [OK] button as instructed.

At this stage the **Excursion Distance** panel will appear

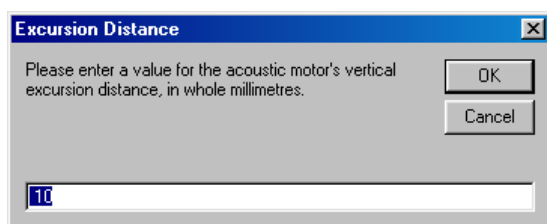


Figure 40. Excursion distance panel (vertical motor).

The user should enter the vertical excursion distance and click [OK]. The transducer housing will then automatically move up to its rest position with the upper P-wave transducer and MS point sensor (if fitted) clear of the core.

It is possible to bypass this procedure by using **CTRL + S** from the keyboard. However, the user should be certain that the vertical motor is still properly referenced to the calibration piece. If in any doubt go through the normal 'zeroing' procedure. Note that this can be done at any time during the logging process by clicking [Advanced...] in the logger control panel. The zero option will then become available.

A micro switch limits the maximum vertical motion of the P Wave transducer, in its housing. This protects the core from being squashed by the vertical slide. In normal operation this limit switch will not normally activate (even with quite rough surfaces if the auto adjust feature (see next section) is on. If it does activate for any reason then the positional reference of the transducers will be lost and the user must 're-zero' the vertical slide as described above.

5.4.2 Vertical slide auto adjust

The amount of variation in core height that can be accommodated by the movement of the upper P Wave transducer in its housing is limited to about 20 mm. The purpose of the Vertical slide auto adjust feature is to enable the vertical motor to accommodate larger variations in core thickness by automatically adjusting the upper position of the slide. This is achieved by resetting the upper position of the vertical slide if successive movements exceed a set distance.

The auto adjust facility is normally on. However, there can be times when the feature is not required and/or is detrimental to the normal logging process: for example when there are large unfilled voids in the core.

The feature can be disabled by clicking [Advanced...] and the auto adjust feature can be switched off.

The threshold for the auto adjustment to activate if on is set by the variable MLFA in line 450 of the I52 code.

5.4.3 Set Reference Point

It is necessary at the beginning of logging a new core to ensure that the computer ‘knows’ the position of both the main core pusher and the vertical ‘acoustic’ motor. After setting the RCT the next message to appear is to set the track reference point (see Figure 41).

The user should follow the instructions and switch the track motor to Auto and click **[OK]**. The pusher will then move to the left until the laser detect system detects the pusher. The pusher will then move to the right and start moving to the left in 0.1 mm increments to accurately position itself. To reduce the time this takes the user can manually move the pusher close to the laser detect system.

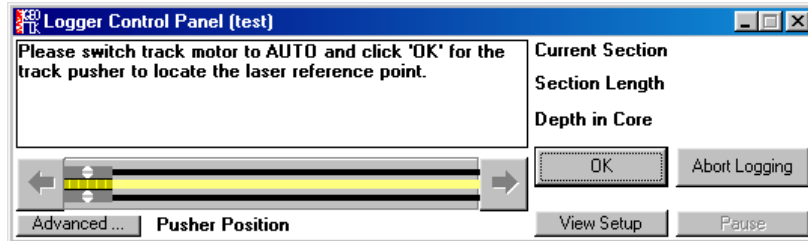


Figure 41. Logger control panel (set ref.).

NOTE

Ensure that the motor is put in the “Auto” position prior to moving the pusher with the scroll bar. Failure to do this will mean that the microprocessor loses its reference position and the logging process must be re-started from the beginning.

It is possible to bypass this procedure by using **CTRL + S** from the keyboard. However if the user does this he should check that the actual position of the pusher is the same as that shown by the logger control panel. This can be done by using the manual control to move the pusher to the position shown in the panel and then returning to ‘Auto’ control, or by using the Advanced Panel (see section 5.5) to set the track position in the software.

5.4.4 Core Pusher Scroll Bar

The next message to appear is

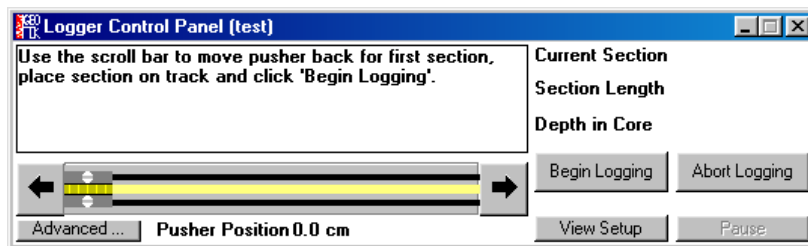


Figure 42. Logger control panel (scroll bar and nudge pusher).

The horizontal core pusher scroll bar represents the pusher on the rails; the exact position at any time is shown numerically beneath the scroll bar. The pusher can be moved in this automatic mode either by:

- i) Clicking on the end arrows. This moves the pusher in 2 mm increments.
- ii) Dragging the pusher along the scroll bar to a set position. To ‘pick up’ the pusher click anywhere on the scroll bar (apart from on the pusher itself) and hold down the button. Drag the pusher to the required position and release the button.

There is sometimes a short delay before the pusher moves as an acceleration routine is computed.

Using the above controls the user has complete control of the pusher from the screen and should move the pusher back to a distance just greater than the length of the first or calibration section. If a mistake is made then the user can press the ESCAPE key while the mouse button is still pressed down and the pusher will stay in its original position. Position the LH edge of the core such that the laser detect system is not

obscured. Note also that the length of the RH track section is set as a parameter in the settings file (see Chapter 6).

5.4.5 Begin Logging

Assuming that all the pre-logging checks have been made and that the sensor systems are suitably calibrated then logging can begin. Click the **[Begin Logging]** button in the Logger Control Panel and the configuration panel will be displayed again. This enables a final check on all the settings to be made before logging begins. Final changes can be made or comments added at this stage. Click **[OK]** when ready and the logging process will begin.

The Logger Control Panel will remain active (showing when the data is being acquired) until at least 2 data points have been obtained. The panel also provides continuous information on the status of the logging process; Current Section No., Section Length, Depth in Core and Current Sample No.

When the logging process has begun the “Raw Data Display Panel” will appear showing the graphical representation of the data as it is collected. For a full description of the features and options in the raw data panel see section 5.6.

When the pusher reaches the reference position it will automatically check its position using the laser detect system and return to the nominal core length position (plus 2 cm). The user will then be prompted to place the next section on the track and can click **[Continue]**.

5.4.6 Pause, Abort and End Logging

During the logging process the user can pause the complete operation by clicking **[Pause]** on Logger Control Panel. Logging will pause after the next set of data has been acquired. The user then has the choice to either click **[Abort Logging]** from the Logger Control Panel or to click **[Continue]**.

The logging process will continue until:

- a) It is aborted (as described above)
- b) The user clicks **[End Logging]** on the Logger Control Panel. Note that this option is only available between sections.
- c) The Maximum Core Length (as defined in the ‘Edit Configuration Parameters’ panel) is reached.
- d) The section designated as the last section has moved past the last sensor.

Note: the user may force this event for any section in progress by clicking on the **[Last Section]** button.

5.5 The Advanced Panel

The **[Advanced...]** button on the Logger Control Panel is only active when the pause button has been activated or between core sections and brings up the Advanced Panel (see Figure 43). This advanced panel enables the user to;

- a) recover from inadvertent mistakes made during logging
- b) change certain settings
- c) test/adjust sensor systems without disrupting the logging process

5.5.1 Horizontal/Vertical Adjust

This region of the panel refers to the adjustable sensors, namely the P Wave transducers, the displacement transducers and the Magnetic Susceptibility Point sensor. If the vertical motor is checked in the settings file then the software assumes that the logging is taking place vertically through either a whole core or a split core and the region of the advanced panel is labelled Vertical Adjust. Otherwise the software assumes the transducers to be ‘looking’ horizontally through a whole core and the region of the advanced panel is labelled Horizontal Adjust.

The excursion distance (i.e.) the distance the motor moves up away from the core between successive readings, is shown in the top box. This value is normally set at the beginning of the logging process but can be altered at any time the logging process is paused by accessing the advanced panel and clicking on the **[Change Exc. Dist.]** button.

The zero position of the transducers is set at the beginning of the logging procedure but once again this can be altered at any time the logging process is paused by accessing the advanced panel and clicking on the [Set Zero] or [Set RCT] button. If when in the vertical mode the user wishes to find the zero position automatically then clicking on [Find Zero] will lower the transducers to the current 'Zero Position'.

If the [Auto Adjust] box is checked then the vertical motor will make adjustment in its rest position to accommodate any major changes in core thickness (>5mm). In this way there is no chance of the slow but large changes in thickness causing the transducers to reach the end of their maximum travel.

Warning: If there are large gaps in the core the Auto Adjust' feature will attempt to find a core sample at the bottom of the liner and will lose its reference position/and or crash into the core when it encounters core after the gap. If in any doubt do not check this box as under most circumstances it is not necessary.

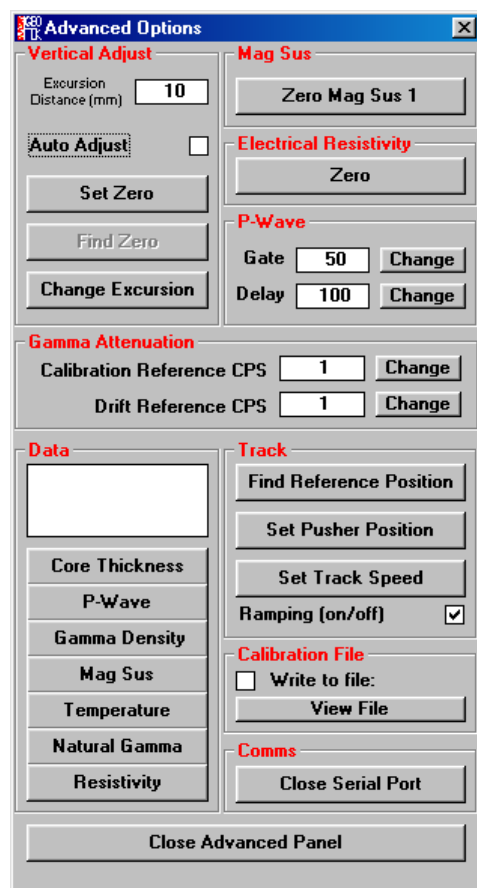


Figure 43. The Advanced Panel.

5.5.2 Data

This region of the panel enables the user to command any of the sensors to acquire data outside the main logging program simply by clicking on the appropriate button. The retrieved data is displayed in the top dialogue box. It operates in a similar mode to the 'Test Panel' in the MSCL Utilities program except that it is not continuous it simply collects a single data value.

5.5.3 Mag Sus

This enables the user to zero the MS meter at any stage during the logging process.

5.5.4 Electrical Resistivity

This enables the user to zero the Electrical Resistivity meter at any stage during the logging process.

5.5.5 P-Wave

This enables the user to change the values of gate and delay (displayed in micro seconds) at any time during the logging process. The initial values are taken from the values provided in the settings file. Note that the

values in the settings file are not altered by changing the values in the Advanced options panel and hence when a new core is logged the values will revert to those saved in the settings file. Note also that this region is active only if the 'Software Gate and Delay' in the settings file is activated. This will always be yes on MSCL Serial #39 and higher as on these systems the thumbwheel switches for these functions have been removed.

5.5.6 Gamma Attenuation

This enables the user to change the values of the calibration reference and the drift reference counts per second values used to correct the gamma attenuation data for drift. Note that the values in the settings file are not altered by changing the values in the Advanced options panel and hence when a new core is logged the values will revert to those saved in the settings file.

5.5.7 Track

This enables the user to resynchronise the software with the track pusher in the event that there has been a problem e.g. the user had the switch in manual mode when it should have been in auto or if the pusher met an obstruction during logging and the motor stalled. **[Set reference Position]** should be clicked when the user has manually moved the pusher to the reference point. **[Set Pusher Position]** should be clicked when the user wishes to synchronise the pusher with the logging program. Note for the logging program to continue to operate correctly the pusher position must be set at the position shown in the Logger Control Panel. The **[Ramping]** check box turns the automatic motor ramping routines off. **[Set Track Speed]** allows the user to change the speed of the track motor.

5.5.8 Calibration File

This enables the user to write test information to a file at any time during the logging process. If the **[Write to file]** box is checked then data collected by clicking in the Data panel or the Mag Sus region can be written to a separate file which can be used later during data processing. The user can choose how it is written as a dialogue box appears before being written to file. It is Geotek's intention in future versions of the software to be able to automatically use these data in the processing panel. It will be particularly useful for correcting any drift that occurs in the magnetic susceptibility and attenuated gamma data sets. The file can be viewed by clicking the **[View File]** button.

5.5.9 Comms

The **[Close Serial Port]** button closes the serial port being used by the program enabling another program to use the serial port if needed (e.g. the MSCL Utilities program).

5.6 Graphical Data Displays (Raw & Processed)

The graphical displays of data can be viewed either while the data is being collected or subsequently when viewing old data. This section describes the facilities for viewing and manipulating data. Raw and processed data are displayed during logging, but the user may also review and process/reprocess data from the files of previously logged cores. A full description of the features available within the data display panel is given in the following sections.

5.6.1 Raw Data Display

The raw data display panel appears automatically when logging cores or when old data is selected. It consists of a series of columns that plots the various raw data collected against a vertical depth scale. Raw data is the primary data collected from the different sensors. For example; core diameter deviation, P-Wave travel time and attenuated gamma counts per second. An example of a typical raw data display is shown in Figure 44.

The size of the panel can be changed in the normal way by either clicking on the buttons in the top RH corner or by dragging on the bottom LH corner or on the sides of the panel. Unlike the processed data the raw data cannot be edited or modified in any way.

On line information:

Along the bottom edge of the display a series of parameters provides the user with on-line information. This information refers to the position of the cursor arrow on the screen. The parameters are:

[Sect] refers to the section number. For example [2 of 6] means that the arrow is located within data collected in Section 2 and there are a total of 6 sections of data available.

[Depth] refers to the depth in the current section. For example 83 cm means that the arrow is located at a position 83 cm down from the top of the current core section.

[SBD] refers to the Sub Bottom Depth. For example, 3.27 m means that the arrow is located at a position 3.27 m down from the top of the core (top of section 1).

[Val] refers to the value of the parameter. For example if the arrow is located in the Attenuated Gamma column and Val = 17560 then this means that the value of gamma counts at the position of the arrow is 17560 CPS.

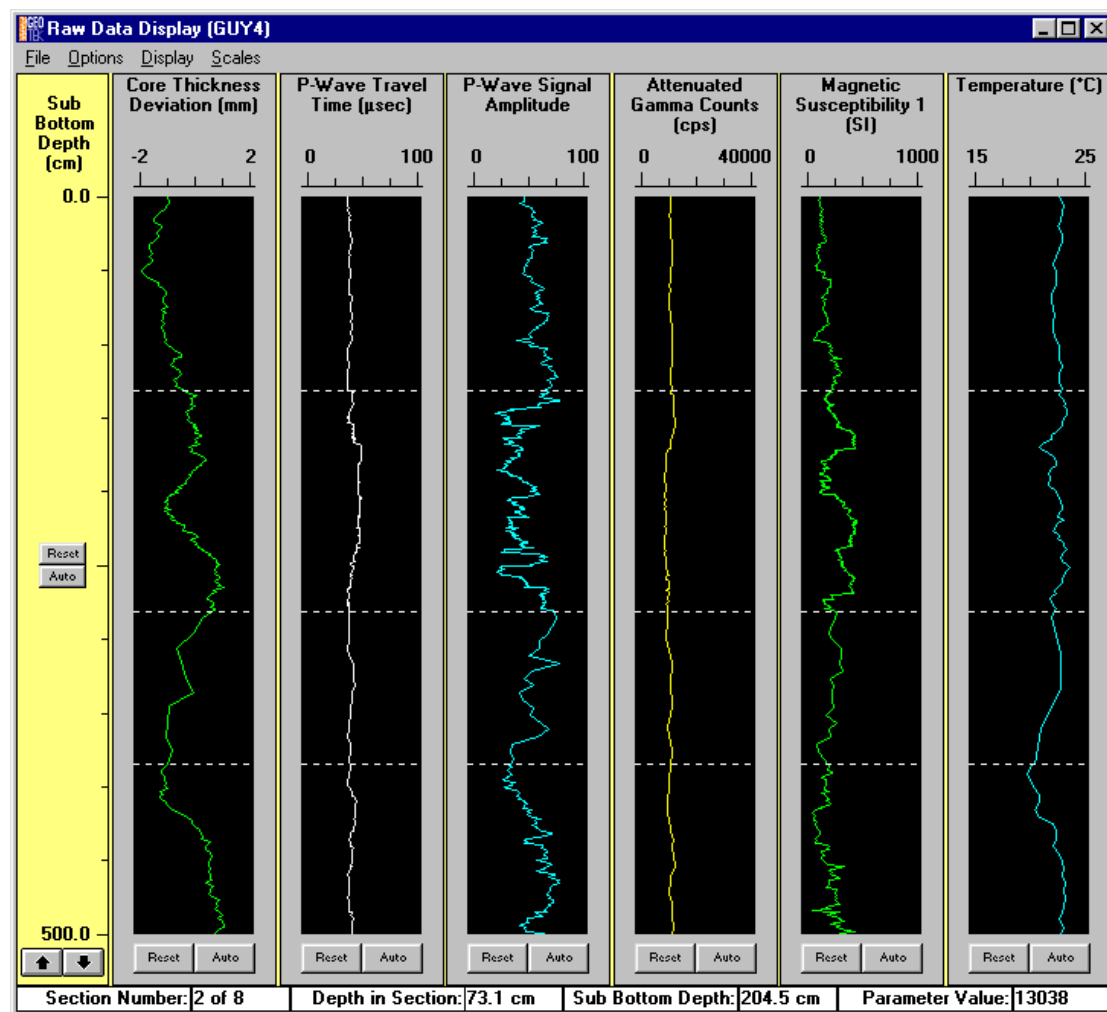


Figure 44. Raw data display panel.

This interactive row of data relating to the position of the mouse arrow is very useful when examining data in relation to the core itself. For example from the data obtained the user may wish to either visually examine the core in the area of interest or take a sub sample for other analysis. All that is necessary is to point to the area of interest and the on-line information will provide the use with the information required to locate the region with an accuracy of better than 1 mm (depending on the scale at which the display is shown).

5.6.2 Processed Data Display

The processed data display is accessed from the raw data display from the pull down menus by choosing **[Options_Processed Data]**. It consists of a series of columns that plots the calculated processed data against a vertical depth scale. Processed data is calculated from the raw data and calibration constants entered by the user (see Chapter 7). An example of such a display is shown in Figure 45.

This panel is very similar to the raw data display in the options available with one or two exceptions that are detailed later in this chapter. Unlike the raw data the processed data can be altered by changing the processing parameters or can be edited to remove bad data points.

At the bottom of the panel there is a line of parameters providing on line information which relate to the position of the mouse arrow on the screen in the same way as with the raw data display.

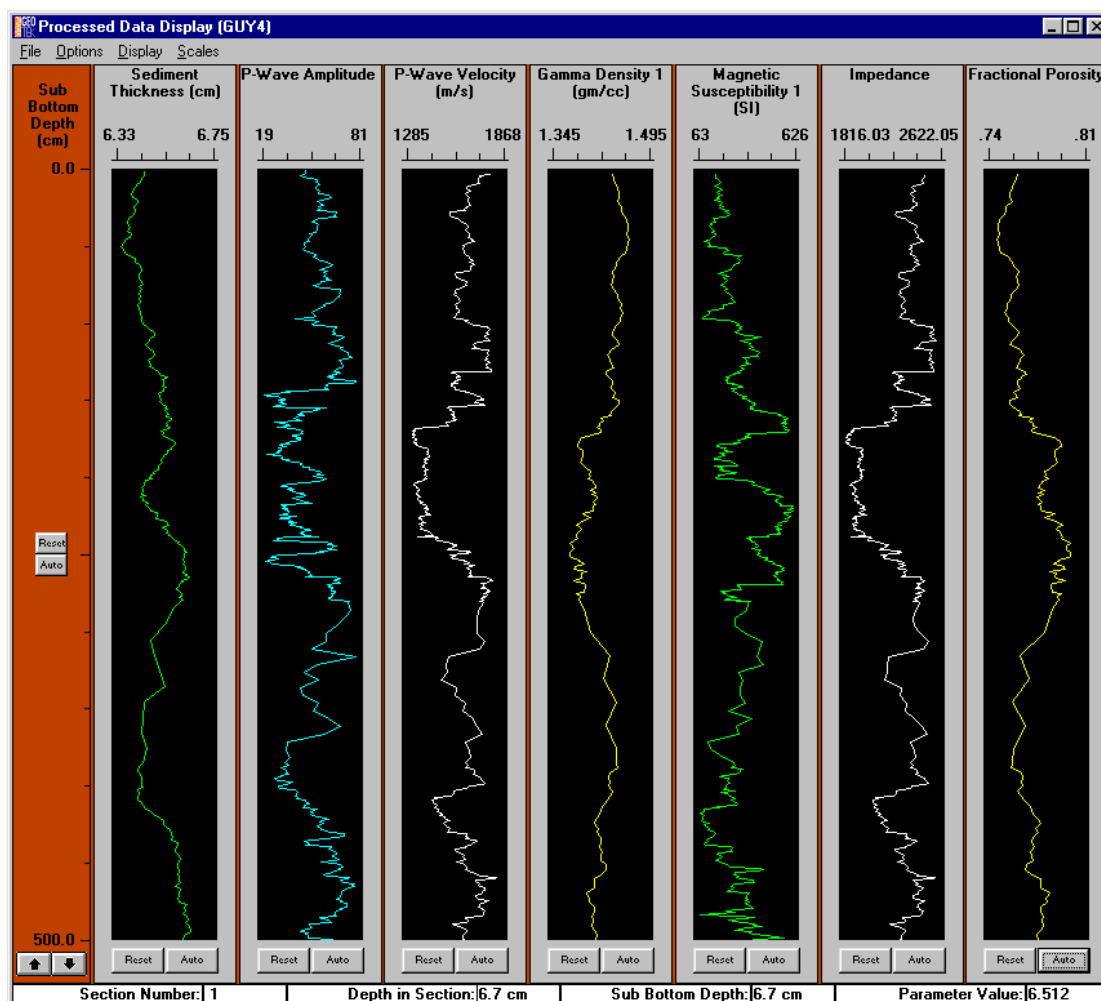


Figure 45. Processed data display panel.

5.6.3 Changing Scales

When the graphical data display panels first appear they are presented at the scales last saved as default values (see later in this section). This format can easily be changed by the user in a number of ways.

Auto Scaling: To adjust the scales to fit the data available click on the [Auto] button in any of the individual graphs or on the sub-bottom depth scale. When [Scales - Auto Scaling - Include deleted points] is chosen the auto scaling function either includes or excludes the deleted points depending on the users selection

Clicking on the axis: To adjust either the vertical sub-bottom depth scale or any of the horizontal sensor parameter scales simply click on the axis of the scale to be changed. A dialogue panel will appear as shown in Figure 46

This prompts the user to insert new Minimum and Maximum values as required. Click [OK] when ready and the graph or graphs will be re-plotted at the new scale. Note that changing the sub-bottom depth scale effects all the graphs whereas changing the sensor parameter scales only effects the parameter of interest.

Zooming with the Mouse: An alternative method for looking in detail at one particular data set is to zoom within the data set of interest. To do this the user must place the arrow at one corner of an imaginary box, which encloses the data of interest. Click and drag the mouse over the area of interest (an active box will appear to guide you). When the selection has been made release the mouse button and click inside the

drawn box. To cancel the operation click outside the drawn box. The graph will be re-drawn according to the box you have selected. Note that this operation changes both the sensor parameter scale in the chosen box and the Sub-Bottom depth scale. Consequently any other parameters that are displayed will also be re-plotted according to the new sub bottom depth scale.

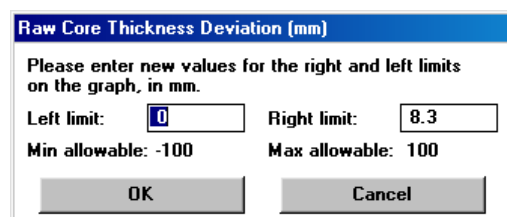


Figure 46. Change graph axis panel.

Scrolling data: By clicking on the **[Up]** and **[Dn]** arrow buttons at the base of the Sub-Bottom Depth scale the user can scroll rapidly through the complete data set. The rate at which the scrolling occurs depends on the range between Min. and Max. depths. Note that when the maximum sub bottom depth exceeds 1000 cm then the scale changes from cm to metres.

Setting default scale values: To make the current limits on the graphs the default for that display, the user must select **[Scales_Set Current As Default]**.

When the user subsequently changes these scales they can be reset by the following commands:

[Scales_Reset All Scales]: which returns both the sub bottom depth scale and the parameter scales to the default value.

[Scales_Reset Vertical Scale]: which returns only the sub bottom depth scale to the default value (leaving the parameter scales unchanged).

Alternatively the user can click on the **[Reset]** button at the bottom of each graph which will return the parameter scale of that graph only to the default value.

Note that the default scale values last set will be the scale values saved and used when the file is reopened.

Scales can also be changed by using the pop up menu that is enabled by right clicking over the graph with the mouse.

5.6.4 Display

Clicking on **[Display]** provides a list of the available graphs.

To select which graphs are displayed the user simply clicks to turn them on or off. Alternatively click on **[All]** to display all the graphs available. If there are more graphs available than will fit in the window the software will automatically limit the number of displays but will start with the first graph selected.

To view a single data set the user can simply click on the title above the appropriate graph. This will expand the graph to fill the available window. To return to the multi-graph display use the **[Display]** menu.

A popup menu can be used to access the commands in this menu item. This is accessed by right clicking inside a graph frame with the mouse.

5.6.5 File_Create ASCII File

To create an ASCII file of either raw or processed data (for export into another application) select **[File_Create ASCII File]**. A dialogue box will appear prompting the user to name the file and its destination. Note that the default convention for ASCII files is:

Raw Data Filename.asc

Processed Data Filename.out

The content of the ASCII file is identical to that viewed by using the Table command (see Chapter 5.5.10).

5.6.6 File_Load Image

Loads an image file (created by the GEOSCAN II image acquisition software) into the MSCL software for display with the other data acquired for the specific core. One of the profiles must be switched off in order to view the image alongside the other graphs.

5.6.7 File_Print Current Display

To obtain a simple print out of the graphs as shown on the screen the user can use the **[File_Print Current Display]** command. This facility only allows for simple reference print outs to be made as it is assumed that the user will use proprietary plotting applications for presentational purposes.

5.6.8 Options_Plot Style

By default the graphs consist of plots with lines only. By selecting **[Plot Style]** the user can choose either lines or points or both. Points can be very useful when viewing in detail a small number of data points but note that the screen refresh rate is much slower when large number of points are used. In both the raw and processed data displays the user can now choose the size of the data points displayed (three choices 1,2, or 3).

5.6.9 Options_Show Section Breaks

It is often useful when viewing the graphs to be able to distinguish where the breaks between each section are. To do this select **[Options_Show Section Breaks]** and a light broken line will be shown horizontally on all graphs at the section break positions. Select **[Options_Show Section Breaks]** again to turn the lines off.

5.6.10 Options_Show Deleted Points

This option can be used to show the points deleted by the user (in the Processed Data Display). These are shown in purple dots.

5.6.11 Options_Correlation Line

It can also be useful when viewing a number of graphs to be able to correlate accurately between different graphs. The **[Options_Correlation Line]** command draws a light red line horizontally across all of the graphs. To adjust the line up and down use the **U** and **D** keys on the keyboard. Select **[Options_Correlation Line]** again to turn the line off.

5.6.12 Options_Table

To view the data being displayed graphically (either in the raw or processed graphical displays) select **[Options_Table]**. A table of data will be generated which is identical in content to the files that are created using the **[File_Create ASCII File]** command (see Chapter 5.5.5).

An example of a data table is shown in Figure 47.

The user can **[page up]** or **[page down]** using the buttons provided. Alternatively to start the table from a depth other than zero, type a value in the 'Start Depth' text box and press **[ENTER]**. Use the scroll bar to look through the data as required.

5.6.13 Options_View Setup

To view the configuration panel of the core being logged or viewed select **[Options_View Setup]**. To look at the set up parameters for different sections enter the required section number in the Section Number box. The comments box can be edited at any time even when viewing old data.

5.6.14 Editing Data (processed data only)

Deleting points: Data points can be deleted from the processed data display and the associated output file 'Filename.out'. Click on the processed graph to be edited and drag a box around the points to be deleted. The points inside the box will appear highlighted. To delete these points, click inside the box while holding down the **'SHIFT'** key. To cancel the operation click outside the box. A warning message will appear to confirm your actions. Deleted points will not be plotted and they are replaced in the output data table by a **DELETED** cell.

Replacing deleted points: Points that have been deleted using the above process can be replaced. Click and drag a box on the graph of interest across the area where the points are missing. To replace deleted points click inside the box while holding down the ‘CTRL’ key. To cancel the operation click outside the box. A warning message will appear to confirm your actions.

Saving a record of deletions: When closing the processed data display the user is prompted to save a record of the points deleted such that when the data is loaded in the future the deleted data points are “recalled”.

Sub-Bottom Depth (m)	Section	Depth in Section (cm)	Core Thickness Deviation (mm)	P-Wave Travel Time (µsec)	P-Wave Signal Amplitude	Attenuated Gamma Counts (cps)
0.000	1	0.00	6.84	104.55	0	28970
0.010	1	1.00	6.41	104.75	0	21244
0.020	1	2.00	7.27	104.80	0	24481
0.030	1	3.00	5.38	104.55	0	14782
0.040	1	4.00	1.43	91.05	0	14708
0.050	1	5.00	0.71	78.50	0	14704
0.060	1	6.00	0.39	103.20	0	14544
0.070	1	7.00	0.30	77.05	0	14337
0.080	1	8.00	0.25	87.90	0	14321
0.090	1	9.00	0.23	82.85	0	14039
0.100	1	10.00	0.20	93.90	0	13861
0.110	1	11.00	0.17	82.90	0	13881
0.120	1	12.00	0.13	88.85	61	13667
0.130	1	13.00	0.12	94.20	35	13844
0.140	1	14.00	0.11	83.40	0	13844
0.150	1	15.00	0.09	82.75	0	13916
0.160	1	16.00	0.05	82.90	0	14412
0.170	1	17.00	0.04	83.35	50	14834
0.180	1	18.00	0.02	84.35	0	14464
0.190	1	19.00	0.02	84.70	0	14526
0.200	1	20.00	0.02	83.70	29	14818
0.210	1	21.00	0.02	82.60	53	14535
0.220	1	22.00	0.01	82.95	0	14426
0.230	1	23.00	0.02	64.45	42	14339
0.240	1	24.00	0.00	65.00	59	14398
0.250	1	25.00	-0.01	65.50	84	15028
0.260	1	26.00	-0.03	66.15	73	15009
0.270	1	27.00	-0.04	76.30	60	14657
0.280	1	28.00	-0.06	83.35	0	14131

Figure 47. Raw data table panel.

5.6.15 Data Processing Panels

The processed data is calculated from the raw data and calibration parameters according to pre-defined equations. The calibration parameters are calculated during the calibration procedures for each sensor system (see Chapter 7). The equations are displayed in processing panels which can be viewed and edited using the [Options Processing Panel] command from the processed data graphical display. A list of processed parameters is displayed which depends on the available data. The user can select (or deselect) which parameters are to be processed simply by clicking on the parameter of interest. If you want the data processed click the tick (the name will be shown in upper case). If you do not want the data processed click the cross (the name will be shown in lower case). The panel will appear ready for examination and/or editing. An example of one of the panels (Gamma Density) is shown in Figure 48.

Within each panel the governing equation is displayed together with a short-form explanation. At the top of the panel there are text boxes which can be edited by entering the correct calibration constants. A detailed explanation of all the processing panels is given in Chapter 7.

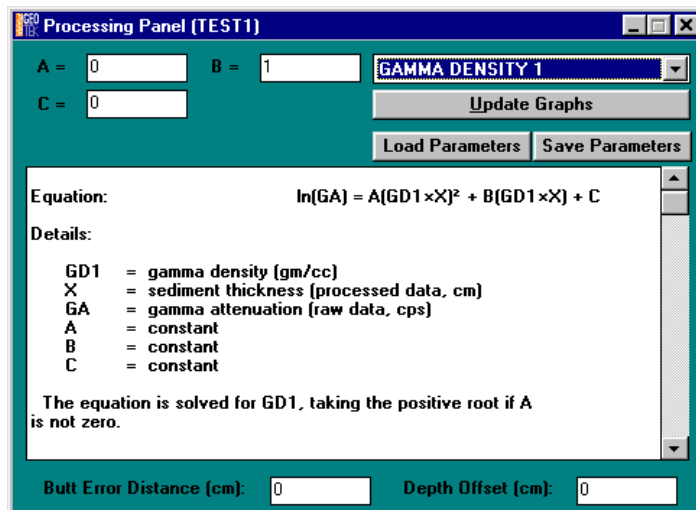


Figure 48. Gamma density processing panel.

In all the processing panels there are 2 text boxes at the bottom of the panel that relate to the sub bottom depth calculation. The **[Butt Error Distance]** refers to the thickness of the core end caps. Obviously the core is longer by the accumulated error of the end caps and the user can correct for this error by assuming that all the end caps have a constant thickness. If a value is entered then any data that falls in the end-cap thickness is deleted from the processed data set and the sub bottom depth is adjusted accordingly. The **[Depth Offset]** value refers to the estimated real depth below the sea floor of the top of Section 1. Obviously if the top of Section 1 has a sub bottom depth of zero then 0 should be entered in this box.

To re-plot the data according to the values entered in the processing panel select **[Update Graphs]**.

The **[Load Parameters]** and **[Save Parameters]** buttons can be used to load and save sets of processing parameters. The parameters are viewed and can be edited in a dialogue box as shown in Figure 49. The files are saved with a *.pro extension.

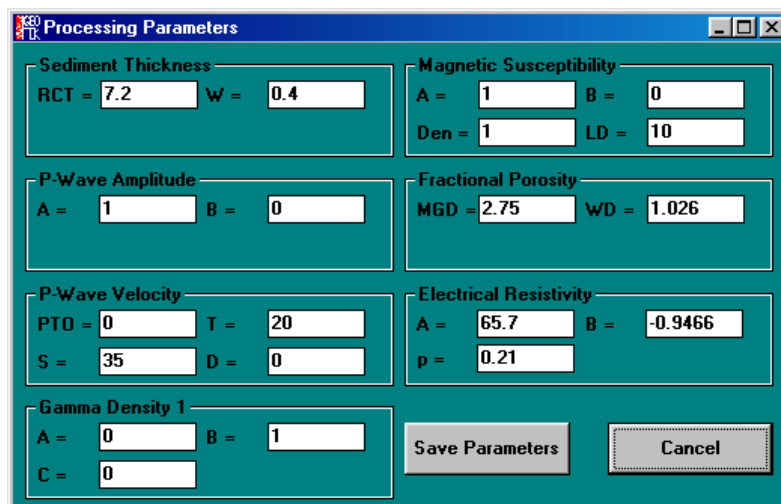


Figure 49. Save/Load processing parameters. All the parameters are shown and are user editable.

6. The PC, Microprocessor and MSCLE Utilities Software

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6.1 Chapter Overview

This chapter briefly describes the interaction between the host PC and the microprocessor. It describes the facilities available in the utilities software which enables the user to perform a number of functions that are necessary to customise the logger and test the individual sensors. It also enables the user to load, view edit and save the Microprocessor software. To load the utilities software onto the host PC please refer to section 3.8. The procedure for loading the microprocessor software is described within this chapter.

6.2 The Microprocessor

6.2.1 Hardware

The primary command software for the MSCL resides in a microprocessor (MP) unit that is in the main electronics rack. The MP is the Intel 8052AH BASIC, a version of the 8051 micro-controller with an on-board BASIC language interpreter. This system provides all the interfacing between the core logger and the PC, using a simple RS232 interface.

Linked directly to the main MP board are the boards containing the A to D converters, the serial interface and the gamma counter board. The complete MP system forms an independent stack, supported over the main PW electronics board.

6.2.2 Software and Terminal Window

When the MSCL Utilities software is run an active terminal window appears that gives the user direct access (in terminal mode) to the MP software. This software is pre-loaded in battery backed Read Only Memory (ROM) and is automatically active when the system is switched on. The MP software has the identifying extension .I52 and if for any reason (e.g. battery failure) the software is erased from ROM then it must be reloaded.

To check that the I52 programme is loaded in ROM turn the power off at the main electronics rack and run the Utilities programme. Turn the main power on and observe the display in the terminal window. If a series of hexadecimal characters are scrolled within the display and end with an active cursor then the programme is present in ROM and is now running.

If nothing happens then there is no programme in ROM either because it has been deleted or because the back up battery has failed. To initialise the MP the space character (ASCII code 32) must be received through the serial port. If it receives any other character first, the microprocessor will not function and must be turned off before continuing. Press the space bar and the following message will appear:

```
*MCS-51(tm) BASIC v1.1*  
READY  
>
```

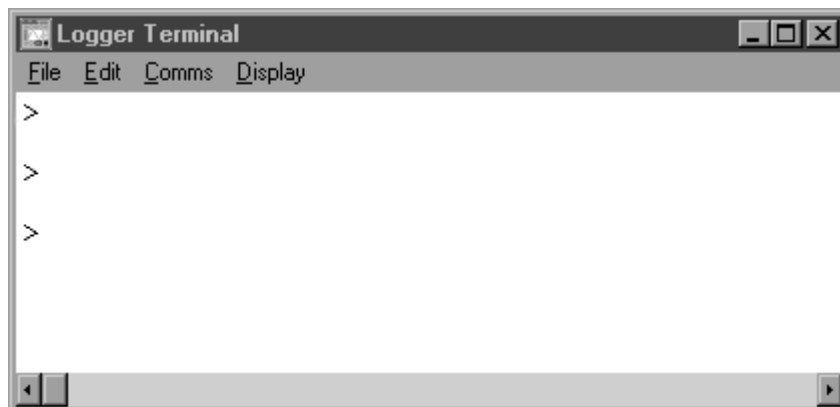


Figure 50. Logger terminal panel.

If this occurs then it confirms that there is no programme in ROM. To reload the I52 software see Section 6.2.4.

6.2.3 ROM/RAM modes

The MP can operate in two modes; ROM mode (which is the default mode when switched on) or in RAM (Random Access Memory) mode. The MP will operate in whichever mode it is set. Programmes in ROM cannot be edited directly and are preserved, when the main power is off, by the backup battery as described above. Programmes in RAM can be edited directly but are lost immediately the power is turned off.

Programmes can be transferred to and from ROM and RAM locations using the following commands:

ROM to RAM: To transfer software from ROM to RAM first ensure that the RAM memory is empty. Type RAM (CR) to ensure you are in RAM mode. Type NEW (CR) to clear the contents of RAM (this is important because the process only updates line numbers and corruption can occur if the memory is not empty. Revert to ROM mode by typing ROM (CR). Then type XFER (CR) to transfer the code to RAM. This can be checked by going back to RAM mode (type RAM (CR)) and then typing LIST (CR). A programme listing will appear.

RAM to ROM: To transfer software from RAM to ROM first be sure that the programme in RAM is the one you want to save. Ensure you are in RAM mode and Type GOTO 30000 (CR). The code will be loaded into ROM and the progress can be viewed in the Terminal Panel. This process can take a few minutes depending on the size of the programme.

6.2.4 File Transfer to and from the PC

To transfer a file from the PC to the MP the user should use the **[File Upload to Micro]** command. A dialogue box will appear asking the user which file is to be uploaded. This process will place the programme in RAM. Once you are sure this is the programme you wish to keep it should be loaded into ROM as described above.

To transfer an I52 programme from the MP to the PC the user must use the **[File Download to PC]** command. A dialogue box will appear asking the user to name and define the location of the file. Note that it is the file from RAM that is downloaded hence if you are saving a programme from ROM then you must first copy it to RAM before downloading to the PC.

If the user wishes to trace the output from the MP then select the **[File Output to File]** command. A file will be written in which the output is recorded.

6.3 Logger Settings

Logger settings are a series of parameters that define the sensor and mechanical configuration of the logger as well as the calibration constants. It is essential that these parameters are set accurately to ensure that the main application operates correctly and provides accurate raw data. When **[File Logger Settings View]** is selected a settings panel is displayed as shown in Figure 51.

You can load a different settings file into the program BUT by default the software, both the Utilities and the Logging Software will load the settings defined in the file MSCL5_2.SET in the C:\WINDOWS directory. To open and use a different settings file you must press **CTRL-ALT-O** and to save the current settings you should press **CTRL-ALT-S**. Following either of these key presses the open and save dialogue boxes respectively will appear. The settings file that you open will not be used during any subsequent sessions of either the Utilities or the Logging Software.

NOTE: By default both applications will load the setting stored in the file MSCL5_2.SET in the C:\WINDOWS directory.

A text file of all the settings parameters can be created by selecting **[File Logger Settings Output to file]**.

It is possible to create a series of different settings columns and choose which one is operational at any time. A list of all the settings together with a description of each setting is given below. Please note that these labels will change according to the type of track installed.

To create a new column click on **[Add Column]** and an additional column will be created that has the same settings as the column on the far right.

To delete an unwanted column click on the column to be deleted and click on **[Remove Column]**.

Name	Standard
Use these settings (yes/no)	yes
Attenuated gamma sensor (yes/no)	yes
Attenuated gamma sensor offset (cm)	20
Gamma detector version (1=old,2=new)	2
Calibration reference counts per second	1
Drift reference counts per second	1
P-Wave sensor (yes/no)	yes
P-Wave sensor offset (cm)	38
Software controlled gate and delay	yes
P-Wave gate (µsec)	50
P-Wave delay (µsec)	100
Minimum signal amplitude (A-D bits)	0
Maximum signal amplitude (A-D bits)	1000
Core displacement sensor (yes/no)	yes
Core displacement sensor offset (cm)	38
Offset on displacement data channel (mm)	0
Scale on displacement data channel (mm/bit)	5.040322E-03
Temperature sensor (yes/no)	yes
Temperature sensor offset (cm)	38
A to D data channel for temperature data (4 or 7)	4
Offset on temperature data channel (deg C)	-18.65541
Scale on temperature data channel (deg C/bit)	.004276
Magnetic susceptibility sensor (yes/no)	yes
Magnetic susceptibility sensor type (point/loop)	loop
Magnetic susceptibility sensor offset (cm)	84
Natural Gamma sensor (yes/no)	yes
Offset on natural gamma sensor (cm)	0
Number of detectors for natural gamma	1
Non-contact resistivity sensor (yes/no)	yes
Non-contact resistivity sensor offset (cm)	0
Offset on non-contact resistivity data channel (mV)	0
Scale on non-contact resistivity data channel (mV/bit)	1
Camera (yes/no)	yes
Camera Offset (cm)	2
Logger type (1=standard,2=unrestricted pusher,3=boat,4=moving sensors,5=vertical)	1
Auto/manual switch detect (yes/no)	yes
Track laser (yes/no)	yes
Track laser offset (cm)	6.8
Right limit of pusher movement (cm)	159
Left limit of pusher movement (cm)	-
Track motor steps per revolution	400
Track motor gear ratio	100
Track motor pulley teeth * belt pitch (mm)	400
Track motor speed (0-2)	1.6
Negative Ramping Threshold (cm)	20
Positive Ramping Threshold (cm)	200
Vertical motor (yes/no)	yes
Vertical motor steps/revolution	400
Vertical motor gear ratio	30
Vertical motor pinion teeth * rack pitch (mm)	50
Vertical motor speed	1.6

Figure 51. MSCL settings panel.

To edit a cell in the table click on the cell to be edited and the current value will be displayed in the top left hand editing box. Highlight the parameter and edit. When correct press **CR** and the new value will be entered.

If a sensor is not present and is set to NO then the parameters relating to it are automatically hidden.

Name	The user can define the name of each column
Use these settings (yes/no)	Yes sets the column to be active and automatically sets all remaining columns to be no (inactive)
Attenuated gamma sensor	“Yes” if gamma detector present; else “No”
Attenuated gamma sensor offset (cm)	Distance between reference position and sensor (whole cm).
Gamma Detector Version (1=old, 2=new)	1 is the old system that uses the SD1 electronics (loggers 1-15). 2 is the new system that uses the integrated detector (loggers >15)
Calibration reference counts per second	Calibration parameter.
Drift reference counts per second	Calibration parameter.
P-Wave sensor (yes/no)	“Yes” if P-Wave system present; else “No”
P Wave sensor offset (cm)	Distance between reference position and sensor (whole cm).
Software controlled gate and delay	“Yes” if software gate/delay present, else “No”
P-Wave gate (µs)	Time of gate, default 500
P-Wave delay (µs)	Time of delay, default 0
Minimum signal amplitude (A-D bits)	Calibration parameter.
Maximum signal amplitude (A-D bits)	Calibration parameter.
Core displacement sensor	“Yes” if displacement transducers present; else “No”
Core displacement sensor offset (cm)	Distance between reference position and sensor (whole cm). Normally same as P Wave transducer offset.
Offset on displacement data channel (mm)	Calibration parameter - see notes below.
Scale on displacement data channel (mm/bit)	Calibration parameter - see notes below.
Temperature sensor (yes/no)	“Yes” if temperature sensor present; else “No”
Temperature sensor offset	Distance between reference position and sensor (whole cm). Normally same as P Wave transducer offset.
A/D data channel for temperature data (4 or 7)	Normally 4 but 7 on some early systems
Offset on temperature data channel (deg C)	Calibration parameter - see notes below.
Scale on temperature data channel (deg C/bit)	Calibration parameter - see notes below.
Magnetic susceptibility sensor (yes/no)	“Yes” if magnetic susceptibility sensor present; else “No”
Magnetic susceptibility sensor type (point/loop)	Point or Loop as appropriate
Magnetic susceptibility sensor offset (cm)	Distance between reference position and sensor (whole cm).
Electrical resistivity sensor (yes/no)	“Yes” if non contact resistivity sensor present; else “No”
Electrical resistivity sensor offset (cm)	Distance between reference position and sensor (whole cm).
Offset on electrical resistivity data channel (mV)	Calibration parameter - see notes below.
Scale on electrical resistivity data channel (mV/bit)	Calibration parameter - see notes below.
Camera (yes/no)	“Yes” if camera present; else “No”
Camera offset (cm)	Distance of the camera to the right of the reference point
Track type (1=standard 2=unrestricted pusher, 3=boat, 4=moving sensors, 5=vertical)	1,2,3,4 or 5 as appropriate. Standard - pusher system where pusher is restricted to RH box section; Unrestricted pusher - pusher system where pusher moves through sensors; Boat - where core is placed in core boat; Moving sensors - where sensor move past stationary core; Vertical – sensors move past vertical core.
Auto/Manual switch detect	“Yes” if present, else “No”.
Track laser	“Yes” if laser is present, else “No”.
Track laser offset (cm)	Distance to the right of the reference point of the laser beam.
Right limit of pusher movement (cm)	Max. distance (cm) from reference position to RH limit switch. This should be set so that the pusher or core boat does not hit the switch.
Left limit of pusher movement (cm)	Only applicable for track types 2 & 3. Max. distance (cm) from reference position to LH limit switch. This should be set so that the core or core boat does not hit the switch.
Track motor steps/revolution	No of steps/rev on track stepper motor (normally 400)
Track motor gear ratio	Gear box ratio (normally 100 or 120)
Track motor pulley teeth * belt pitch (mm)	No of teeth on pulley (normally 40) * belt pitch (normally 10 mm).
Track motor speed	Speed of track motor (normally 1.6)
Negative Ramping Threshold (cm)	Distance above which the motor will ramp in a negative direction
Positive Ramping Threshold (cm)	Distance above which the motor will ramp in a positive direction
Acoustic motor (yes/no)	“Yes” if acoustic/vertical motor present; else “No”
Acoustic motor steps/revolution	No of steps/rev on acoustic/vertical stepper motor (normally 400)
Acoustic motor gear ratio	Gear box ratio (normally 30 or 60)
Acoustic motor pinion teeth * rack pitch (mm)	No of teeth on the pinion on the vertical slide (normally 50) *pitch of teeth on rack (normally 1)
Acoustic motor speed	Speed of vertical motor (normally 1.6)

Scale and offset values are required for analogue data inputs such as the displacement transducers and temperature sensor. They can vary between different systems and are calculated at the factory and entered into the settings file before the equipment is commissioned. However, the calibration can be checked by the user. Full details are given in Chapter 7.

Calibration Reference CPS and Drift Reference CPS are values that enable the user to correct for small amounts of drift which may occur with the gamma detector system without the need to carry out a complete recalibration. A slightly new calibration/drift correction protocol is needed. At the time of the main calibration the user should select a reference piece which ideally should be a block of aluminium with a thickness that provides a gamma count rate that is similar to the cores being logged. At the time of the calibration the user should measure the gamma count rate CPS in the reference piece. This value should be entered as the Calibration Reference in CPS (CR). Initially the Drift Reference (DR) in CPS is the same as CR. During the logging process the user may wish to check on any drift that has occurred by measuring DR again. The new value can be entered into the settings file before logging a new core. All measured values are corrected according to the ratio of DR/CR.

i.e. Corrected CPS = Measured CPS * DR/CR

The measured and corrected values are shown in the results when using the test panel. If there is no correction to be applied then ensure that the values of CR and DR in the settings file are the same. Note also that the values of DR and CR can only be changed before logging a new core not in the middle of logging a core.

Minimum & Maximum Amplitude. These values relate to the P Wave amplitude measurements. Prior to logging open the test panel and select P Wave amplitude. Place the transducers close together but leaving a small air gap and note the AD(7) number. This should be entered in the setting file as the value under "Minimum Amplitude". Then place a water core between the transducers and note the AD(7) number again. This should be entered in the setting file as the value under "Maximum Amplitude". The relative P wave amplitude value will then be calculated and displayed on a Log scale 0 to 100 between these 2 values.

6.4 Test Panel

The test panel enables the user to operate the track, vertical slide and all the sensor systems through the PC. In this way the user can test individual systems and monitor the output of the different sensors during set-up procedures. The test panel routines use the same software elements as the main application programme and hence the test panel acts as a complete software and hardware test system. The Test Panel appears when [File_Test Panel] is selected as shown in Figure 52.

The configuration of the test panel depends on which sensors are available as defined by the Settings File. To operate any test simply select the appropriate test box. The output of the test routine is displayed in the Terminal display panel. To stop the routine either select the box again or another box.

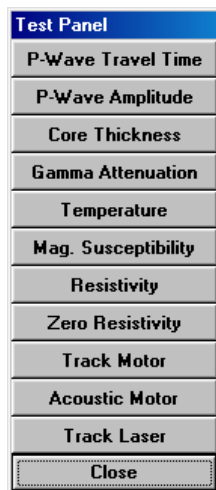


Figure 52. Test panel.

P-Wave Travel Time: provides the travel time between the two PWTs in µs; e.g. 50.05 µs.

P-Wave Amplitude: provides the digital AD output together with the computed value which is obtained from the settings file parameters (scale and offset).

Temperature: provides the digital AD output from the PRT together with the computed value of temperature which is calculated from the settings file parameters.

Core Diameter Deviation: provides the digital AD output together with the computed value which is obtained from the settings file parameters.

Gamma Attenuation: When selected the user is prompted to enter a count time in seconds. The display then shows both the total counts and the CPS (counts per second) value.

Magnetic Susceptibility: When this box is selected ensure that the MS2 meter is in automatic mode (toggle switch in centre position). The value will be displayed which should be the same as that shown on the MS2 LCD.

Resistivity: provides the digital A-D output from the resistivity meter with the computed value or resistivity response that is calculated from the settings file parameters.

Zero Resistivity: zeroes the resistivity meter

TrackMotor: When this box is selected the user is prompted to enter a distance that the pusher will move. If a positive number is entered the pusher will move to the left and a negative number will cause the pusher to move to the right. The user can test the ramp routine by checking the box provided, ramping will only occur when the pusher moves to the right.

Acoustic Motor: When this box is selected the user is prompted to enter a distance that the vertical slide will move. If a positive number is entered the slide will move down and a negative number will cause the slide to move up. The acoustic motor will ramp up and down.

Track Laser: Selecting this button displays if the track laser beam is broken or unbroken.

6.5 Edit

The edit facility enables the user to view and edit the I52 programme in the microprocessor.

***** **Warning** *****

Editing the I52 programme should only be carried out under instructions from GEOTEK or by advanced users of the system.

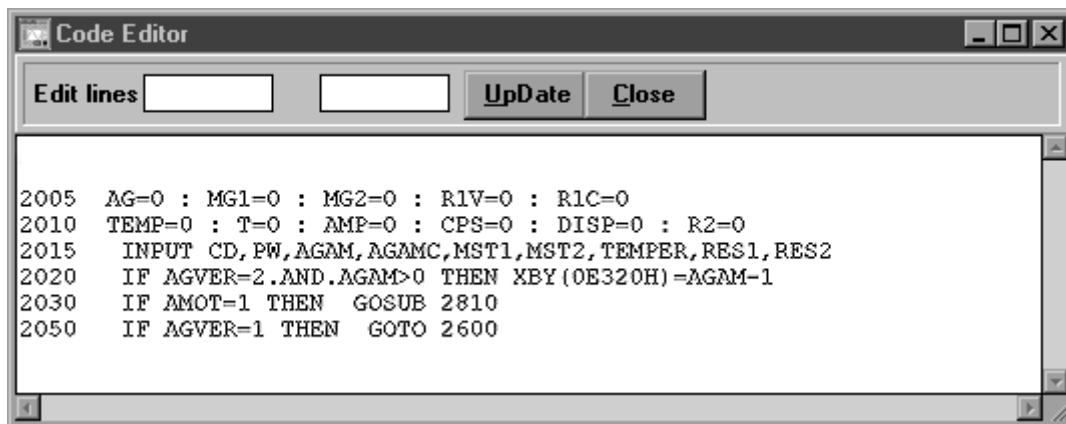


Figure 53. Code Editor panel.

To edit the I52 programme then it must be in RAM mode (see Chapter 6). Therefore the user must first copy the file to RAM. After selecting **[Edit]** an edit panel appears in which the user should enter the line numbers to be viewed and/or edited in the 2 boxes available. The lines of code can be edited in the window and saved by selecting **[Update Code]**. This updates the code in RAM only. If the user wishes this edited code to be the one automatically used in the future then it must be copied to ROM (see section 6.2.3).

6.6 Other Commands

6.6.1 Comms

Comms_Change Serial Port: enables the user to change the serial comms port being used to connect the PC to the MP. Note that normal PORT 1 is normally used for the PC mouse (unless a PS/2 mouse is installed) and PORT 2 is used for the MP.

Comms_Send Break enables the user to send a 'Break' character to the MP if needed. This will only be required by advanced users who are changing the MP I52 code and are in a test mode.

6.6.2 Display

This command enables the user to clear the display, change the background colour (black or white and change the font size on the display. Increasing the font is can be valuable when attempting to view numbers on the monitor when the user is at some distance from the screen. If you find that the terminal window does not store a sufficient number of lines to scroll back to the information required then the maximum number of lines can be increased up to 5000 (in practice this does not generally need to be altered). To invoke the dialogue box that permits a change press **CTRL-ALT-L**.

7. Operational Protocols, Calibration and Data Processing

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7.1 Chapter Overview

This chapter explains in detail the general operational protocols that are assumed by the automated logging software. It explains how the various sensor systems should be calibrated and how the software automatically uses this information in processing the data. It is important that the user follows these protocols to ensure that the data obtained is accurate and of the highest quality. It is also important to understand how the system works if the user wishes to depart from the normal operating protocols and procedures if the implications of that departure are to be appreciated.

7.2 Core Handling

It is important to recognise at the outset that the quality, and hence value, of core logs is to a large extent dependent on the physical quality of the cores being logged. No matter how sophisticated the individual measurement techniques are or how skilled the operator is, poor quality core will result in poor quality logs.

Log data quality is a function of:

1 - Quality of the recovered core.

Problems:

- a) Poor recovery and disturbed sediment cores.
- b) Disturbance to cores as a result of bad handling and storage.

Solutions:

- a) Use the correct coring equipment for the prevalent conditions, accounting for weather, operator skill and the ship's capabilities.
- b) Once a core is recovered treat it with care and ensure correct storage (i.e. the right way up and at the correct temperature).

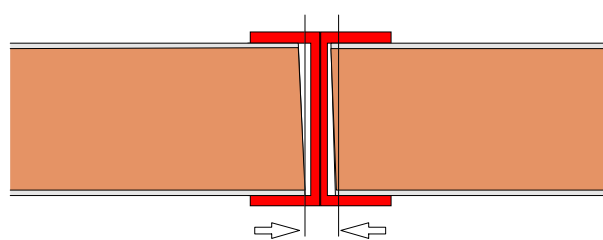
2 - Core sectioning.

Problems:

- a) Errors in measuring section lengths and butt error distance (see Figure 54).
- b) Compounded length problems.

Solutions:

- a) Sections should be cut perpendicular to the core length.
- b) Adjacent sections should be oriented during sectioning and aligned during logging.



Butt error distance

Figure 54. Representation of butt error distance.

3 - Core splitting.

Problems:

- a) Inconsistent core thickness and cross-sectional area.
- b) Poor sensor contact and variable thickness due to uneven core surfaces.

Solutions:

- a) Split the liner consistently and correctly align adjacent sections.
- b) Ensure that the core surface is as flat as possible.

4 - Liner quality.

Problems:

- a) Core liner that is not perfectly round.
- b) Variations in liner thickness.

Solutions:

- a) Use liners as soon as possible after purchase and ensure that adjacent sections are marked so that they can be aligned during splitting and logging.
- b) It is a fair assumption that liner thickness will not vary greatly although the user should be aware that these variations cause errors.

5 - Corer endcaps (Figure 55).

Problems:

- a) Loss of acoustic contact for p-wave transducers with errors compounded by inaccurate core diameter measurements.
- b) Endcaps necessitate the use of a larger magnetic susceptibility loop.
- c) Endcaps increase the overall length of the core (1-2% depending on the care taken to ensure a good fit).

Solutions:

- a, b & c) Ideally cores should be logged without endcaps, internal endcaps are a viable second choice (i.e. for soupy cores) and a third alternative is to make cut outs in the end caps as shown in Figure 55. One solution, often employed, is simply to discard the data around the end caps. This is hardly satisfactory as the user could be discarding up to 10% of the data. Most users who adopt this technique normally find that the most interesting lithological boundaries occur within the end-cap region of each section!

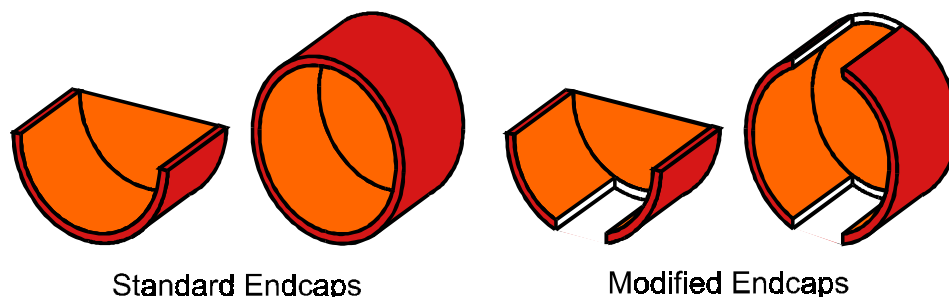


Figure 55. Cut away endcaps to improve quality of p-wave velocity and gamma density data.

7.3 Track and Vertical Slide Positioning

7.3.1 Track and Core Pusher

As explained in Chapter 2 each core section passes through the sensor array by using the pusher system. The microprocessor does not independently 'know' at any time the position of the pusher. The position of the pusher is known only when it is at the 'reference position' and the user informs the computer that it is there by the [Set Ref. Point] instruction. All other positions are continuously calculated by summing all the subsequent pusher motions.

The motion of the core pusher is calculated as the number of steps (needed to move a set distance. The relationship is:

$$NS = \frac{D * SPR * GBR}{P * NT}$$

where:

- D is the distance moved (mm)
- NS is Number of steps
- P is the pitch of the toothed belt (1.0 cm)
- NT is the number of teeth on the drive pulley

SPR is the number of steps for a revolution of the stepper motor
 GBR is the gearbox ratio

All these parameters are defined in the settings file, apart from the belt pitch, which is assumed to be 1 cm.

7.3.2 Vertical Slide and PWTs

When logging split cores it is normally necessary to lift the P Wave transducers and point magnetic susceptibility sensor clear of the core prior to moving the core to its next position. The positioning of the slide is similar to the way the pusher operates in that all movements are monitored after a zero position is set (see Chapter 5.4.2).

The motion of the vertical slide is calculated as the number of steps needed to move a set vertical distance. The relationships is:

$$NS = \frac{D * SPR * GBR}{P * NT}$$

where:

D is the distance moved (mm)
 NS is Number of steps
 P is the pitch on the rack (1.0 mm)
 NT is the number of teeth on the pinion
 SPR is the number of steps for a revolution of the stepper motor
 GBR is the gearbox ratio

All these parameters are defined in the settings file, apart from the rack pitch that is assumed to be 1 mm.

7.4 Displacement Transducers/Core Diameter/Sediment Thickness

7.4.1 Calibrating the displacement transducers

The thickness of the sediment in the core is an important component parameter in the calculation of many logs. It is measured using the 2 displacement transducers. In the case of whole cores the outside diameter of the core is measured and the sediment thickness is calculated by subtracting 2 * the liner wall thickness. In the case of split cores the half diameter of the core is measured and the sediment thickness is calculated by subtracting 1 * the liner wall thickness.

The analogue voltage from the transducers is digitised channel AD(5). It is scaled so that the output on the LCD display (core diameter deviation) is correct. This can be checked and adjusted if necessary by using the 'span' adjustment pot (Serial # <39). Select 2 suitable round calibration bars of know diameter (with a difference in diameter of about 20 mm). Adjust the relative positions of the P-Wave transducer housings such that both pieces can be placed between the transducers with them in contact.

Select [**Core Thickness**] from the test panel in the Utilities programme. In the Logger Terminal panel a continuously updated display will show the digital value of core and the computed value of displacement (e.g. AD(5) = 3130 Displacement = 6.17 mm). Secure the housings and place the smaller calibration piece between the transducers and adjust the 'zero' pot so that AD(5) = 0; the LCD should also read 0. Note that using the values from the computer screen is more accurate than using the value from the LCD display. Remove the smaller calibration piece and insert the larger piece. The LCD displacement reading should read the difference in diameter between the 2 pieces. If not then adjust the span adjustment so that the reading is correct. Repeat the process to ensure that it is set correctly. It can be further checked by inserting different diameter pieces.

The above process ensures that the LCD reads correctly which is useful for visual monitoring during core logging. To ensure that the computer collects the correct number it is necessary to calibrate the digital output as follows. Repeat the above process whilst the [**Core Thickness**] test from the test panel is running.

The computed value of displacement $DISP(mm) = AD(5) * DISP(scale)$

where $DISP(scale)$ is the value entered in the settings file. Typically this value will be about 0.002

Calculate DISP(scale) using the AD(5) value and DISP (the difference in diameter of the 2 calibration bars in mm). Enter the new value into the settings file and check that the correct value of Displacement is shown when the test is run again.

The method of setting the position of the transducers prior to logging is described in Chapter 3.

7.4.2 Sediment Thickness Data Processing

Having calibrated the displacement transducers the raw data provides the deviation in diameter between a reference piece of known thickness and the actual thickness at any point. The sediment thickness (which is the real parameter required) is therefore calculated using the following equation:

$$X = RCT - W + CTD/10$$

where:

- X = sediment thickness (cm)
- RCT = reference core thickness (cm)
- W = total liner wall thickness (cm)
- CTD = core thickness deviation (raw data, mm)

This equation is shown in the Sediment Thickness processing panel as shown below.

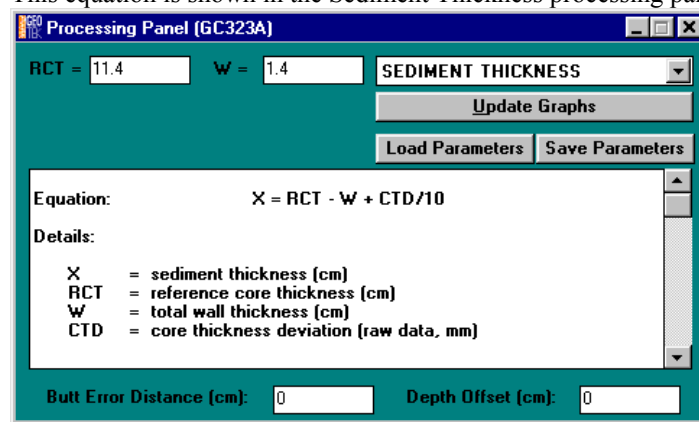


Figure 56. Sediment thickness processing panel.

The user simply enters the values of RCT and W in the boxes provided. Note that for whole cores W=2 * liner wall thickness; whereas for split cores W=1 * liner wall thickness. Having followed the above procedures the correct values of sediment thickness will be recorded, displayed and used to calculate other important parameters (e.g. P Wave velocity and gamma density).

7.5 Temperature

7.5.1 Calibrating the PRT temperature probe

The analogue voltage from the PRT probe/electronics is digitised (normally on AD(4)). When [Temperature] is selected from the test panel a continuously updated display is provided in the terminal window; for example:

$$AD(4) = 10136 \quad \text{Temperature } ^\circ\text{C} = 16.35$$

The output from the temperature probe is proportional to temperature. Therefore, to calibrate the temperature probe the user must obtain 2 AD(4) readings (A1 and A2) at 2 known temperatures (T1 and T2). This is most easily done by inserting the probe in a beaker of water with a calibrated thermometer. The scale (S_t) and offsets (O_t) for the temperature probe must be entered in the 'settings file' and then the temperature output will be correct. This can be checked by observing the temperature reading when the temperature test is running.

$$\text{Temp} = AD(4) * S_t + O_t$$

To calculate S_t & O_t use the following relationships:

$$S_t = (T2-T1)/A2-A1 \quad \text{Typical value around } 0.0038$$

$$O_t = T1-A1 * S_t = T2-A2 * S_t \quad \text{Typical value around } -24$$

7.6 P Wave

7.6.1 P Wave Velocity

The P Wave velocity of the ultrasonic pulse through the sediments inside the core liner is given by;

$$VP = X/TT$$

where:

X is the sediment thickness inside the core liner as measured.

TT is the pulse travel time in the sediment.

The measured total travel time, TOT, is given by;

$$TOT = TT + PTO$$

where: PTO is the P Wave Travel time Offset which is all the additional time delays.

PTO includes the pulse travel time through the liner, the pulse travel time through the transducer faces, the delay caused by picking a point on the wave form which is about 1 cycle after the onset, as well as a small electronic delays in the system circuitry. This parameter must be determined to calibrate the system. It will vary depending on both the core liner being used and whether whole core or split core measurements are being made.

Determining PTO:

Cut a short length of liner (about 30 cm) of the type (and preferably the same manufacturer's batch) being logged. Fill the liner with distilled water and place between the P-Wave transducers as if logging a normal core. When using whole cores the whole core liner should be capped, taped and inserted between the transducers (see Figure 57). When using split cores a split liner should be used with the upper transducer inserted just beneath the water surface.

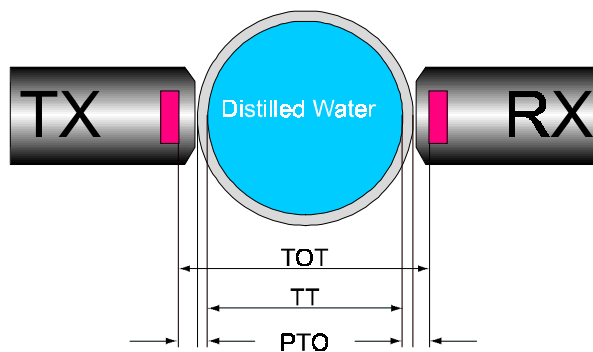


Figure 57. Schematic view of p-wave calibration.

The following numbers should be recorded:

T = water temperature

D = distance between the transducer faces

TOT = total travel time recorded using the test panel

The velocity, V_t , of the distilled water at the given temperature T should be looked up from a standard reference source (also see Figure 58).

PTO can then be simply calculated from the following equation

$$PTO = TOT - (D - W) / V_t$$

where: W is the total liner wall thickness as used in the sediment thickness calculation (see section 7.4.2).

Sound Velocity in Distilled Water at Atmospheric Pressure

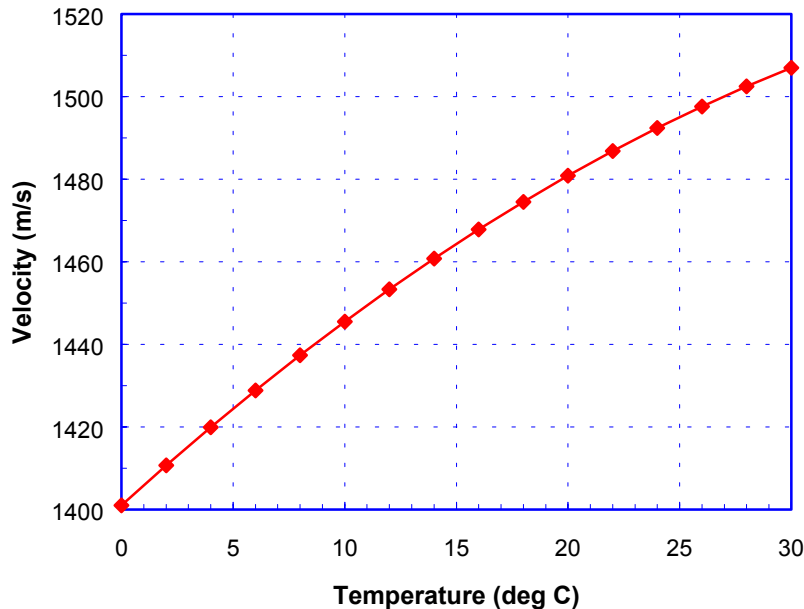


Figure 58. Variation of sound velocity with temperature. Data taken from Wilson's Tables, NAVORD REPORT 6747, "Tables for the speed of sound in distilled water and in sea water", 1959, US Ordnance Lab. Maryland.

7.6.2 Sediment Velocity Data Processing

Having determined the value of PTO this can be entered into the box provided in P-Wave velocity processing panel.

The velocity will then be automatically calculated using the equations shown for VP

Salinity, Temperature and Depth corrections

It is often the case that cores are inevitably logged at different temperatures and because velocity is affected by temperature it is important to compensate the measured sediment velocity for temperature. Velocity measurements are often corrected to a velocity at a set temperature. Ofcourse, velocity is also affected by salinity and pressure (water depth) and so it is convenient to correct for these parameters as well.

The temperature of each core section can be measured during logging by inserting the temperature probe into the end of each section, the salinity of the water from the core site may also be known and the depth will certainly be known. This means that all of these parameters can be corrected for in the processed data. Geotek use an empirically derived formulation developed by Medwin in the processing panel to apply a factor to the measured p-wave velocity.

This correction is simply defined as:

$$VP_{\text{Corr}} = VP * VP_{\text{Fac}}$$

where:

VP_{Corr} = corrected p-wave velocity

VP = measured pwave velocity

VP_{Fac} = Ratio of V_w at required conditions/ V_w at measured conditions

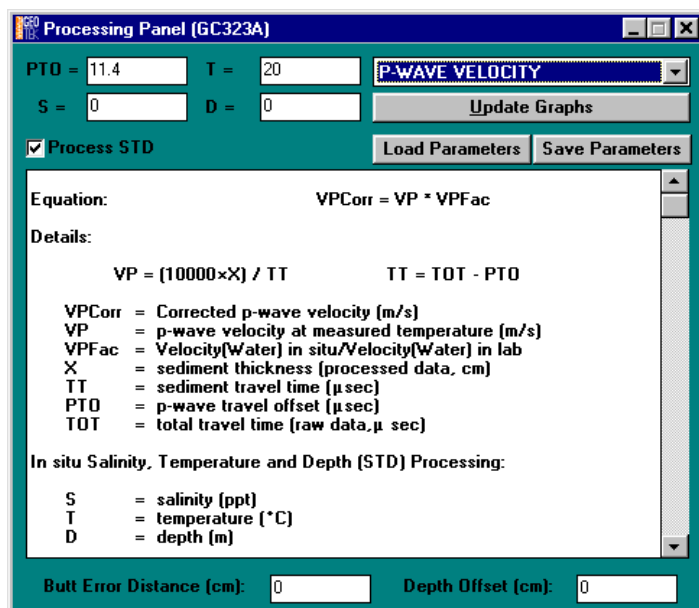


Figure 59. P-Wave velocity processing panel.

7.6.3 Velocity amplitude

The P-Wave amplitude processing panel simply allows the user to make a linear correlation with any standard numbers required.

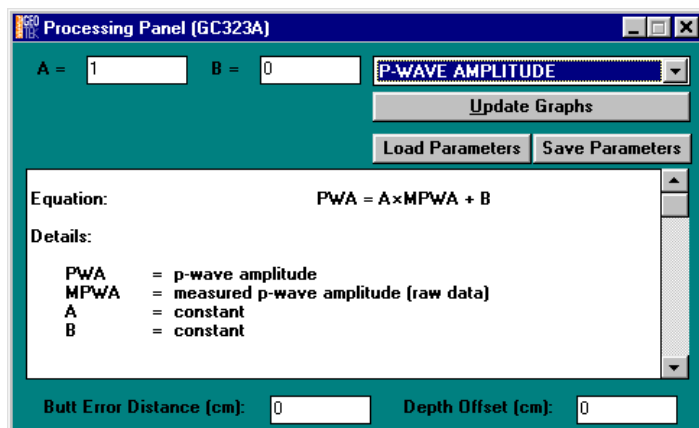


Figure 60. P-Wave amplitude processing panel.

7.6.4 Impedance

Acoustic impedance is the product of P-wave velocity and density. The processing panel is self-explanatory and requires no inputs from the user.

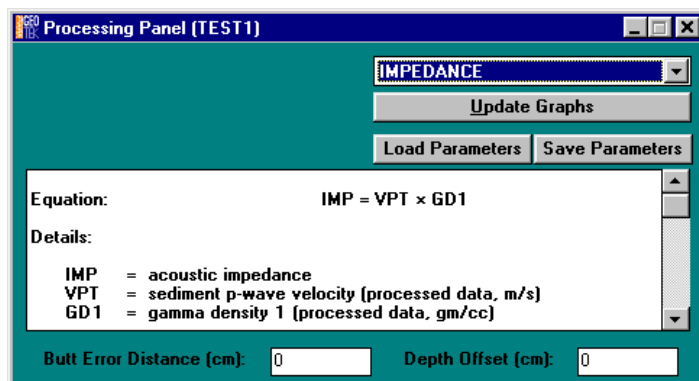


Figure 61. Impedance processing panel.

Note the values of impedance are reported as $*10^3 \text{ kgs}^{-1}\text{m}^{-3}$

7.7 Gamma Density

The basic equation for calculating bulk density from gamma ray attenuation measurements is:

$$\rho = 1/\mu d * \ln(I_0/I)$$

where:

ρ = sediment bulk density

μ = the Compton attenuation coefficient

d = the sediment thickness

I_0 = the gamma source intensity

I = the measured intensity through the sample

In practice many experimental factors need to be addressed in order to obtain valid bulk density measurements; for example; beam spreading, the attenuation through the liner wall and the effect of water in the sediments which has a significantly different attenuation coefficient to the sediment minerals.

Consequently the simplest and most reliable method for the calibration and calculation of gamma density is to use an empirical approach which has been shown to provide excellent results. The technique relies on calibrating the system using both the liner in which the core is contained and the fluid which the sediment contains. For example; when using a whole core with water saturated sediments a calibration section should be made which consists of a cylindrical piece of aluminium of varying thickness surrounded completely by water in a sealed liner (see Figure 62). For a dry split core the calibration should be done with aluminium in a dry half liner.

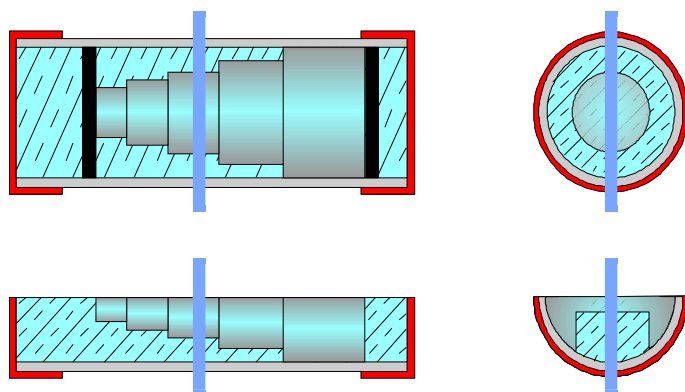


Figure 62. Gamma calibration pieces.

Gamma counts should be taken through the calibration sample for long count times (e.g. 100s) at different Aluminium thickness' and plotted as a graph of average $\rho * d$ vs. $\ln I$. $\ln I$ is the natural log of the measured intensity in counts per second (CPS) and $\rho * d$ is the average density * thickness of the aluminium and water. The resulting graph may deviate from the theoretical straight line because of the factors cited above. Each thickness of aluminium and water has an average density as follows:

$$\rho_{av} = d_i/D * \rho_{Al} + (D-d_i)/D * \rho_{water}$$

where:

D = total thickness

d_i = thickness of aluminium

ρ_{Al} and ρ_{water} = density of aluminium and water respectively

To accommodate any variations from a straight line a second order polynomial equation can be fitted to the graph of the type (see Figure 63):

$$y = Ax^2 + Bx + C$$

where:

$x = \rho * d$

$y = \ln I$

If the test data is best represented by a straight line then simply set $A=0$

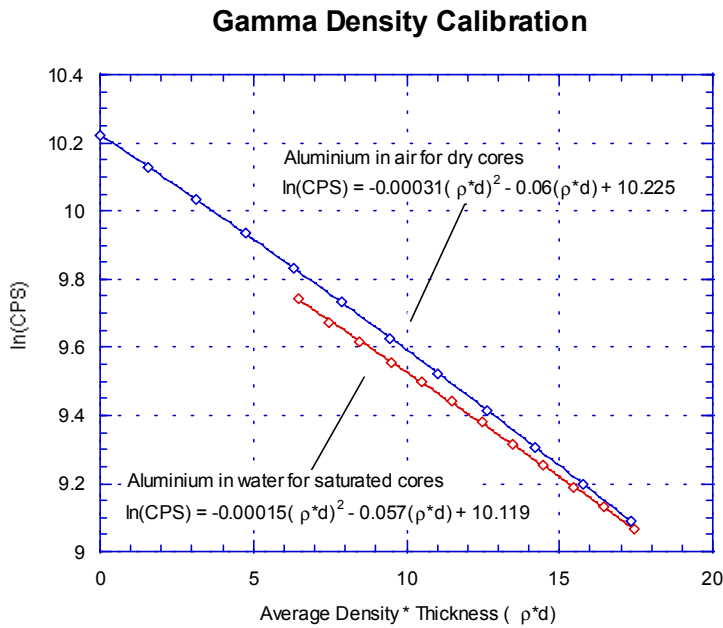


Figure 63. An example of a density calibration for dry and saturated cores.

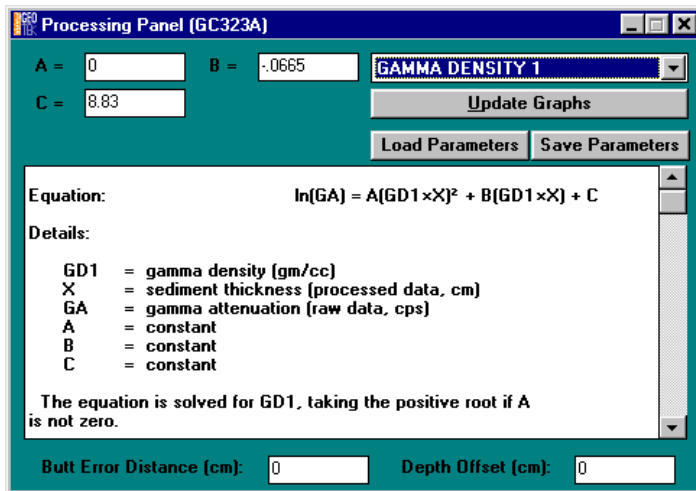


Figure 64. Gamma density processing panel.

The coefficients A, B & C in the equation can then be entered directly into the gamma density processing panel. This calibration and calculation will then make all the necessary empirical adjustments.

7.7.1 Fractional porosity

Porosity can be calculated directly from sediment density if the following is known or can be sensibly assumed:

- a) the sediment is fully saturated (this can be water, air or anything else)
- b) mineral grain density
- c) fluid density

If so then the user can use the Fractional Porosity processing panel.

Simply enter the values for mineral grain density (MGD) and fluid density (WD) in the boxes provided.

The fraction porosity is then calculated from the simple expression:

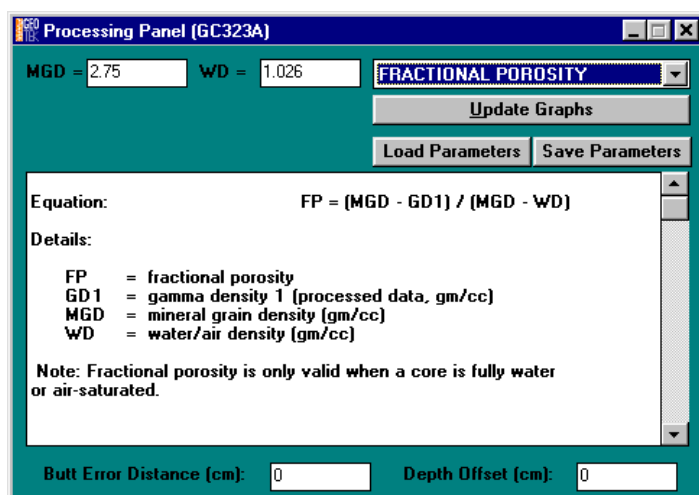


Figure 65. Fractional porosity processing panel.

$$FP = (MGD - GD1) / (MGD - WD)$$

where:

FP = fractional porosity

MGD = mineral grain density (gm/cc) (typically 2.7)

GD1 = gamma density as determined by the gamma density processing panel

WD = fluid phase density (gm/cc) (typically 1.0)

7.8 Magnetic Susceptibility

7.8.1 Loop Sensor

The magnetic susceptibility sensor is electronically set to measure a single standard sample of a stable iron oxide which has been tested and analysed by the manufacturer (Bartington Instruments Ltd). Therefore, all magnetic susceptibility sensors supplied should record exactly the same value for any given sample, and that value should be the same as a measurement made on a different measuring system. In that sense the magnetic susceptibility system is calibrated absolutely. Since the calibration has been set electronically it should not alter. A calibration sample is provided which can be used to check the long term consistency of the calibration. Any changes in the calibration are a fault in the system's electronics which only the manufacturer can rectify.

Note: Magnetic susceptibility measurements are temperature sensitive, so it is important to maintain a stable temperature environment during measurement.

Volume specific magnetic susceptibility

The data obtained from the magnetic susceptibility system provides uncorrected, volume specific magnetic susceptibility, K_{uncor}

K_{uncor} is dimensionless (* 10^{-5} SI units)

To obtain the corrected Volume Specific Magnetic susceptibility (K) the data must be corrected for the relative effect of size of the core and the size of the loop sensor being used; where:

$$K = K_{uncor} / K_{rel} \quad (* 10^{-5} \text{ SI units})$$

$$K \text{ (SI units)} = 4\pi * 10^{-6} K \text{ (cgs units)}$$

The relationship between core loop diameter (D_l), core diameter (d) and K_{rel} has been determined experimentally (see Figure 66) and the following relationship can be used:

$$K_{rel} = 4.8566 (d/D_l)^2 - 3.0163(d/D_l) - 0.6448$$

This relationship is used automatically in the processing panel for magnetic susceptibility.

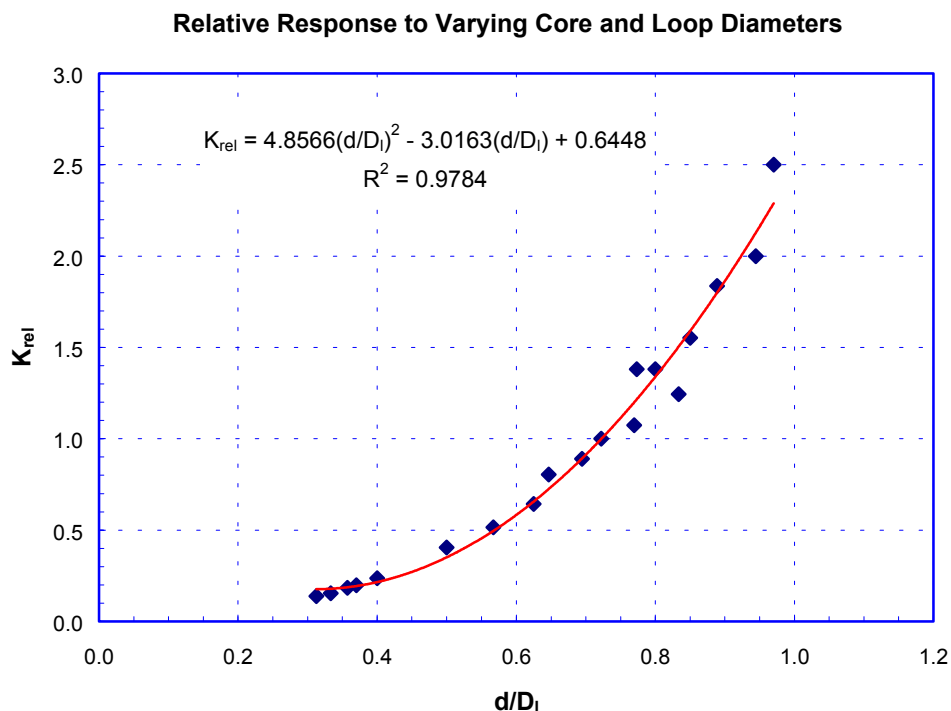


Figure 66. Response of magnetic susceptibility measurements to varying core and loop diameters.

Mass specific magnetic susceptibility

The volume specific magnetic susceptibility takes no account of the density of the sample being measured. Consequently it is possible to have variations in K down the length of a core that reflect changes in density only rather than changes in proportion of magnetically susceptible minerals to other minerals. Mass specific magnetic susceptibility, overcomes this problem by taking into account the density of the sample being measured. The mass specific susceptibility (χ) is given by:

$$\chi = K/\rho \quad (\text{m}^3\text{kg}^{-1})$$

where:

ρ = sediment density (kgm^{-3})

χ in cgs units has units of cm^3g^{-1} and can be converted from SI units as follows:

$$\chi (\text{SI units}) = 4\pi * 10^{-3}\chi (\text{cgs units})$$

For further, more detailed, information on the measurement of magnetic susceptibility the user is referred to the manuals supplied by Bartington. The nomenclature above is the same as that used in these manuals.

Processing Panel

The user has the option in the processing panel of calculating either K_{uncor} , K or χ .

The general processing panel is shown below; the actual appearance of this panel will depend on whether the user is using a point or loop sensor and which form of data output is required.

The nomenclature used in the processing panel is different from that used above.

CMS is the corrected magnetic susceptibility which can be either K_{uncor} , K or χ depending on the users requirements.

MS is the measured magnetic susceptibility, K_{uncor}

The user can enter numbers into the boxes; A, B, Den and LD.

A and B are constants which enable the user to make a linear correction to the raw data (MS) if needed; so that $MS_{corrected} = A \cdot MS + B$. This is most applicable when using the point sensor (see below). When using a loop and no correction to MS is required the set $A=1$ and $B=0$.

Den is used to obtain mass specific susceptibility and LD is used to correct for the size of loop being used.

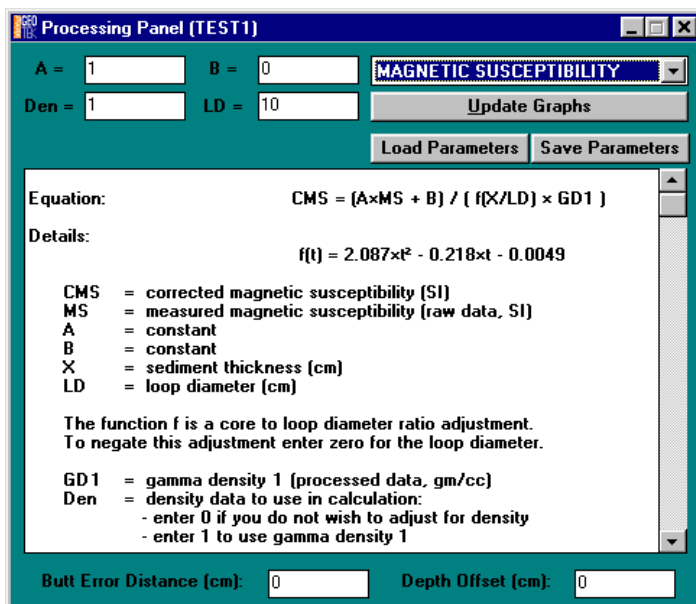


Figure 67. Magnetic susceptibility processing panel (loop sensor).

Calculating uncorrected volume specific magnetic susceptibility

If the user wants the output (CMS) to be the uncorrected volume specific magnetic susceptibility (K_{uncor}) then set $A=1$, $B=0$, $Den=0$ and $LD=0$. The values then (if using SI) are $CMS \cdot 10^{-5}$ SI units.

Calculating corrected volume specific magnetic susceptibility

If the user wants the output (CMS) to be the corrected volume specific magnetic susceptibility (K) then set $A=1$, $B=0$, $Den=0$ and $LD = \text{loop diameter in cm}$. The values then (if using SI) are $CMS \cdot 10^{-5}$ SI units.

Calculating corrected mass specific magnetic susceptibility

If the user wants the output (CMS) to be the corrected mass specific magnetic susceptibility (K) then set $A=1$, $B=0$, $Den=1$ and $LD = \text{loop diameter in cm}$. The values then (if using SI) are given in $CMS \cdot 10^{-8} m^3 kg^{-1}$.

7.8.2 Point Sensor

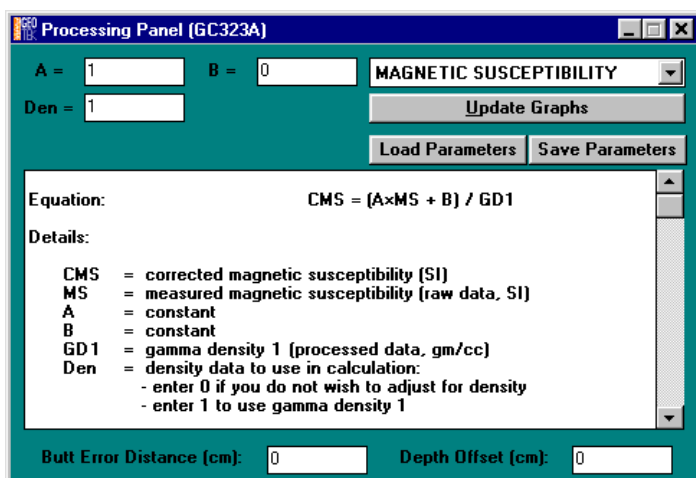


Figure 68. Magnetic susceptibility processing panel (point sensor).

The protocol for inter calibrating the new point sensor with the loop sensor is not well established. A calibration piece is supplied which can be used to check for any major problems. The user is advised to perform some comparative measurements between the point sensor and the loop sensor. Values of corrected volume specific magnetic susceptibility (K_{loop}) should be obtained from a whole core using a loop and then a comparative set of uncorrected values obtained from a split core using the point sensor (K_{point}). Fit this data to a linear relationship:

$$K_{point} = A * (K_{loop}) + B$$

These values of A & B can be used directly in the processing panel.

7.9 Electrical Resistivity

The sensor electronics in the electrical resistivity unit need time to warm up after being switched on. Ideally the unit should be switched on half an hour prior to logging cores in order for the system to stabilise. The resistivity sensor is sensitive to changes in temperature so if the instrument is being used in a room without air conditioning then the user should re-zero the sensor using the Advanced Panel (see section 5.5) at regular intervals when logging cores.

To calibrate the non-contact resistivity a series of saline solutions are needed at different concentrations. Ideally these concentrations should span the range of resistivity to be measured. It is unlikely that a resistivity greater than seawater (35‰) will be encountered (0.21 ohm.m @20°C) and so this can be considered the upper bound for most applications.

Laid out in the table below are a series of concentrations of saline solution that can be used for calibrating the system. These range from resistivities of 0.21-15.48 ohm.m (@20°C). The solutions should be prepared in the size of core liner that the cores to be logged were collected in. This is very important as the resistivity sensor is very sensitive to different measurement geometries.

Concentration (g/l)	Resistivity (ohm.m)
35	0.209
17.5	0.390
3.5	1.730
1.75	3.321
0.35	15.481

This gives nearly 2 orders of magnitude range in resistivity.

The different saline solutions are positioned over the electrical resistivity sensor and readings taken using the Test Panel in the MSCL Utilities software.

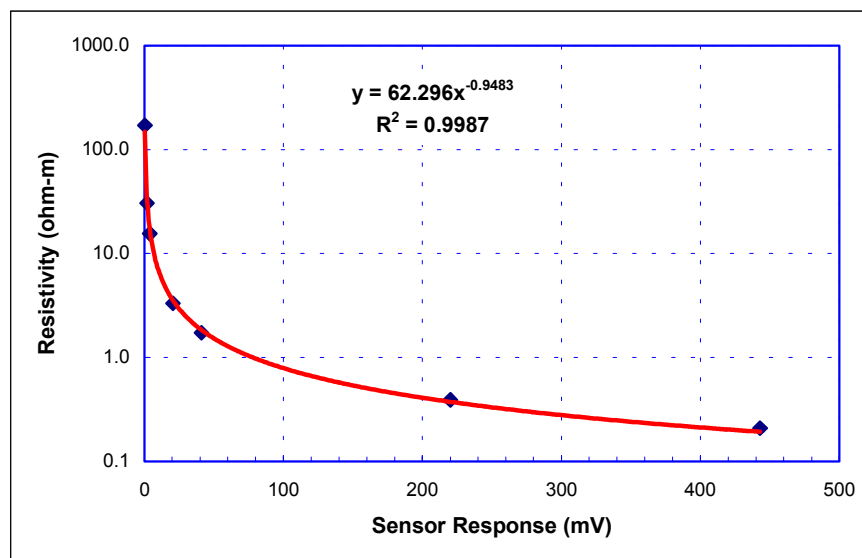


Figure 69. Resistivity (ohm-m) vs. NCR response (mV).

If the user wishes to use different saline concentrations than those given above then the equation below relates concentration to resistivity. Using this relationship the user can make up different saline solutions as required.

$$ER = 5.3394 * C^{-0.8987}$$

where:

ER = electrical resistivity (ohm-m)

C = salt concentration (g/l)

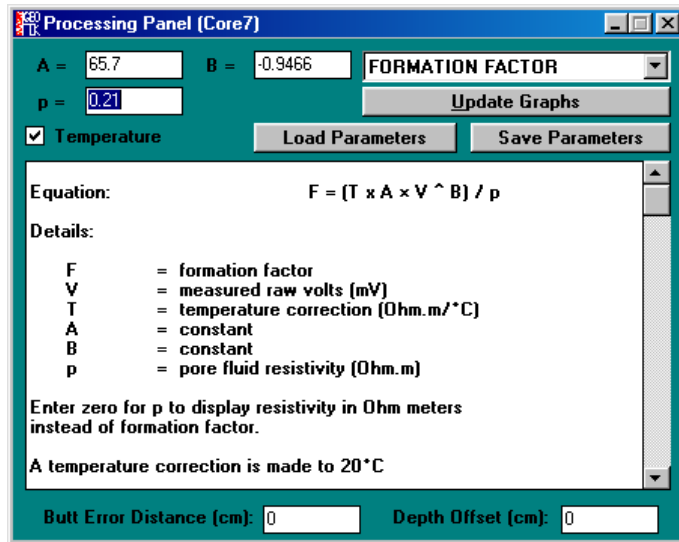


Figure 70. Electrical Resistivity processing panel.

Having produced the calibration pieces the user can then go on to calibrate the sensor to convert its response (mV) into resistivity (ohm-m). The best way to do this is by plotting the response from the resistivity sensor against the resistivity of the calibration samples as shown in Figure 69. The user should fit a power law curve to these data and use the coefficients (A and B) in the processing panel (see Figure 70). The equation takes the form;

$$y = Ax^B$$

where:

y = electrical resistivity (ohm-m)

x = sensor response (mV)

A and B = coefficients used in the processing panel.

The data can be displayed as resistivity (ohm-m) or as formation factor, the ratio of the sediment resistivity to the pore fluid resistivity. To display the formation factor the user must enter a non-zero value into the p field in the processing panel, where p is the resistivity of the pore fluid.

The resistivity of sediments varies with temperature and so a correction to 20°C is included in the processing panel. The user can choose whether or not to correct for temperature using the tick box.

8. Trouble shooting

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Chapter Overview

This chapter provides a simple guide to basic things that the user can check if he is experiencing difficulties. It should be remembered that most difficulties experienced are nearly always simple once you know the answer! Most of the system is remarkably rugged and historically GEOTEK have had relatively few components fail in service. The main component that should be considered to be very delicate is the Gamma Detector. Please do not subject it either mechanical or thermal shock. If you need to transport it ensure that it is very well insulated and protected. If in any doubt then contact GEOTEK.

If the user is experiencing any software difficulties the first step should always be to go to the Utilities programme, ensure that the settings file is correct and that the test panel functions correctly. If so then there are not many circumstances in which the main programme will not function correctly.

For convenience this chapter is divided into sections applicable to the computer/microprocessor, the track mechanism and the various sensor systems.

8.1 The PC and Microprocessor

Terminal mode does not function in Utilities Software

If you are terminal mode and you do not get a cursor to appear when you press return check the following:

- Serial lead connected to the computer
- Power at MP turned on (main switch on front panel)
- Correct serial port selected (change from COMMS menu)

If you still have a problem then try:

- Sending CTRL-C from keyboard
- Send break from COMMS menu
- Turn MP off and then on again.

Test panel does not work

Check terminal mode functions correctly.

8.2 The Track

Motor button does not appear in the Test Panel

Check that the track system is correctly defined in the active settings file.

Motor test button does not work

- Check that switch is set to auto and red light is on.
- If no red light check power is on at mains supply.
- Check that the track cables are connected and the track works in manual mode.

Track & Vertical motor does not work in manual mode from front control panel

- Check that the red light on the panel is displayed - if not check all connections.
- There is an occasional mode which requires the stepper controller to be reset. To do this turn power off and then on again. If the problem persists then disconnect motors and repeat.

Laser does not work

Check that the cable is connected. If the problem persists then contact Geotek.

8.3 P Wave measurements

No signal on oscilloscope

- Check oscilloscope set up; especially the trigger mode (see Figure 9 and section 3.4.7).
- Check that all connections are made to transducers. There is a 200Hz noise that is emitted from the Tx box (for ARC transducers, 1 kHz for piston transducers).
- Place water core between transducers and ensure a good coupling with a little water between the core and the transducers (for piston transducers).
- Ensure that the ARC transducers are aligned correctly (the flats on the shaft should be facing the core).

P Wave test panel does not appear

Check settings file to ensure P Wave system is registered as being present.

P Wave travel time is incorrect

Check correct functioning of threshold and count functions. Check that the delay and gate are set to envelope the expected signal. Adjust set high and set low if required (see section 3.4.5).

8.4 Gamma Density Measurement

Gamma button does not appear in the Test Panel

Check that the gamma attenuation system is selected in the active settings file.

Gamma test button does not work

Check that the main power is on.

Check that the gamma detector cable is connected in the correct socket at the rear of the electronics rack.

Gamma count rate is not stable

The gamma count rate will vary slightly with both time and temperature. If problems arise that cause the user to believe that the variability is excessive and is effecting the reliability of the measurements then the user is advised to contact GEOTEK.

Excessive drift in count rate can be caused by exposure of the scintillation detector to very high count rates. Therefore GEOTEK recommend that the collimator should not be left open at 5 mm whilst there is no sediment core or calibration piece in the path of the gamma beam.'

The user can check the spectral output from the detector. Remove the detector carefully from its shield and reconnect the normal cable. Connect the BNC output to the oscilloscope. This analogue output displays the complete spectrum of energies detected. With the detector in the gamma beam the user should see multiple traces at different levels on the oscilloscope.

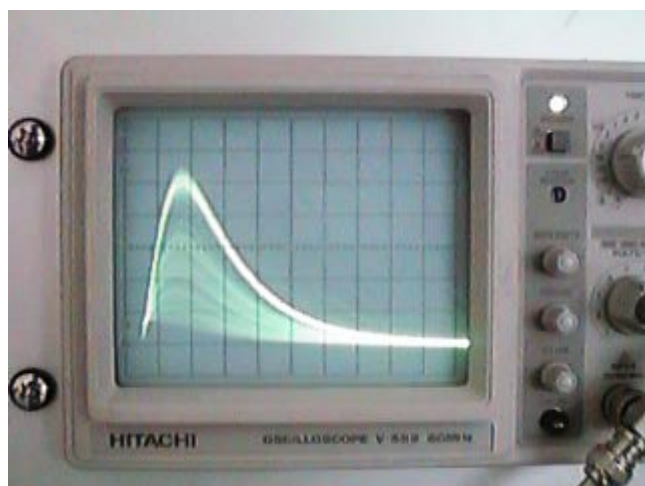


Figure 71. Oscilloscope trace showing spectrum from the gamma detector

The oscilloscope should be set up with a 50 μ s/DIV timebase, 0.2 v/DIV scale and with INT trigger. The user will note that the majority of traces form a bright band; these are the unscattered gamma photons at the principal energy level. The voltage level of this broad band should be between 0.9 and 1.0V on older detectors and between 1.6 and 1.8 on more recent detectors. If not then the detector may not be functioning correctly.

It is possible to correct this level by adjusting the high voltage inside the detector. This can be done by GEOTEK or in special circumstances the user may be able to perform this operation following instructions that can be provided.

8.5 Magnetic Susceptibility Measurements

No reading obtained on meter in manual mode

Check that the sensor is connected to the rear of the meter.

Magnetic Susceptibility test panel does not appear

Check settings file to ensure Magnetic Susceptibility system is registered as being present.

Magnetic Susceptibility test panel does not work

Check that the toggle position is in its central position (between M & Z).

8.6 Core Thickness Measurements

Incorrect reading given on LCD display

Check that both LVDTs are plugged in and connected to rear of main electronics rack.

Core Thickness test panel does not appear

Check settings file to ensure Core Thickness system is registered as being present.

Core thickness test panel gives different reading to LCD display

Check that the system has been properly calibrated and that the constants are entered correctly in the active settings file.

8.7 Temperature Measurements

Temperature test panel does not appear

Check settings file to ensure Temperature system is registered as being present.

Temperature test panel gives incorrect readings

Check that the system has been properly calibrated and that the constants are entered correctly in the active settings file.

8.8 Fuses for the MSCL

There are four fuses in the MSCL, each of which differ in value according to the supply voltage used. The table below outlines the fuses that should be used. A selection of these is provided with your logger.

Fuse	240 V operation	115 V operation
AC fuse on the main logger unit. Situated in the IEC inlet on the rear of the logger	3.15 AT HBC	3.15 AT HBC
12 V DC fuse on main logger unit. Note: this should be as low as possible, 2.0 or 2.5 AT are recommended. This has occasionally blown, if this occurs in normal operation the it can be replaced with a 3.15 AT	2.0 or 2.5 AT	2.0 or 2.5 AT
36 V DC fuse on main logger unit.	3.15 AT	3.15 AT
Output fuse on track Power Supply unit. (before Serial #39)	3.15 AT	3.15 AT
AC fuse on track Power Supply unit. Located in the IEC inlet. (before Serial #39) Note: this can vary depending on the transformer so a 3.15 AT may be installed.	1.0 AT HBC	2 AT HBC

9. Natural Gamma Measurements

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9.1 Chapter Overview

This chapter explains the calibration and operational procedures for the GEOTEK natural gamma measurement system. It provides some background information on natural gamma measurements in rocks and sediments, but users should also familiarise themselves with other sources of information. It is important that the user follows these protocols to ensure that the data obtained is accurate and of the highest quality. The user must understand how the system works if the user wishes to depart from the normal operating protocols and procedures so that the implications of the departure are to be fully appreciated.

9.2 Natural Gamma Radiation

9.2.1 Gamma Rays

Gamma rays are electromagnetic radiation given off by an atomic nucleus during the spontaneous decay of an unstable element (radioisotope). These waves are characteristically at frequencies between 10^{19} and 10^{21} Hz (wavelengths between 10^{-9} and 10^{-11} cm). A gamma event corresponds to the transition from one state to another of lower energy and the emission of a photon with energy equal to the difference between the two states. The energy (E) is related to the wavelength (λ) and frequency (ν) as given below. The energy is expressed in electron volts (eV).

$$E = h\nu = hc/\lambda$$

where:

c = velocity of light

h = the Planck constant

Gamma rays have energies of the order of keV and MeV.

9.2.2 Sediment and Rock Radioactivity

The elements that constitute the Earth, both stable and unstable (radioactive), were formed in very extreme environments. The present day conditions on Earth are not suitable for the formation of these elements and therefore only elements that are stable or have a decay time greater than or equivalent to the age of the Earth are found here.

The naturally occurring radioisotopes with sufficiently long lives and that produce significant amounts of gamma rays are; potassium (^{40}K) with a half life of 1.3×10^9 yrs; uranium (^{238}U) with a half life of 4.5×10^9 yrs; and thorium (^{232}Th) with a half life of 1.4×10^{10} yrs. Minerals that fix K, U and Th, such as clay minerals, are the principal source of natural gamma radiation. K, U and Th are known as the 'primeval' emitters.

Potassium disintegrates to give Argon (^{40}A) which is stable. The decay spectrum of potassium therefore contains one peak.

Uranium and thorium decay is more complex as both disintegrate to give a series of daughter isotopes, only some of which are gamma ray emitters. These include thallium (^{208}Tl), actinium (^{228}Ac), bismuth (^{214}Bi) and lead (^{214}Pb).

It is important to note that it is assumed secular equilibrium has been reached. This means that the intermediate daughter isotopes decay at the same rate as they are produced by the parent isotope and the relative proportions of parent and daughter remain constant. Most equilibrium problems occur with the uranium series in recent or recently exposed deposits. Starting from pure uranium it takes approximately one million years of undisturbed decay to reach secular equilibrium.

9.2.3 Use of Natural Gamma Data

Natural gamma measurements have three purposes:

- 1) core/core and core/borehole correlation
- 2) evaluation of clay/shale content
- 3) abundance estimates for K, U, Th

The first item and to some degree the second item can be achieved by measuring bulk emissions (total counts) of the material. Elemental analysis is a much more complex process requiring spectral data acquisition and much longer sampling times.

9.3 Natural Gamma Measurements

The well logging industry uses a relative unit standard known as the GAPI (Gamma ray, American Petroleum Institute), sometimes abbreviated to API. This scale is defined at a calibration pit at the University of Houston which consists of three zones of specific mixtures of K, U and Th, two of low activity and one of high activity. A GAPI is defined as 1/200 of the deflection measured between the high and low activity zones in the calibration pit. Limestones have readings of 15-20 GAPI while shales vary from 75-150 GAPI although in highly radioactive shales readings of 300GAPI are known.

The GEOTEK Natural Gamma Logger cannot be calibrated in the calibration pit and therefore measurements are presented in counts per second (cps). This unit is dependant on the device (i.e. detector geometry) and the volume of the material measured.

9.3.1 Natural Gamma Total Counts

Total counts refers to the integration of all emission counts over the gamma ray energy range between 0 and 3 MeV. This radiation is, as detailed above, primarily emitted from three isotopes, ^{40}K , ^{238}U and ^{232}Th , and their decay products. If the purpose of the measurements is to obtain total counts, i.e. for core-core correlation, a reasonable precision can be obtained on relatively low counting times (minutes per sample). This allows cores to be logged in limited time schedules.

9.3.2 Natural Gamma Spectrometry

The GEOTEK natural gamma logger acquires 2048 channel spectral data which may be used for calculating elemental yields for K, U and Th. The radiation spectra of rocks and sediment are composed of a number of peaks at discrete energy levels corresponding to gamma emissions from isotopes in the three primeval series.

These peaks can be degraded in three different ways:

- 1) Compton scattering in the sediment, between the core and the detector and in the detector and shield structure itself.
- 2) pair production in the sediment and the detector (at energies above 1.02 MeV).
- 3) an intrinsic broadening of the peaks by the detector itself.

This results in a large background in the spectrum that is added to by low intensity discrete emissions from the ^{238}U and ^{232}Th series which are indiscernible from the scatter.

The aim of natural gamma spectrometry is to determine the components of spectra, discrete peaks and portions of the background, in order to effectively estimate the abundance of K, U and Th.

Acquiring data for spectral analysis will require significantly longer counting times than total count sampling for a comparable precision (hours per sample).

Analysing Spectra

The Schlumberger method for analysing gamma radiation spectra involves division of the spectrum into five discrete energy windows. Two windows cover the low-energy region which include the energy range of gamma rays resulting from pair production and Compton scattering as well as lower energy emissions from the Th and U series. The three remaining windows cover the high energy region including the three main peaks; ^{208}Tl at 2.62 MeV (from the ^{232}Th family); ^{214}Bi at 1.76 MeV (from the ^{238}U family) and ^{40}K at 1.46 MeV. It is important to consider the low energy window as much improved results can be obtained.

Schlumberger use a calibration pit in Clamart, France for their natural gamma spectrometry (NGS) downhole tool from which they gain their calibration coefficients (A_i , B_i and C_i) in the following equation:

$$W_i = A_i\text{Th} + B_i\text{U} + C_i\text{K} + r_i$$

where:

W_i = count rate from window i (1-5)

r_i = statistical error factor

The equations are solved by minimising r^2 which is the sum of all r_i^2 .

The Schlumberger windows are defined as follows:

- Window 1: 0.20-0.50 MeV
- Window 2: 0.50-1.10 MeV
- Window 3: 1.10-1.59 MeV
- Window 4: 1.59-2.00 MeV
- Window 5: 2.00-3.00 MeV

9.3.3 Measurement Constraints

Any natural gamma measurement requires the acquisition of a zero-background spectrum. The resulting spectrum must be subtracted from the measured spectrum of a core sample to remove any environmental radiation effects within the measurement window. This type of background should be differentiated from the peak baseline which is often referred to as background (see Figure 72).

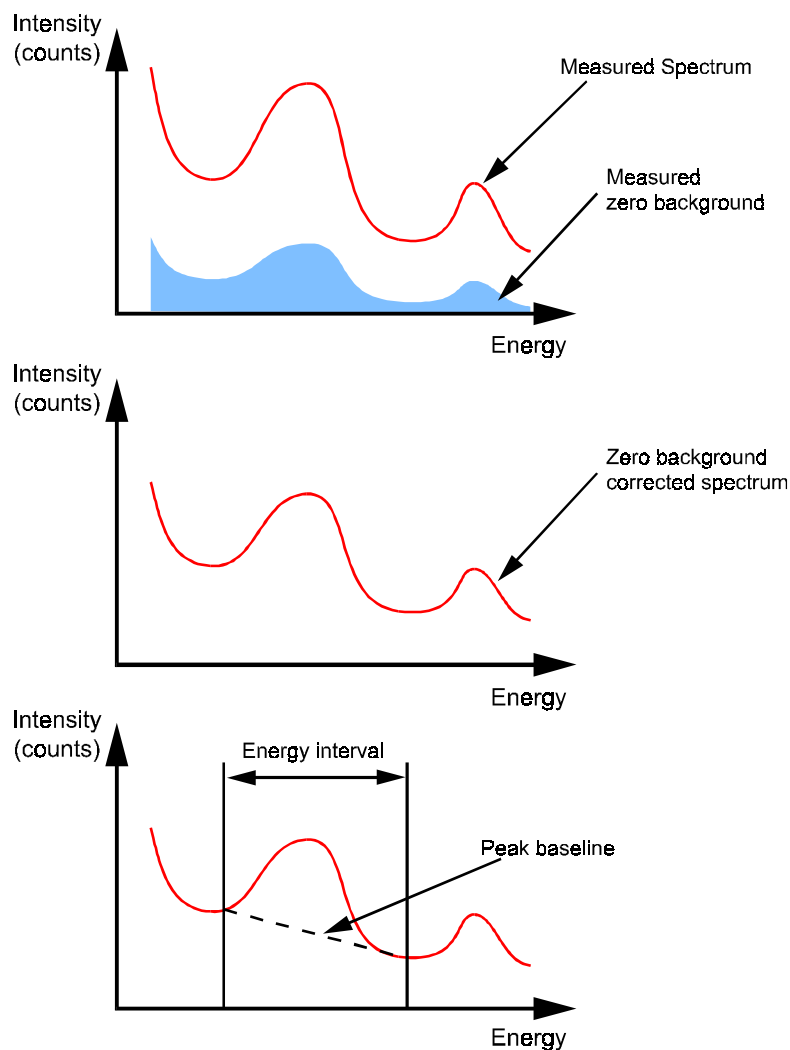


Figure 72. Differentiation of zero background and peak baseline.

9.4 GEOTEK Natural Gamma Logger

9.4.1 Hardware Configuration

The components of the natural gamma system are mounted on a separate stand positioned between the magnetic susceptibility section and the LH track section. The mechanical arrangement is mounted on an adjustable plate similar to that used for the main sensor stand in horizontal mode. This plate can be raised or lowered to accommodate differently sized cores. Mounted in a central position is a large lead cube into which the two detectors are mated and through which the core is moved.

The central lead cube provides a radioactively 'quiet' area for measurements to be taken in. For ease of assembly the cube is split into several pieces which can be bolted together. Two lead inserts are placed in either end of the core hole to adjust the diameter to fit the cores being logged (see Figure 73). Into the centre of the complete assembly a plastic sheath (in two parts) is placed. This acts to prevent any contamination of the core liner and the lead housing (the sheath is easy to clean). On the top of the central lead housing there is a plastic block that holds a small calibration piece for spectral energy calibration.

To put the system together, start by attaching the horizontal support legs to the aluminium frame supported by the wooden legs. Locate the horizontal plate (with the detector clamps and the spacer for the lead housing bolted on) on the adjustable plastic supports and ensure that the plate is seated in a level stable position (see Figure 73). Once the plate is in place put the detector housings into the clamps and secure them, leaving enough room in the centre to position the lead cube (do not tighten yet as some adjustment will be required).

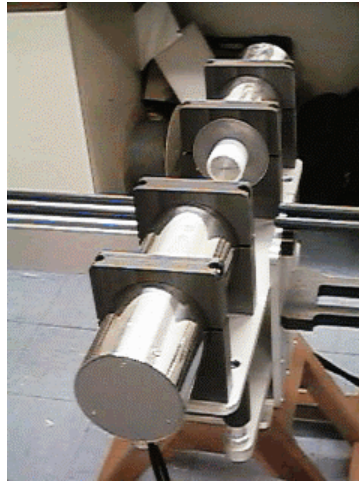


Figure 73. Horizontal plate and detector housing in place for natural gamma measurements.

Now the lead cube can be put into its place. Be very careful as it is extremely heavy. At least two people will be required to lift and position it. Place the housing centrally on the plastic spacer. The position should be adjusted to allow cores to move freely through the centre hole (Figure 74).



**THE LEAD SHIELDS ARE VERY HEAVY:
MIND YOUR BACK!
USE GOOD STRONG HANDS NOT YOUR
FEET!**

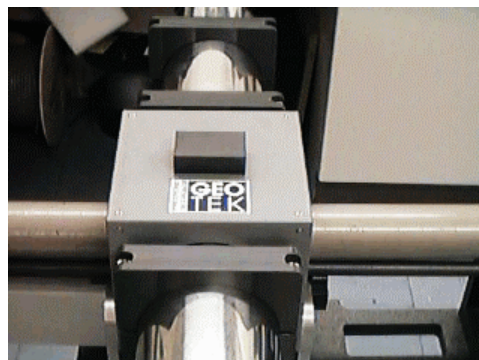


Figure 74. Lead cube in position allowing the core to move easily through.

Sensors

The sensor itself comprises at least two 2" x 2" or 3" x 3" NaI(Tl) detectors housed in 6" diameter lead shields. A detector comprises a NaI(Tl) crystal optically coupled to a photomultiplier tube and connected to a bias base (an Aptec BB200 model) that supplies the high voltage power and a signal pre-amplifier.

Emitted gamma rays hit the NaI(Tl) crystals which produces a pulse of light which then strikes the photomultiplier tube producing a small electrical current to give a voltage pulse. The peak height of the voltage pulse is related to the energy of the gamma emission which is recorded by the multi channel analyser in one of 2048 channels.

Each detector has a dedicated Multi Channel Analyser (MCA) card (an Aptec 5002 model) housed in the logging PC. These are numbered consecutively from 1 starting on the right hand side of the computer when viewed from the rear. Each MCA card contains an optional pre-amplifier and amplifier and the Analogue to Digital Converter (ADC) under the control of software.

9.4.2 Measurement Philosophy

Multiple detectors are used in order to increase the recorded signal level because natural rocks and sediments have very low natural radioactivity, so combining data collected with multiple detectors improves the data quality. The system provided by GEOTEK makes the use of multiple detectors relatively easy. The sensor suite is controlled through the software interface that allows collection of stabilised spectra, meaning that each detector and MCA card pairing is calibrated using known isotopes at specific energy levels.

The stabiliser works by splitting a long collection into a series of shorter collections. The duration of short collections are defined in the software setup and should be long enough to accurately establish the positions of the energy peaks used for stabilising, BUT short enough so that no drift occurs in the short collection. The short collection is known as the Intermediate Spectrum. The stabiliser uses the energy calibration and at least two identified peaks.

When the centroids of the peaks are known in the Intermediate Spectrum a new energy calibration is conducted (knowing the energies of the peaks) and the Stabilised Spectrum is updated. This is done by examining each channel in the Intermediate Spectrum, calculating its new energy using the new energy calibration, calculating the channel in the Stabilised Spectrum that has the same energy then adding the counts from the Intermediate Spectrum channel to the Stabilised Spectrum channel. The Intermediate Spectrum is then cleared and the next short collection is started. The Stabilised Spectrum is displayed in a preset energy range (for natural gamma measurements this should be 0 to 3 MeV).

Using the stabiliser means that as long as each detector is energy calibrated and operating under the SAME Stabiliser setup options the resulting spectra will be presented in a fully calibrated and balanced way. Because each detector is calibrated and stabilised independently any differential drift that may occur is counteracted.

Energy Calibration

Six sources are provided for energy calibration of the detectors. These are three each of two gamma emitting isotopes, providing 5 peaks of known energy which can be used for energy calibration and subsequent collection of Stabilised Spectra. The isotopes are ¹³³Ba (giving three identifiable peaks) and ⁶⁰Co (giving two peaks), the energies of these peaks are known and are shown in the table below.

Isotope	Peak	Energy(keV)
¹³³ Ba	1	81.01
		302.71
		355.86
⁶⁰ Co	1	1173.23
	2	1332.51

The calibration sources should be kept in a safe place. Although they are designed to be handled do not carry them around for long time periods and do not put them in any pockets where they can be forgotten. Normally for data acquisition the calibration sources are positioned in the counter bores where the detectors sit in the central lead cube.

If the system is to be used in a temperature stable room then it may be that the calibration isotopes may not be required for the stabilisation process because there is no observed drift over time with temperature. This has the advantage of removing any effects of the check sources from the final sample spectra that is used for any analysis.

9.5 GEOTEK Natural Gamma Data Acquisition Software

The Geotek MSCL 5.2 version software provides features for continuous logging of sediment cores. The natural gamma logging protocols have been integrated into the existing Geotek software.

The Geotek software enables the user to log an entire core at fixed sampling intervals and for specified count times. Since accurate natural gamma measurements require long count times, this enables the user to set up a core to be logged for a period of several hours or days without the need for user intervention.

Please Note: The Geotek Software acquires data by communicating with the Aptec programs referred to later in this chapter (see sections 9.6 and 9.7). When running the Geotek MSCL program, do not close any of the Aptec windows that are automatically loaded.

9.5.1 File Structure

For each core logged, the MSCL software will create a directory bearing a name entered by the user to represent the core. All data files created for the core will be placed in that directory.

Data files relating to natural gamma created by the Geotek software comprise:

File Type	Name format
Geotek binary raw data file	*.dat
Geotek raw ASCII file	*.raw
Geotek processed ASCII file	*.out
Aptec binary spectral file	*.s0
Aptec ASCII spectrum file	*.apt

The Geotek MSCL software automatically creates a raw data file (*.dat) bearing the core name chosen by the user. This file contains the total counts per second recorded by the detectors at each sample point, as well as the configuration information for the core, including sampling interval, sample time, and processing parameters. The counts per second data stored in this file may be exported from the Geotek MSCL software as tab-delimited text files either of raw counts per second (*.raw) or processed counts per second (*.out). See Chapter 5 for more information.

If the user chooses to acquire spectral data as well as total counts per second, then the spectral data is saved in two different file formats: standard Aptec spectral file format (*.s0) and Aptec ASCII file format (*.apt). Each *.s0 file contains a large amount of header and setup information and is stored in binary format whereas the *.apt file is a text file that contains little superfluous information and may be easily viewed or read by another application (such as Microsoft Excel™). The data from each detector is saved in the Aptec spectral file format (*.s0). A spectral file is created for each detector and each sample point. The files are saved in the core directory with the following name format:

sssdxxxx.s0

Here sss refers to section number, d refers to detector number and xxxx gives the depth in section of the sample point in millimetres. For example, file 00120045.s0 would contain the spectral data acquired by detector 2 for section 1 at a depth of 45 mm. If the spectral data is for a background reading then the data is saved in a file of the format bkgnd_x.s0 where x indicates the detector number. For example, bkgnd_3.s0 would contain the background spectrum for detector 3.

9.5.2 Natural Gamma Logging Setup

Select 'On' in the Natural Gamma box of the logging configuration panel. Unless you have a system with other sensors, all other sensor boxes will not appear (see Figure 75).

This panel is very similar to the normal logging configuration panel. You must enter or select the relevant settings for logging natural gamma at this point using the various text entry boxes and selection boxes.

Sampling time

Enter the time you wish to count for natural gamma in hours, minutes and seconds in the text boxes provided, underneath 'Sampling Time'. The time you enter represents live time, that is, the actual time the detectors will be actively detecting. In order to enable collection of stabilised data, the detectors occasionally require brief periods of down time, so that the total time elapsed for each acquisition may be greater than the specified live time. You can also specify at what stage to take the background. You can

make the software take a background reading before the core reaches the sensor or prompt the software to get a reading immediately or use a background acquisition that you collected earlier (with this option you must select the files containing the background spectra).

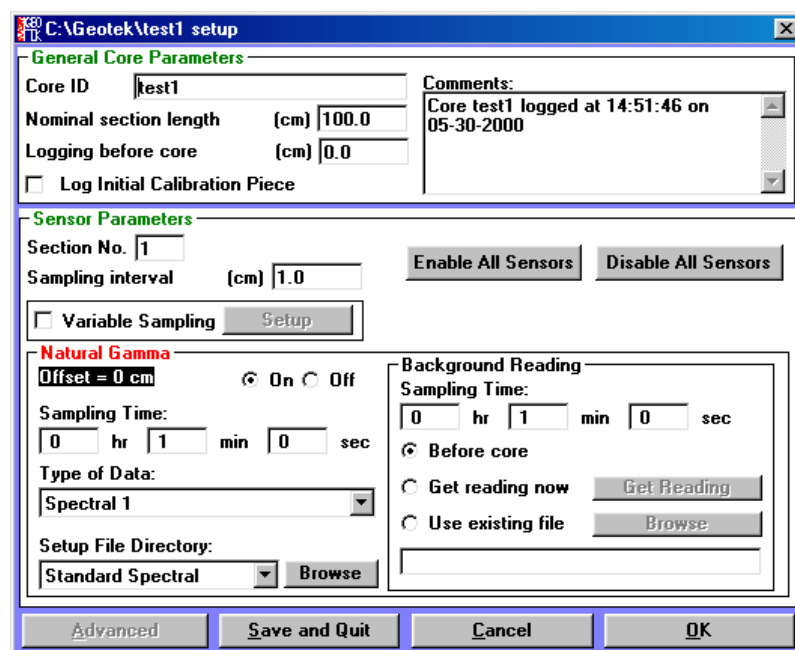


Figure 75. Natural Gamma logging configuration panel.

Type of Data

Under 'Type of Data' select either **[Spectral1]**, **[Spectral2]** or **[Counts per second]**, depending on whether you want to record the full spectral data for the core or just the total counts per second.

The **[Spectral1]** option collects data from all detectors from each sample point and manipulates the data into a single ASCII file (*.apt) with data from each detector combined and with the background data removed.

The **[Spectral2]** option does exactly the same as above but retains the intermediate spectral files (*.s0) from each detector at each sample point. This allows the user to conduct their own manipulations of the spectral data using their own methodology.

The **[Counts per second]** collects only the total gross counts from each detector and records this as a standard data set in the MSCL data file (*.dat). This data can be processed to remove the total background counts and the outputted to an ASCII file as with other MSCL data sets. The total counts data is collected in the energy range 250-3000 keV.

Setup Files

In order to acquire stabilised, calibrated data, you must also select which files to use as setup files. Each detector requires a setup file of the format setup_n.s0 where n represents the number of the detector. These files are loaded into the Aptec software before data acquisition and contain important information such as detector voltage, stabilisation peak and calibration data that ensure the detectors acquire good data. The Geotek software provides 2 default sets of setup files, one for spectral data acquisition (**[Standard Spectral]**) and one for counts-per-second acquisition (**[Standard CPS]**). The user can specify the setup files to be used (use the **[Browse]** button), for example the user may have created these files using the Aptec software (see sections 9.6 and 9.7). Geotek recommends using the predefined setup files, only advanced users should attempt to create their own. The predefined setup files are contained in hidden directories in the Geotek directory in the computer's hard disk.

Background Reading

A background reading must be taken in order to correct the data for the ambient levels of radiation. The user can collect a background reading as part of the automated logging procedure, the **[Before Core]** option, collect a background reading immediately (**[Get Reading Now]**) or use a reading already collected and stored (**[Use Existing File]**). The background reading should be taken whilst there is a non-radioactive

sample of similar density to the sediment being logged. This means that any cross talk of the radiation from the check sources to different detectors and the scattering of background radiation through the central lead cube will be constrained to the same levels as during core logging.

The problem of cross talk may also be overcome by not using the check sources during core logging. The user can employ this option if the system is in a temperature controlled environment and the detectors have been tested for any drift.

9.5.3 Natural Gamma Logging

Start Logging

Once the user has completed the configuration panel then the software will prompt the user to setup the track in the same way as during normal logging. The Logger Control Panel will appear and guide the user through this process. See Chapter 5 for more details.

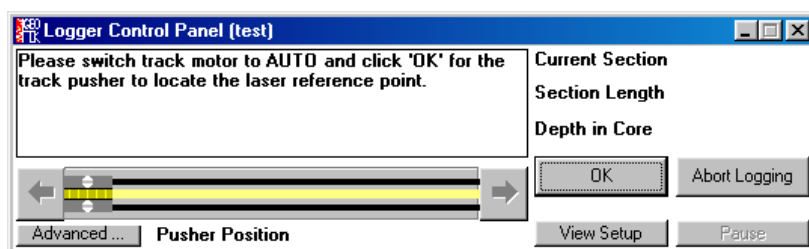


Figure 76. Logging Control Panel. The user is guided through the process of setting up the track through this interface.

When the track has been setup, the core section has been placed on the track and the user has clicked on **[Begin Logging]** the configuration panel will reappear as confirmation of what the user has selected – settings can be changed at this point. Click **[OK]** and the system will start logging.

During Logging

While natural gamma acquisition is in progress, a window will appear in the bottom left of the screen showing the amount of time left for natural gamma acquisition at the current sample point:

If you do not wish to see this window, minimise it. Closing the window will interrupt the acquisition. However, if you wish to interrupt the current acquisition, click the **[Stop]** button. The data acquired on the detectors up to that point will be saved just as for a completed sample point and the logging software will go into pause mode.

If you wish to pause the logging without interrupting data acquisition at the current sample point, click the **[Pause]** button on the logger control panel. The acquisition for the current sample point will continue until completed, after which the logging software will go into pause mode.

During logging, a raw data display appears, giving the gross counts per second recorded at each sample point. This number is an average of the count rates for each detector, and does not include a subtraction of the background counts per second. The raw counts per second data can be exported to an ASCII file as with other MSCL data. The spectral data are stored as specified by the user in the Configuration Panel (Figure 75).

Ending Logging

The user can end logging at any stage by clicking on **[Abort Logging]** in the middle of a section or **[End Logging]** at the end of a section.

9.5.4 Processed Natural Gamma Data

Total Counts

To view the processed counts per second, select 'Process Data' from the 'Options' menu in the raw data display window. The numbers displayed in the processed data display represent the raw counts per second minus the background counts per second, where the latter are taken from the background files for the core. The value of background counts per second may, however, be altered in the processing panel. The processed counts per second may be exported in an ASCII file format. See Chapter 5 for details on exporting data.

Spectral Data

The spectral data are saved according to the users specifications in the configuration panel, either as *.s0 and *.apt files or only as *.apt files. The user can manipulate these files as required using proprietary software such as Microsoft Excel™ or the Aptec software. The *.apt file format contains only channel number and counts so to view the spectra in terms of energy the user must perform an energy calibration where channel 0 is 0 keV and channel 2047 is 3000keV (see section 9.6.3 for details). Geotek is currently upgrading the natural gamma logging software to enable the user, with the use of calibration samples, to decompose these spectra in to elemental concentration estimates for K, U and Th. These data will then be incorporated into the standard Geotek data sets.

9.5.5 Known Software Bugs

These errors occur very infrequently and are a result of the communications between the Geotek MSCL software and the Aptec software. One way of avoiding these errors is to limit the number of other applications that are running at the same time because logging many sample points can become very memory intensive and so less memory is available to the Geotek and Aptec software. If these errors become more frequent then try logging using the 'Type of Data' option [**Spectral2**] as this may give some improvement. The two error messages are:

“Full menu not available on MCARD#2”

“System error: The file you are trying to access is being used by another application.”

9.6 Aptec Data Acquisition Software

9.6.1 Aptec Software Installation

Windows 3.1™

- Run the Windows 3.1™ application: **C:\Win**
- Insert the Geotek installation disk provided into drive d:
- Using the file manager find and double click on [**install.exe**] in the aptec\setup directory.

Windows 95/98™

- Insert the Geotek installation disk provided into drive d:
- Choose RUN from the START menu and type **d:\aptec\setup\install**.
- Choose RUN from the START menu and type **d:\aptec\upgradeto** to install the latest version of the software.

The install procedure will now take place ensuring that all the appropriate files are created. Note that if any of the files are already present they will automatically be overwritten. The user should install the Aptec MCA software in the C:\Program Files\Aptec directory. The following files will be installed:

APTEC.EXE	Main PCMCA application, provides data acquisition and display. At start-up it automatically loads MCARDWIN.EXE.
MCARDWIN.EXE	An Aptec Windows application to monitor and control up to eight MCA cards.
MCARD.DLL	Dynamic Link Library. This is the main data acquisition portion of the data acquisition package.
MCARD.EXE	This is a DOS terminate and stay resident (TSR) and is portion of the data acquisition package. It is not used by the Aptec software if MCARDWIN.EXE is installed.
S_CSV.EXE	This application allows on screen display of the data in the current spectrum.
S_HEADER.EXE	Lists the data stored in the file header of the current spectrum. APTEC.EXE calls this application when required.
S_LIST.EXE	Report generator. APTEC.EXE calls this application when required.
S_IDENT.EXE	Application used by APTEC.EXE for isotope identification.
ISO_EDIT.EXE	Can be used to create or edit isotope libraries. Can be used as a stand alone application or through APTEC.EXE.
PCSCREEN.EXE	Produces a screen print out when called from APTEC.EXE.
SUPER.EXE	Provides a limited automation of the Aptec suite of software.
PCMCA.DLL	Dynamic Link Library. Contains common routines used by other applications.

PCMCA2.EXE Additional DLL.

Associated files are also installed, including sample spectrum files (*.S0), a sub directory (CONVERT) containing file conversion DLLs and some initiation files (*.INI) that store the defaults for the main Aptec MCA program (APTEC.INI) and the MCA cards (MCARD*.INI).

PC Requirements

A Pentium PC operating at least at 66MHz, a 500Mbyte hard disk and at least 8Mb of RAM. The Aptec software suite will work under Windows 3.1 or later.

9.6.2 Using MCARDWin Software (for Total Gamma Counts)

Use the MCARDWin software to acquire total natural gamma counts. To start the MCARDWin control software click on the [Start Menu_Programs_Aptec_MCARDWin]. The application will start up with the settings as set by GEOTEK. These settings may need to be altered by the user, if this is the case use the Aptec MCA software described in section 9.6.3. When the MCARDWin application starts up the window that appears contains a box containing the pertinent information for each MCA card installed (see Figure 77).

< -- >		< -- >	
MCARD = 1		MCARD = 2	
Detector = BB200/Crismatic		Detector = BB200/Crismatic	
Geometry = NGAM		Geometry = NGAM	
Status = Stopped	PHA	Status = Stopped	PHA
True Time = 1802.361 sec		True Time = 1801.883 sec	
Live Time = 1799.999 sec		Live Time = 1799.999 sec	
Preset = 1800.000 sec		Preset = 1800.000 sec	
Gross Counts = 438477 counts		Gross Counts = 447890 counts	
Dead Time = 0.13 %		Dead Time = 0.10 %	
Count Rate = 243.60 cps		Count Rate = 248.83 cps	

Figure 77. MCARDWin window with information on each MCA card installed.

If the setup parameters are correctly set then the user will only need to use two commands in the MCARDWin application. These commands start and stop data acquisition. To start collection on the MCA cards use the [Collect_Start MCARDs...] menu item (or F8) and then, in the dialog box that appears select the cards you want to collect data on. To stop collection use the [Collect_Stop MCARDs...] menu item (or F9) then select the MCA cards to stop. The data will be updated every 10 sec by default. To change the update interval use the [Update_Interval] (or F2) and enter the time required. It is recommended that the update interval is not changed as it may interfere with other operations the computer is attempting to process.

9.6.3 Using Aptec MCA Software (for Spectral Gamma Measurements)

Use the Aptec MCA software to acquire spectral natural gamma data. To start the Aptec MCA card control software click on the [Start Menu_Programs_Aptec_Aptec MCA]. The application will start up with the settings as set by GEOTEK. The majority of setup parameters set by GEOTEK prior to shipping should not be altered.

A detailed listing of all the menu items is given in the *PCMCA/SUPER Basic Display and Acquisition Software* manual that is provided. However, in this section only commands used for calibration and data acquisition will be dealt with.

File Menu Item

To view the data and associated settings stored in one of the MCA cards click on the [File_Look at MCARD] menu item and select a card from the list (see Figure 78). To view the data and associated settings stored in a file click on the [File_Open File] menu item (CTRL and F12) and select the file required.

Use [File_Save] (Shift and F12) and [File_Save As] (F12) to save spectra to disk. The Aptec MCA software uses the DOS 8.3 file naming convention, this must be followed. Only the spectrum on display will be saved, for example to save the Stabilised Spectrum the user must ensure it is displayed (Stabilised will appear at the top right of the spectrum window). To display the Stabilised Spectrum use the [Display_Stabilised Spectrum] menu item.

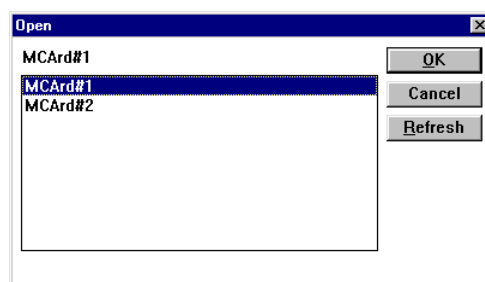


Figure 78. Open MCA card dialogue box.

Important Note: Spectra and settings altered in the Aptec MCA software affect only the MCA card or file displayed.

Edit Menu Item

From this list of options the user is likely to want to edit the Sample Description (**Shift and F5**) and use the Library option (runs S_IDENT.EXE) to view or edit isotope data (only to view data in the GEOTEK.LIB and to create new user defined libraries). The Load Header item is useful for loading sample information and setup parameters from a different file (i.e. a file with the recommended GEOTEK defaults).

Display Menu Item

The user can view the Normal Spectrum (unstabilised), the Intermediate Spectrum (a stage in the stabilisation process) and the Stabilised Spectrum (a compilation of intermediate spectra stabilised over the range specified in the Stabiliser Setup, Figure 83). Once an energy calibration has been completed the user can view the calibration using the **[Display_Energy Calibration]** menu item.

Setup Menu Item

All the setup parameters relating directly to the detectors and the hardware configuration have been setup as the user defaults. The user should not change these but to view the current settings use the Setup menu item (the settings that appear will be those that were used on the MCA card or file displayed). If at any stage the settings supplied are lost or changed then they will be stored in a locked file (for each MCA card) from which they can be loaded. These include:

- 1) The HV & LV Power Management (**CTRL and 1**). Each detector has an optimum operating voltage and this has been set here. The high voltage power supply is incorporated in the BB200 bias base. This will be indicated in the dialogue box and the appropriate value will be displayed. Generally the HV should be set between 500 and 550V. See Figure 79.

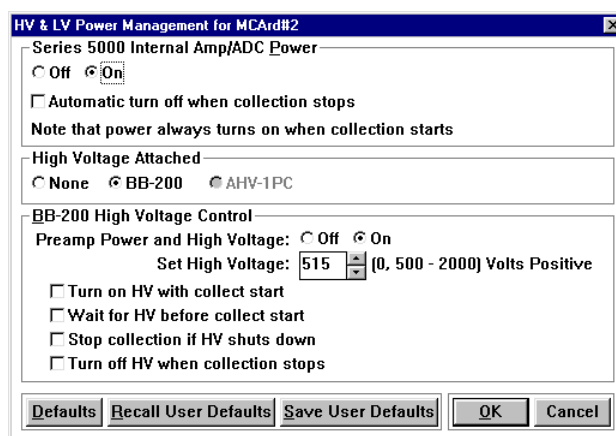


Figure 79. Power Management dialogue box as set for a series 5000 MCA card and a BB200 bias base.

- 2) The Pre-amplifier (**CTRL and 2**). There is an external pre-amplifier integrated into the BB200 bias base so the internal pre amp on the MCA card should be disabled. The BB200 pre-amplifier is a normal resistive feedback type and has a positive input polarity. The pre-amplifier setup is shown in Figure 80.

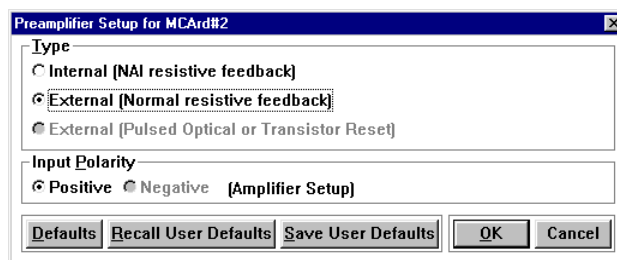


Figure 80. Pre-amplifier setup parameters.

- 3) The Amplifier (**CTRL and 3**). The amplifier should be set to Bipolar type with Positive input polarity. The time constant should be set at 1.00 sec, coarse gain to x2 and a fine gain according to the GEOTEK settings as they are specific to the detector that is connected to the MCA card. The remaining parameters should be set as illustrated in Figure 81.

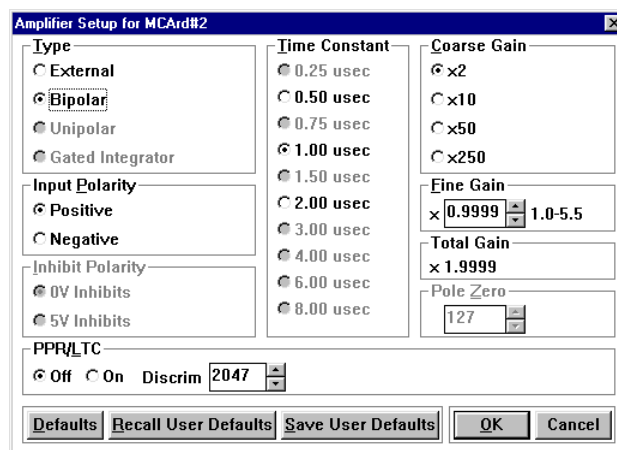


Figure 81. Amplifier setup parameters.

- 4) The Analogue to Digital Converter (ADC) (**CTRL and 4**). The number of channels in the spectrum should be set to 2048 (the maximum for the MCA card supplied). The ADC gain should also be set at 2048. The Lower Limit Discriminator (LLD) should be set at about 20 channels to remove any low energy end effects which detract from the data quality. Although there are a lot of settings available, these should not be altered from the defaults which are shown in Figure 82.

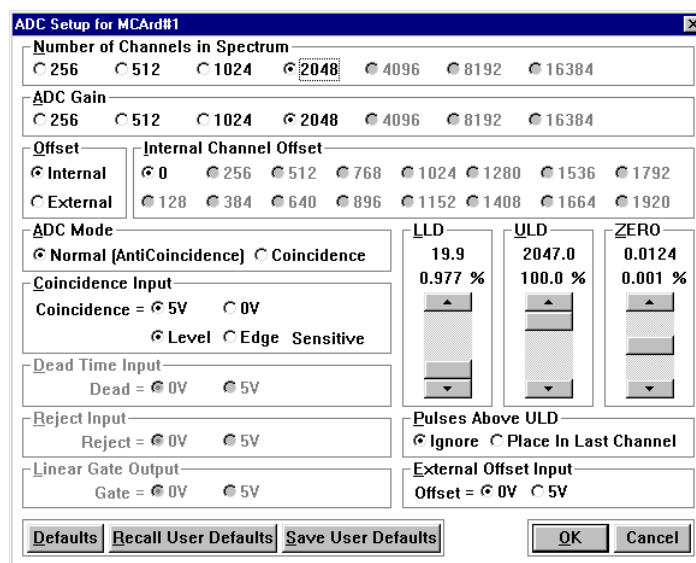


Figure 82. Analogue to digital converter setup parameters. The LLD, ULD and ZERO scroll bars are not used and should not be adjusted as they may adversely affect any measurements.

- 5) Stabiliser Setup (**CTRL and 5**). This is very important for acquiring spectra from multiple detectors that will be manipulated and compared at a later date. These settings must not be changed and are shown in Figure 83.

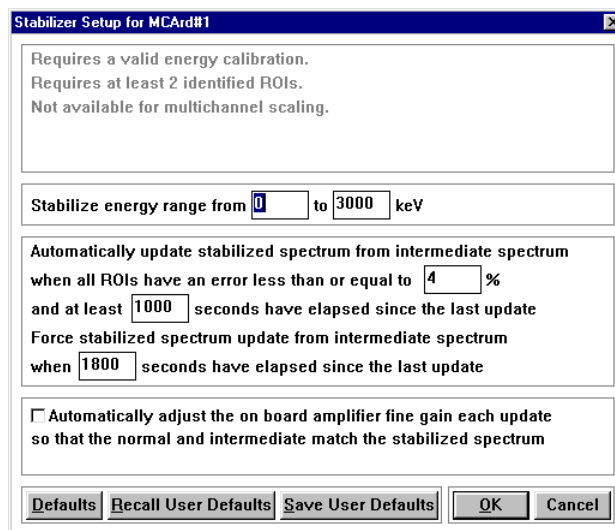


Figure 83. Stabiliser Setup.

- 6) Preset Setup (**CTRL and 6**). In this dialogue box the user can set the limits on the length of time that the MCA card and detector unit acquire data. For natural gamma measurements the user will only use the Live Time preset type. When using the Live Time preset type the preset value entered by the user should be the sample time. The other settings should be set as in Figure 84.

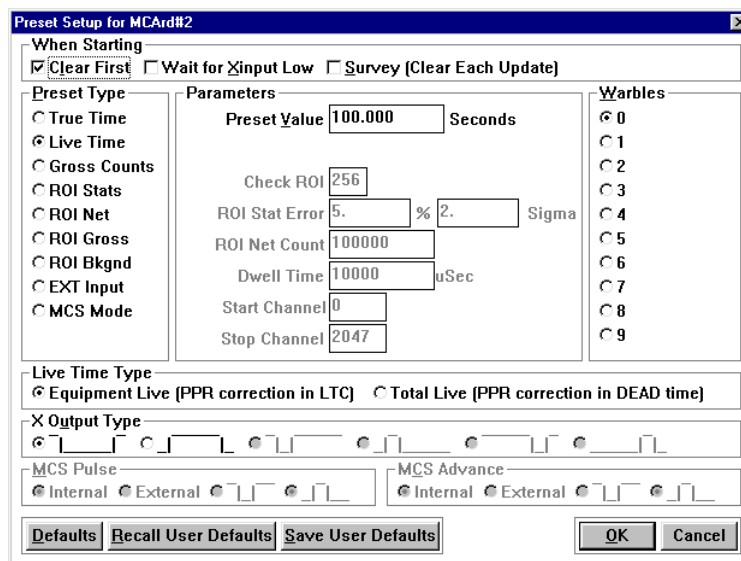


Figure 84. Preset Setup dialogue box.

- 7) Test Pulser Setup (**CTRL and 7**). The test pulser is not used during natural gamma measurements so the user does not need to use this menu item. The test pulser should be switched off.
- 8) Quick Energy Calibration (**F2**). This is used to calibrate the energy of spectra (see later section). The dialogue box that appears consists of a series of boxes into which the calibration can be entered. The position of the marker in channels is automatically entered so it is best to position the marker on a particular peak then press **F2**, enter the relevant energy level (in keV) and click OK. Do this for all the peaks required. The remaining parameters do not change from those shown in Figure 85. The Max Degree section of the dialogue box determines the order of the polynomial equation used to fit a line to the calibration points. A straight line fit

has been found to work best using the calibration source provided. The calibration units should be in keV if the units quoted in this manual are to be used. The numbers used in the equation are also given.

Collect Menu Item

The controls for starting and stopping collection of data are in the Collect menu item. The user can clear the currently displayed spectrum using the Clear Spectrum item (or **F7**). To start collection use the Start Normal Collection item (or **F8**) or to start stabilised collection use the Start Stabilised Collection item (or **Shift+F8**). To stop collecting data use the Stop Collection item (or **F9**).

The user will be prompted to confirm all these requests before any action is taken by the software. To stop these prompts appearing use the Preferences item. The Auto Adjust Pulse Pileup item is not used.

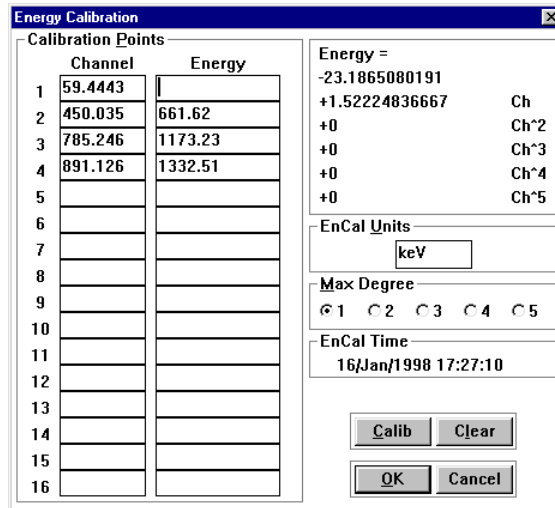


Figure 85. Energy calibration dialogue box.

ROI (Region Of Interest) Menu Item

The user may wish to use this item to highlight the peaks produced by the calibration piece. To paint in an ROI move the marker to the central position of the ROI and use the Paint item (or **F3**) and adjust the size of the ROI using the following short cut keys or use the special ROI menu items (see Figure 86):

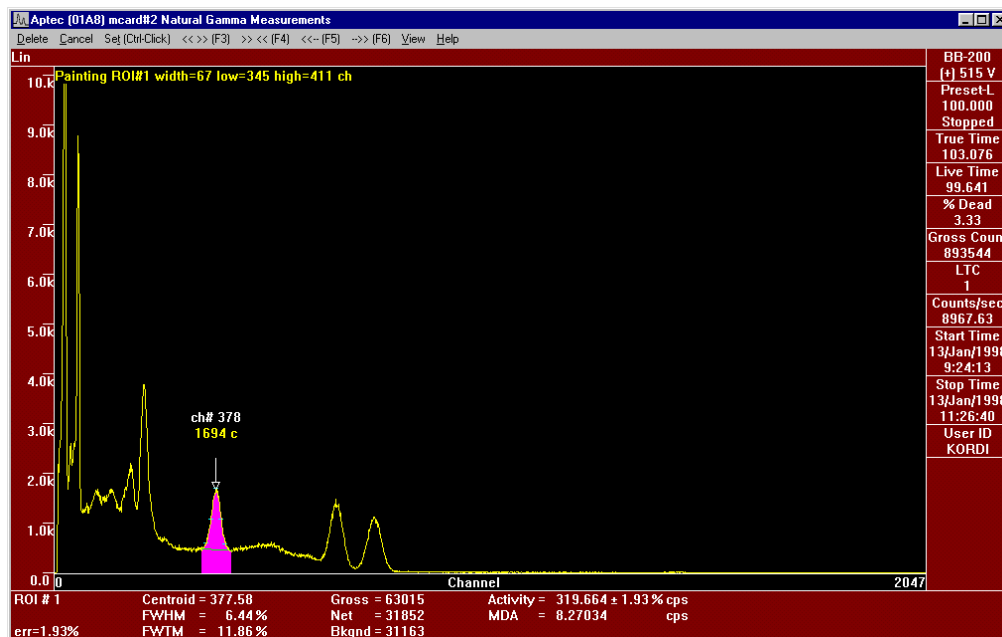


Figure 86. Configuration of Aptec software window during ROI painting mode.

- F3** (<< >>) Expands the ROI symmetrically around the marker.
- F4** (>> <<) Contracts the ROI symmetrically around the marker.

- F5** (<<-) Shift the ROI to the left
- F6** (->>) Shift the ROI to the right

To cycle through the ROIs press the space bar which moves the pointer to the centre of the next ROI (to the right) and indexes (highlights) it displaying its properties at the bottom of the window (Figure 86). Use Shift and Space to index the next ROI to the left. The remaining menu items are self explanatory. The Edit item (**F4**) allows the user to edit the indexed ROI using the same commands as when first painting an ROI. To delete the indexed ROI use the Delete key or use menu item Delete All..., the user will be prompted before any ROIs are deleted.

The ROI sort item sorts the ROI numbers in a left to right ascending order.

Analyse Menu Item

This set of menu items allow the user to perform various analysis routines on the currently loaded spectrum data. To setup the system for natural gamma measurements the user will have to use two of the items in the Analyse menu. Firstly the Peak Search which will search for peaks according to the criteria set in the setup options (see Figure 87) and then paints ROIs around those peaks. Secondly the Identify option that identifies the painted ROIs using a predefined library selected in the setup options (see Figure 88). The Aptec MCA software uses a secondary application (S_IDENT.EXE) to conduct the identification.

The analysis setup options have been preset by GEOTEK. The options that may need to be changed are for the Peak Search (an automatic peak identifier and ROI painter) and the Identification (isotope identification tool) analysis. The only parameter that may need to be altered in the peak search setup is the Max Peak Error (see Figure 87). This defines the sharpness of the peak that will be found, i.e. the greater the number the broader the peaks that will be selected.

The Identification setup options are shown in Figure 88. This dialogue box indicates the library that S_IDENT.EXE uses and the criteria used to select which ROIs to identify.

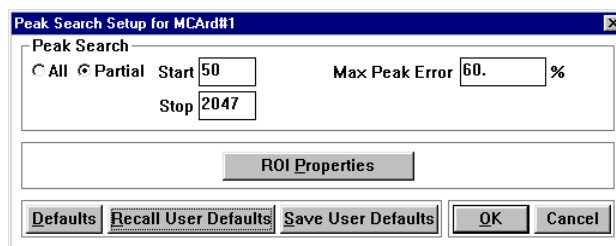


Figure 87. Peak Search setup options. Part or all of the spectrum can be chosen for the search and the Max Peak Error can be changed.

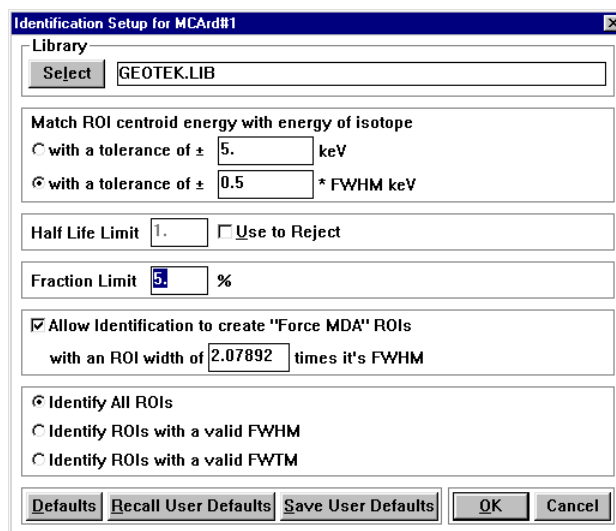


Figure 88. Isotope identification setup options.

The only other items in the Analyse menu that should be used are those in the lower most section of the menu structure. The Compare item allows the user to view two spectra at a time, a dialogue box will appear in which the user must select the spectrum for comparison. Once two spectra are displayed various

manipulation of the data can take place. The original spectrum is displayed in yellow and the compare spectrum in purple, assuming default colours are used.

The Combine item simply adds the two spectra together on a channel by channel basis. The resultant spectrum is then displayed in yellow (the original spectrum is modified) and can be saved to disk.

The Strip item subtracts the compare spectrum (purple) from the original spectrum (yellow) on a channel by channel basis. The resultant spectrum is then displayed in yellow (the original spectrum is modified) and can be saved to disk.

View Menu Item

Allows changes in the configuration of the screen display. The more useful options and their short cut keys are described below.

Command	Shortcut Keys	Description
Vertical Scale Auto Vert Scale	A	Auto range Y scale.
Vertical Scale Next Scale Type	S	Cycles through Y scale types.
Vertical Scale Raise Spectrum	Up Arrow	Increase Y scale
Vertical Scale Lower Spectrum	Down Arrow	Decrease Y scale
Horizontal Scale Channel X Scale	C	Displays horizontal scale in channels.
Horizontal Scale Energy X Scale	E	Displays horizontal scale in energy.
Horizontal Split	H	Split the screen horizontally.
Vertical Split	V	Split the screen vertically.
Expand	NumPad+	Expand X scale (x2).
Contract	NumPad-	Contract Y scale (/2).
Next ROI	Space	Index next ROI to the right.
Previous ROI	Shift and Space	Index next ROI to the left.

The remaining items in the View menu list are described in detail in the *PCMCA/SUPER Basic Display and Acquisition Software* manual.

Help Menu Item

This menu offers a series of online help pages which deal with the operation of the Aptec MCA software suite, information about the latest release of the software and a list of the most recent changes and upgrades to the software.

There are several additional files that have been added by GEOTEK. These files hold the GEOTEK recommended settings. These are named setup_1.s0, setup_2.s0 etc where the number represents the detector and MCA card pairing. These files are stored in hidden directories that can be accessed if required.

9.7 Aptec Software - Operational Procedure

Natural gamma core logging should take place following the standard logging procedures so that the user can determine exactly where and what type of measurements are required. This will cut down the number of natural gamma measurements required thus reducing the overall logging time. Once the sample positions have been determined the user must decide whether total gamma counts or spectral gamma analysis is required, this will determine the data acquisition time.

The MCA cards and detector units are controlled using the Aptec MCA software suite as supplied with the MCA cards. Use of the Aptec MCA software is described in section 9.6.3.

9.7.1 Collection of Total Natural Gamma Counts

Before total counts data can be acquired the user must ensure that the setup parameters are correct. This means that the HV Power, the Pre-amplifier, the Amplifier, the ADC and the Presets are appropriate for acquiring total gamma counts. For total gamma counts all these settings should be at the defaults supplied by GEOTEK on delivery, except for the Preset (set as Live Time) which should be an appropriate time period (e.g. 100 sec). These settings can be checked using the Aptec MCA software (see section 9.6.3). The procedure for collecting total counts is as follows:

- 1) Remove the calibration piece from the top of the central cube of lead shielding.
- 2) Start the Aptec MCA software [**Start Menu_Programs_Aptec_Aptec MCA**].
- 3) Display MCA card #1 [**File_Look at MCArd**], see Figure 78.

- 4) Ensure that the HV Power, the Pre-amplifier, the Amplifier, the ADC and the Presets are appropriate for acquiring total gamma counts
- 5) Set the Preset as Live Time and the Preset Value to an appropriate time in seconds ([**Setup_Presets...**], or **CTRL and 6**), see Figure 84.
- 6) Repeat steps 3, 4 and 5 for each MCA card installed.
- 7) Start the MCARDWin application (if not already open).
- 8) Start collection on all MCA cards [**Collect_Start MCARDs...**].
- 9) Wait for data acquisition to stop on all MCA cards.
- 10) Take a note the Count Rate on each detector and average these numbers together to give the Total Count Rate on both detectors.

9.7.2 Collection of Natural Gamma Spectra

Before acquisition of sample data the user must go through a series of setup procedures to ensure the following:

- 1) All the detectors used run in an energy stabilised mode which requires:
 - a) peak selection
 - b) energy calibration
 - c) peak identification
- 2) A stabilised background spectrum is collected for each detector

The MCA cards and detectors installed in the GEOTEK Natural Gamma Logger can run in a stabilised mode. This means that when calibrated using at least two peaks of known energy the spectrum is stabilised so that the centroid of the peaks stay in the same channel. The stabiliser is a very important feature as it counters the effects of drift that may occur due to temperature. The data produced in the stabilised mode are within a designated energy window, so if the energy calibration is good all the detectors will be balanced which makes subsequent data analysis very much easier.

Setup Procedure

- 1) Create a directory named as the core to be logged for data storage.
- 2) Start the Aptec MCA software [**Start Menu_Programs_Aptec_Aptec MCA**].
- 3) Display MCA card #1 [**File_Look at MCARD**], see Figure 78.
- 4) Clear all ROIs [**ROI_Delete All...**].
- 5) Ensure that the HV power, Pre-amp, Amplifier and ADC are set correctly for the detector attached (in the Setup menu), see Figure 79, Figure 80, Figure 81 and Figure 82.
- 6) Set the Preset as Live Time and the Preset Value to 100 sec ([**Setup_Presets...**], or **CTRL and 6**), see Figure 84.
- 7) Put the calibration piece inside the inner sheath (this shortens the setup procedure by increasing the count rate from the calibration source).
- 8) Start data acquisition ([**Collect_Start Normal Collection**], or **F8**).
- 9) Wait for data acquisition to stop on all MCA cards.
- 10) Ensure that the peak search setup is correct ([**Analyse_Setup_Peak Search**], or **Shift and P**), see Figure 87.
- 11) Conduct a peak search ([**Analyse_Peak Search**], or **P**).
- 12) Add and remove any unwanted ROIs as required (**Space** to cycle through, **Delete** to remove and repaint any that are required using the ROI menu list).
- 13) Cycle to lowest energy ROI (left side of screen) using the space bar.
- 14) Conduct an energy calibration ([**Setup_Quick Energy Calibration**], or **F2**). Replace old calibration points as necessary.
- 15) Repeat steps 13 and 14 until all ROIs have been used in the energy calibration.

- 16) Ensure that the isotope identification setup is correct ([**Analyse_Setup_Identification**], or **Shift and I**), see Figure 88.
- 17) Conduct an isotope identification ([**Analyse_Identify**], or **I**).
- 18) Save the spectrum to file in the directory created in step 1 ([**File_Save As...**], or **F12**) with the file name convention **SETUP(cardnumber).S0**. Note: *cardnumber* refers to the MCA card displayed. This file will be referred to later as the setup spectrum file.
- 19) Repeat steps 1 through 18 for each MCA card installed.
- 20) Ensure that the calibration piece is returned to its position on top of the central lead housing.

Background Spectrum Acquisition

- 1) Start the Aptec MCA software if not already running [**Start Menu_Programs_Aptec_Aptec MCA**].
- 2) Display MCA card #1 [**File_Look at MCARD**], see Figure 78.
- 3) Clear all ROIs [**ROI_Delete All...**].
- 4) Load Header Setup information [**Edit_Load Header Information**] from the relevant setup spectrum file (i.e. the MCA card displayed must correspond to the number in the filename) and ensure that the items loaded include those shown in Figure 89. If a sample description has been entered an earlier stage this can also be loaded.
- 5) Set the Preset as Live Time and the Preset Value to the sample time required (in seconds) ([**Setup_Presets...**], or **CTRL and 6**), see Figure 84. Note that the live time used for acquiring the background spectra must correspond to live time used subsequently for acquiring the sample spectra.
- 6) Ensure that the calibration piece and the background sample are in place.
- 7) Start stabilised data acquisition ([**Collect_Start Stabilised Collection**], or **Shift and F8**).
- 8) Repeat steps 1 through 7 for each MCA card installed.
- 9) Ensure acquisition has stopped on all MCA cards. Use [**File_Look at MCARD**] to view different cards.

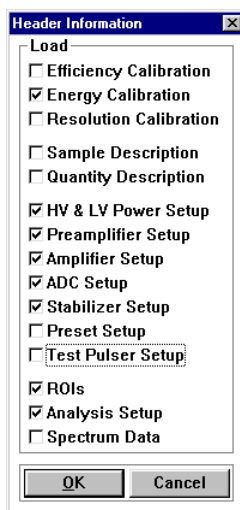


Figure 89. Header Information to be loaded from the header of the setup files prior to background spectrum acquisition.

- 10) **Ensure that the Stabilised Spectrum is displayed** [**Display_Stabilised Spectrum**].
- 11) Save the background spectra to file ([**File_Save As...**], or **F12**) in the directory created for the core data. Use the filename convention **BKGND(cardnumber).S0**.
- 12) Repeat steps 9 through 11 for each MCA card installed.

Sample Spectrum Collection

- 1) Start the Aptec MCA software if not already running [**Start Menu_Programs_Aptec_Aptec MCA**].
- 2) Display MCA card #1 [**File_Look at MCARD**], see Figure 78.
- 3) Clear all ROIs [**ROI_Delete All...**].
- 4) Load Header Setup information [**Edit_Load Header Information**] from the relevant setup spectrum file and ensure that the items loaded include those shown in Figure 89. If a sample description has been entered an earlier stage this can also be loaded.
- 5) Set the Preset as Live Time and the Preset Value to the sample time required (in seconds) ([**Setup_Presets...**], or **CTRL and 6**), see Figure 84. Note that the live time used for acquiring the sample spectra must correspond to live time used for acquiring the background spectra.
- 6) Ensure calibration piece and core sample are in place.
- 7) Start stabilised data acquisition ([**Collect_Start Stabilised Collection**], or **Shift and F8**).
- 8) Repeat steps 1 through 7 for each MCA card installed.
- 9) Ensure acquisition has stopped on all MCA cards. Use [**File_Look at MCARD**] to view different cards.
- 10) Ensure that the Stabilised Spectrum is displayed [**Display_Stabilised Spectrum**].**
- 11) Save the sample spectra to file ([**File_Save As...**], or **F12**) in the directory created for the core data. Use the filename convention: *sample position ID(cardnumber).S0*. Remember to use the DOS 8.3 file naming system. Note: *sample position ID* refers to the user's identifying code (5 characters).
- 12) Repeat steps 10 and 11 for each MCA card installed.
- 13) Repeat steps 1 through 12 for each sample position.

9.7.3 Data Manipulation

Combining Spectra

Any multiple spectra simultaneously acquired must be combined before any subsequent analysis can take place. To combine spectra use the guidelines outlined below:

Important Note: When manipulating spectra use only those collected with the same collection and calibration settings.

- 1) Start the Aptec MCA software if not already running [**Start Menu_Programs_Aptec_Aptec MCA**].
- 2) Open one of the files containing the data to combine ([**File_Open File...**], or **CTRL and F12**), e.g. BKGND(1).S0.
- 3) Compare the displayed spectrum with the spectrum to be combined [**Analyse_Compare...**], e.g. BKGND(2).S0.
- 4) Combine the spectra [**Analyse_Combine...**]. The resulting spectrum replaces the spectrum displayed in step 2.
- 5) Save the resulting composite spectrum ([**File_Save As...**], or **F12**) with an appropriate name. For example, if the two spectra that were combined were named BKGND(1).S0 and BKGND(2).S0 the most appropriate name for the composite spectra would be BKGND.S0.

Stripping Spectra

All of the composite sample spectra must be stripped of the composite background spectra to remove any environmental background effects. To strip the background spectrum from a sample spectrum follow the instructions outlined below:

Important Note: When manipulating spectra use only those collected with the same collection and calibration settings.

- 1) Start the Aptec MCA software if not already running [**Start Menu_Programs_Aptec_Aptec MCA**].
- 2) Open the file containing the sample spectrum from which the background must be stripped (**[File_Open File...]**, or **CTRL and F12**).
- 3) Compare the displayed sample spectrum with the background spectrum to be stripped [**Analyse_Compare...**], e.g. BKGND.S0.
- 4) Strip the background spectrum from the sample spectrum [**Analyse_Strip...**]. The resulting spectrum replaces the spectrum displayed in step 2.
- 5) Save the resulting stripped spectrum (**[File_Save As...]**, or **F12**) with an appropriate name. For example, *sample position ID-BG.S0*.

Outputting Data

To output the data into a spreadsheet for plotting or further manipulation click on the [**File_Preview Spectrum Listing...**] (or **CTRL & SHIFT & F12**). This will start a supplementary program to allow the user to view the spectrum data called S_LIST. To ensure that the data is shown click on [**Setup_Listing...**] and click the items required for output (see Figure 90).

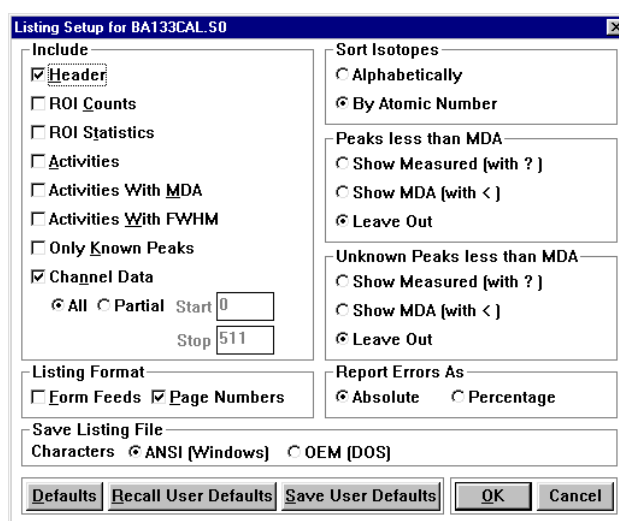


Figure 90. Output setup dialogue box.

The user is most likely to want the header information and the spectrum channel data. Once displayed the data is shown in a format as follows:

Channel	Energy	keV	Counts				
0	19.69		0	0	0	0	0
5	38.39		4	578	2734	3916	4094
10	57.10		4320	4568	4806	5637	7749
15	75.83		10244	12513	11869	9690	6471
20	94.57		4072	2734	2252	2171	2186
25	113.33		2335	2408	2384	2247	2076
30	132.11		2052	2003	2116	2100	2161

The data is arranged in an unusual way but is relatively easy to manipulate using a macro in Microsoft Excel™ for instance. In the five columns under Counts the data are arranged so that the first column represents the channel number given under Channel and the last column is the channel number given under Channel plus five.

10. GEOSCAN Digital Imaging

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10.1 Technical Specification

The GEOSCAN colour line scan camera is a 3 CCD device using 3 * 1024 pixel CCD arrays. A standard Pentax K-mount lens fitting is used which enables the user to easily purchase and change lenses depending on the exact imaging requirements. This is an important consideration when considering focussing and depth of field issues. Light from the object passes through the lens and is split into 3 paths by the beam splitter to fall on the red, green and blue detectors which when combined reproduce a conventional colour image.

All CCD detectors are sensitive to light in the 400 to 950 nm waveband. However they are relatively insensitive to light at shorter wavelengths (400-500nm - the blue end of the spectrum) than at the longer wavelengths of the visible spectrum wavelengths (600-700nm - the red end of the spectrum). Consequently the beam splitter is designed to direct 50% of the light towards the blue detector while 25% each is directed at the red and the green sensors.

To ensure that there is minimal overlap between the wavebands in the 3 channels (red, green and blue) for scientific applications, the light leaving each exit face of the splitter passes through a dichroic colour interference filter before falling on the detector which is located at the focal plane of the lens. The transmission characteristics of the filters used are illustrated in Figure 91 which clearly shows how the filters ensure true colour separation.

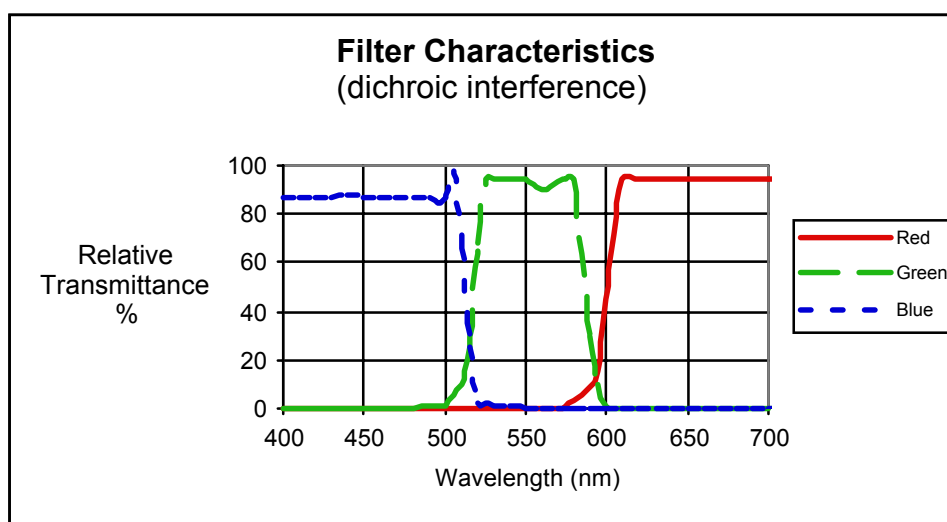


Figure 91. Dichroic interference filter characteristics.

The overall system response is also a function of the spectrum of the light used to illuminate the object. For normal RGB imaging the Geoscan system uses high frequency fluorescent lamps which produce light in 3 main wavebands corresponding to the red, green and blue parts of the spectrum. The light unit uses 2 fluorescent tubes that illuminate the core evenly from both sides of the image line. This provides a flooded illumination that minimises any shadow effects that could be caused from micro-topographic effects. The camera is arranged directly above the light and “looks” through a slot in the top surface of the light unit. Spurious reflections are eliminated by black anodising both the camera and light units.

The combined effect of all the elements in the camera and lighting unit produces an overall system response as shown in Figure 92.

This graph clearly shows that with the Geotek system we have almost achieved complete separation of the data into the R, G and B wavelength bands. Compare this with a typical system response from a 3 CCD camera where normal dye filters are used as illustrated in Figure 93.

Whilst the latter system response may give perfectly good images for viewing they will not enable any rigorous colour analysis to be performed because of the lack of true colour separation.

The 3 CCD sensors used have 1024 active elements each. A dark reference pixel is used which is electrically identical to the active pixels, but has been fabricated with an opaque layer over it. It is used to compensate for electrical drift within the sensor due to temperature variations. Each pixel is 14µm square

with a total active array length of 14.4 mm. The digitised data from the 3 sensors is 8 bit and is multiplexed and transmitted differentially to the interface electronics.

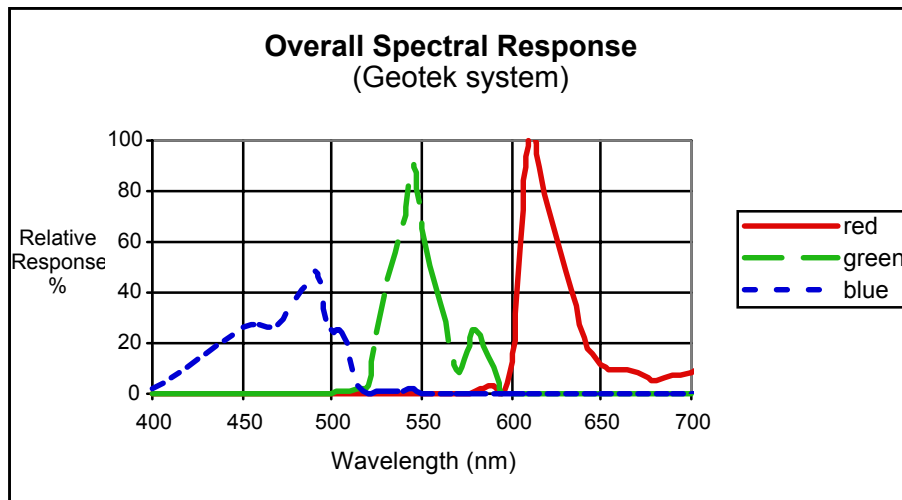


Figure 92. Overall response of the GEOSCAN digital imaging system.

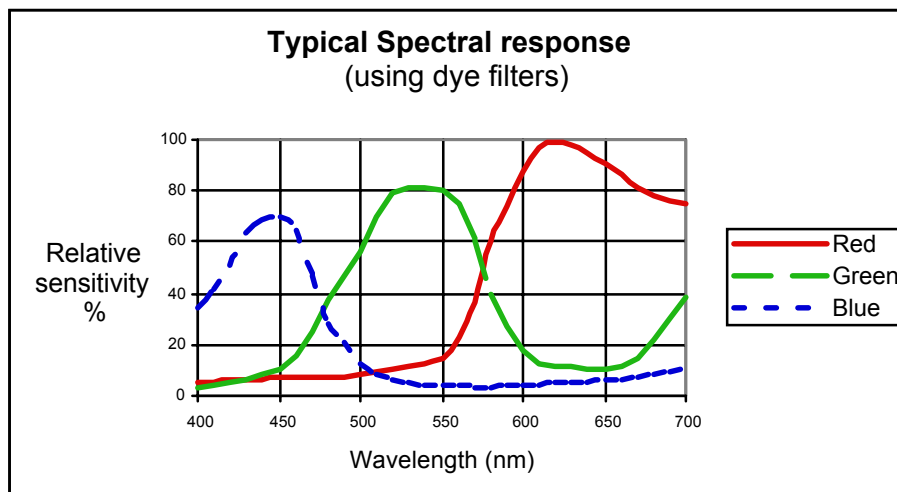


Figure 93. Typical response of a system using overlapping dye filters.

Synchronisation between the camera and the track is achieved by using the stepper motor pulses to trigger the line acquisition of the camera. Since each motor pulse corresponds to a fixed amount of track movement it can be seen that the camera images a line across the core at precise spatial intervals down the core. This means that there is no optical distortion from the lens in the down-core direction, an important factor for high-resolution studies. Motor speed defines the time between pulses and hence the integration period (exposure time). The software-controlled pulse divider allows the distance between scans, i.e. down-core resolution, to be defined. Camera data is de-multiplexed in the interface box, and 24-bit data is transmitted differentially to the PC interface card. Once in the PC the data is corrected for convergence, gain and offset.

A software convergence routine applies a correction that compensates for any minor mechanical differences between the 3 sensor arrays. This feature is particularly valuable when assessing the performance of the camera. In the event that the camera is subjected to excessive mechanical shock (it gets dropped!) the convergence routine would enable the user to assess the extent of any damage that had been sustained and, within limits, apply a software correction to the data. Offset correction ensures that the 3 channels are referenced to a true black level. This is achieved by measuring the signal level of the black reference pixel for each sensor. Gain correction compensates for pixel-to-pixel response variation, uneven lighting, and lens effects. Lenses tend to darken the edges of the field of view, an effect which becomes more pronounced with increasing aperture. To correct for all of these the camera images a white tile and a software gain correction is calculated for each pixel. This correction is then applied to subsequently acquired image data.

The corrected data are stored in a BMP format with appended depth and calibration information that can then be read by the image replay software.

10.2 GEOTEK Digital Imaging Software

10.2.1 Running the program

- Click on [Start], [Programs], [Geotek MSCL 5.2], [Geotek Digital Imaging 5.2]
- The Main Menu will appear as below providing the four menu items:
 - [Acquire Image] (see section 10.2.2)
 - [View Image] (see section 10.2.3)
 - [Camera Setup] (see section 0)
 - [Exit] (exit from application)



Figure 94. Main Menu Panel.

10.2.2 Acquire Image

This is the normal starting position from the main menu when the user wants to image a core for the first time, after having set up the imaging system correctly.

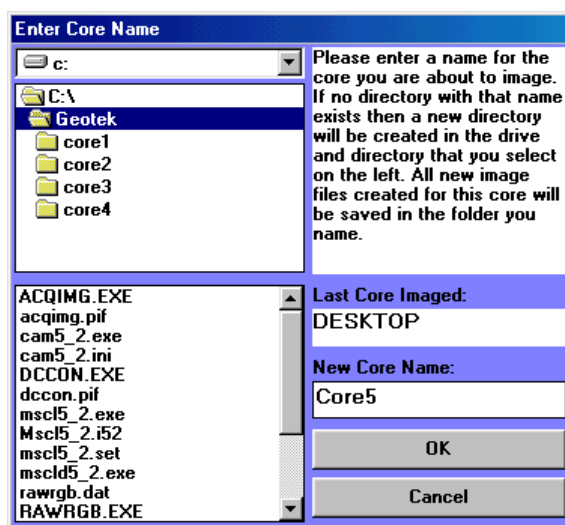


Figure 95. Enter Core Name Panel.

Enter Core Name: The “Enter Core Name” panel will then be displayed. This prompts the user to enter the new core name and select the destination for the data to be logged. The last core logged is shown as a guide.

It is very important that the imaging system has been set up correctly. This requires the focus and aperture to be set correctly, a white tile calibration has been performed with the camera and light in their current position and that the relevant cross-core resolution has been set (see section 0 for more details).

Once the core name has been chosen the user will be prompted by the Image Acquisition Setup panel (see Figure 96). This panel shows the details of the core and the setup parameters including the Core ID, the directory the data will be stored in, the calibration file (to be used for white level correction) and the cross-core resolution. These are defined in the **[Camera Setup]** as accessed from the main menu (see section 0).

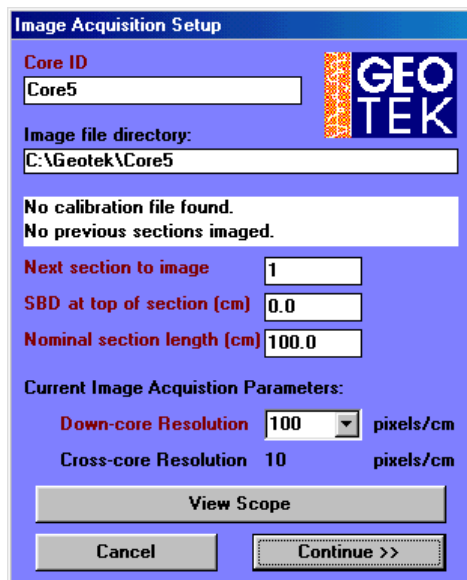


Figure 96. Image Acquisition Setup Panel.

The user must define the section number to image, the sub-bottom depth (SBD) at the top of the section and the nominal section length (as defined in previous chapters). The down-core resolution must also be chosen using the pull down option box, the options are 100, 200 and 500 dots per cm for a standard logger system.

At this point the user can view the response of the camera by clicking on the **[View Scope]** button. A scope window will appear displaying the levels of light received at each of the CCDs behind the filters as shown in Figure 97.

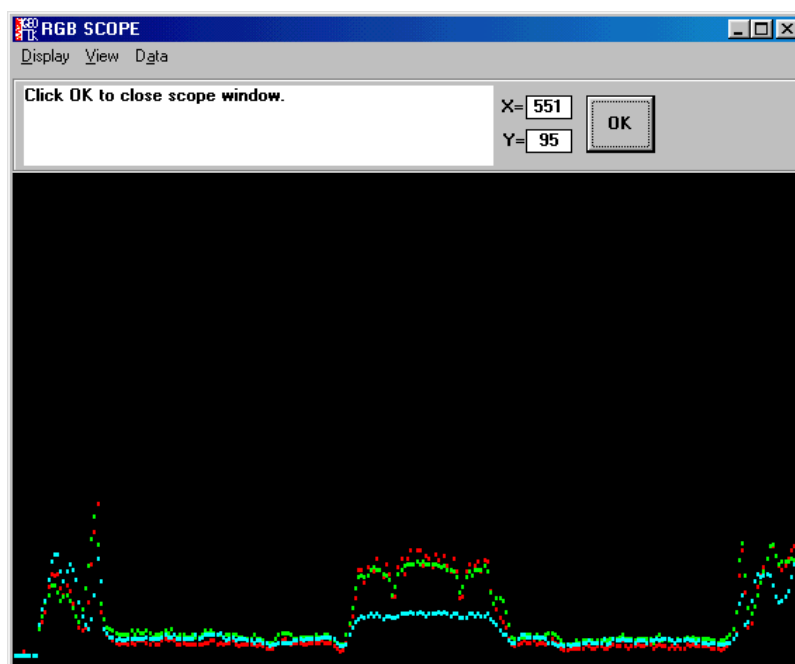


Figure 97. RGB Scope window.

The user must then click [**Continue>>**] and the Logger Control Panel (Figure 98) will appear and guide the user through the track setup procedure which is very similar to a normal core logging scenario (see Chapter 5) but some of the messages will be different (see Figures). The user must have gone through all the setup procedures before the software will allow data acquisition to continue (see section 0).

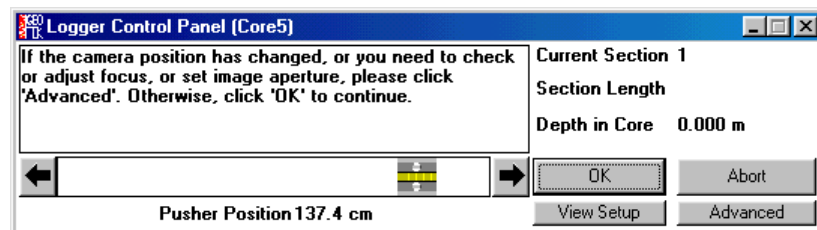


Figure 98. The logger control panel will prompt the user through the relevant setup procedures.

Once the section has been imaged it will be displayed and the user can continue imaging core sections.

10.2.3 View Images

The user can view images collected using the Geotek Digital Imaging software by clicking on this button from the main menu (this works in the same way as the [**View Images**] button on the main menu in the Geotek MSCL logging software. The user will be prompted to select an image file (see Figure 99) which will then be loaded into the software and displayed.

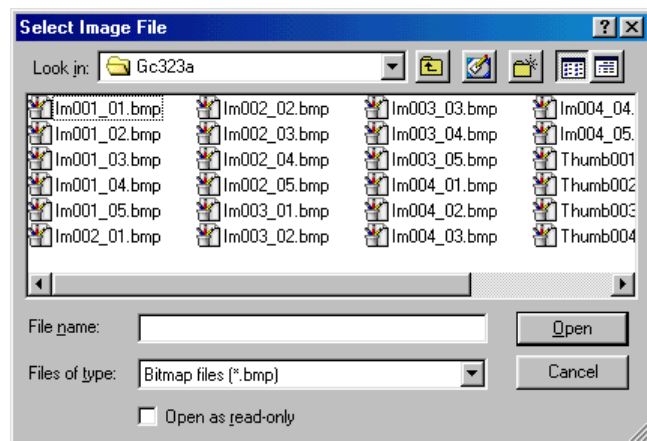


Figure 99. Select Image File dialogue box.

Once the images have been loaded into the software the user can scroll up and down the core through the images. The images can be viewed in full resolution (as imaged in short lengths) or as a thumbnail, a decimated image of an entire core section. By default the software automatically selects the resolution but the user can override this using the [**Image Auto Resolution**] menu item. The numbers on the scales represent the image width across the top and the depth down-core at the side.

To zoom in on an area of interest simply draw a box with the mouse and click inside the box. The area bounded by the box will be displayed in the window. When zooming in the user should be aware that the pixel size in the image is not held proportional. This means that images may appear distorted if the width and depth scales are not similar.

This display does not give the full set of features provided with the main MSCL software. The user should run the main MSCL software to extract the reflectance data for red, green and blue and to display the images and RGB profiles alongside any other core data that has been collected.

The user can zoom in on an area of the image by drawing a box around the area of interest and clicking inside it.



Figure 100. Image display.

10.2.4 Camera Setup

This option should be chosen before any images are acquired. The camera must be checked for errors and certain setup procedures adhered to. The user will be prompted with a setup panel as shown in Figure 101.

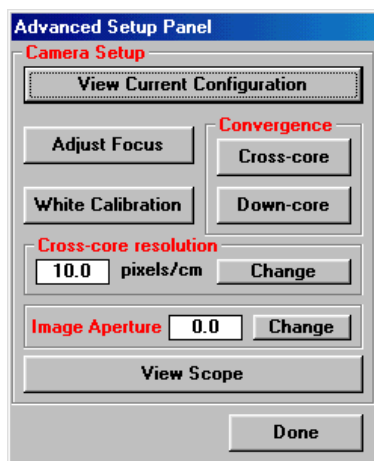


Figure 101. Advanced Setup Panel for the GEOSCAN Digital Imaging system.

During much of the camera setup the user can make use of the testcard that is supplied. If the testcard becomes damaged then the user can download the digital version from the Geotek website (<http://www.geotek.co.uk/>). The testcard is illustrated in Figure 102.

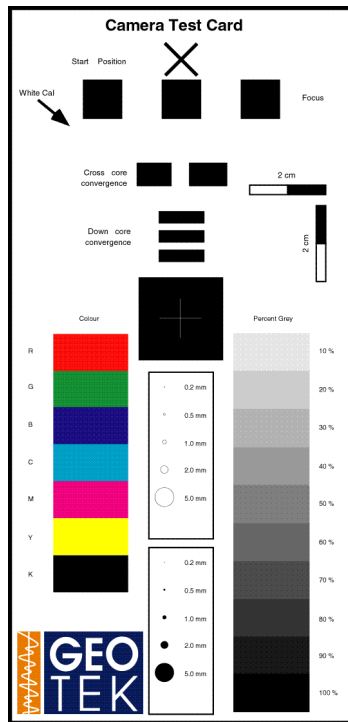


Figure 102. GEOSCAN Testcard.

View Current Configuration

A window will appear displaying the current data stored for the camera system (see Figure 103). The version numbers of the camera, the framestore electronics and the PC interface are shown. The position of the camera (camera offset), the serial port for communications with the logger electronics and the number of pulses sent to the track motor for a cm of movement are also displayed. Below these parameters the Convergence values are shown. The convergence values correct for any mechanical misalignment between the CCDs within the camera unit. These values can be changed using other options in the Advanced Setup Panel, see below.

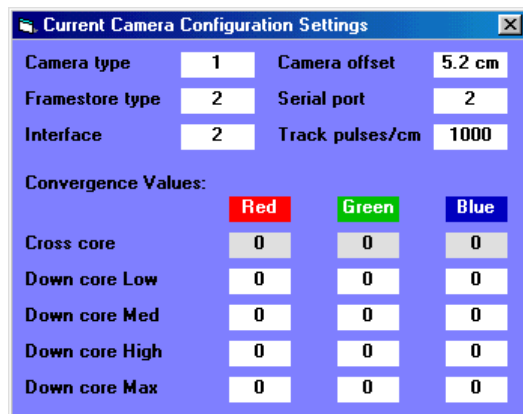


Figure 103. Current Camera Configuration Panel.

Adjust Focus

A scope display of the RGB responses from the camera is displayed. The user should place a sharp black to white boundary under the camera (at the level of the core surface) and adjust the focus ring on the lens until a sharp transition is seen on the scope display. The bar and number at the top of the scope display is an aid to focussing. The number is an arbitrary figure that represents the best focus achieved and the bar shows the current focus. To reset the number click on the arrow below the bar display.

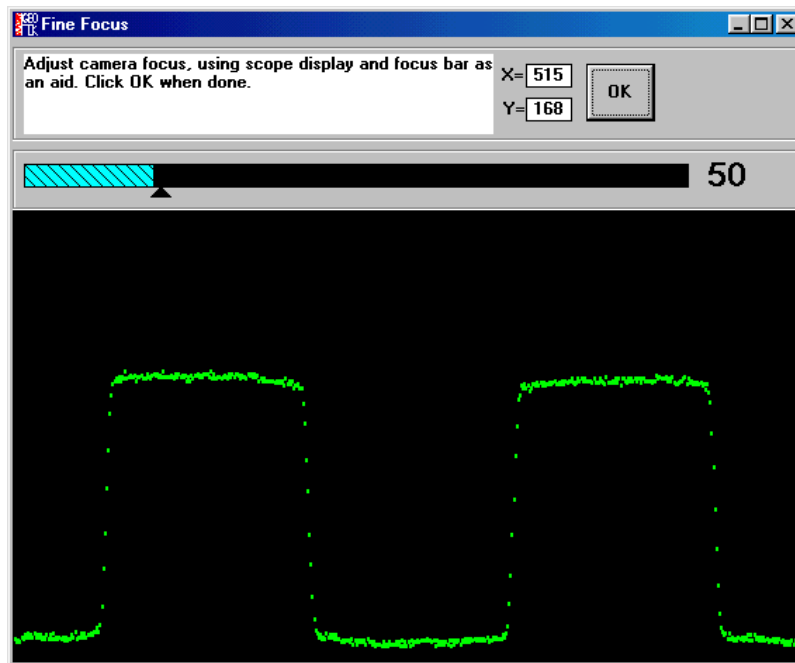


Figure 104. Adjust Focus Panel.

White Calibration

A scope will again appear. The user is prompted to put a white calibration tile under the camera (at the height of the core surface) and adjust the aperture ring on the lens so that the maximum response is achieved without saturating the CCDs (the red, green and blue levels will level out at the top of the scope display).

The user should select the relevant aperture setting using the option box and click [Save]. This will create a white calibration file that corrects the image data to a known white standard.

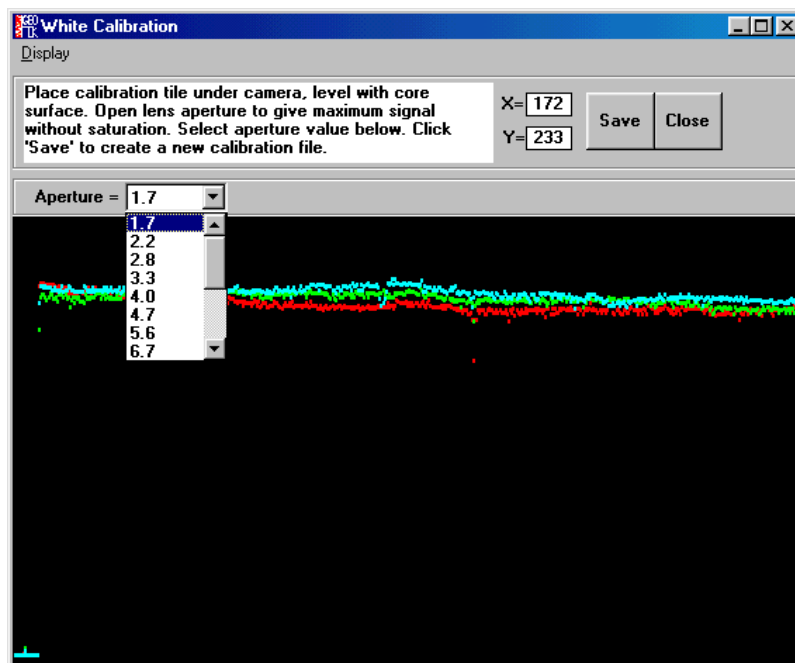


Figure 105. White Calibration window.

Cross-core Resolution

The cross-core resolution is defined as the number of pixels imaged divided by the field of view of the lens. Cross-core resolution is therefore dependent on the height of the camera above the subject. To define the cross-core resolution the user must place a subject with blocks of black and white (of known width) under the camera at the level of the core surface. The user must then move the marker lines over the edges of the

known width and enter the known width into the text box at the top left of the scope. The **[Auto]** button can be used if required.

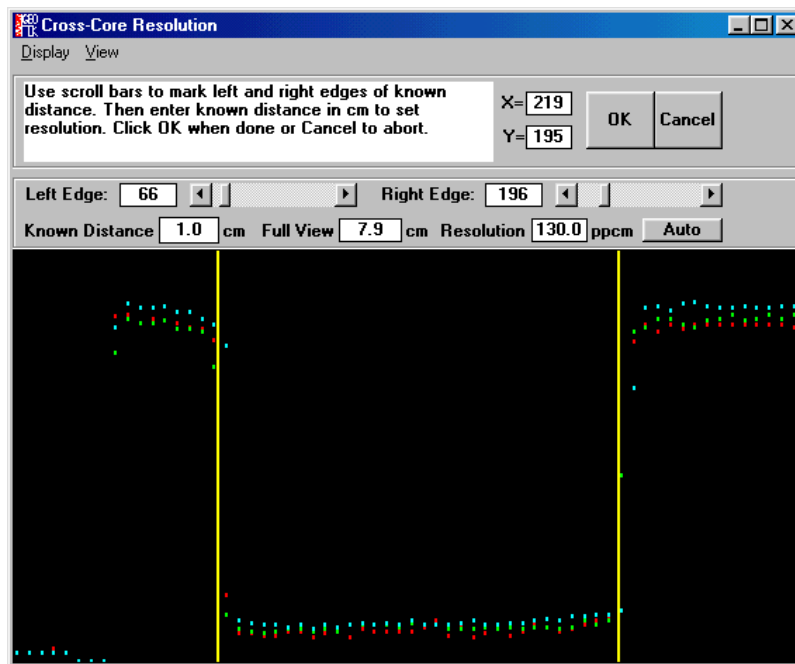


Figure 106. Cross-core resolution setup panel.

Image Aperture

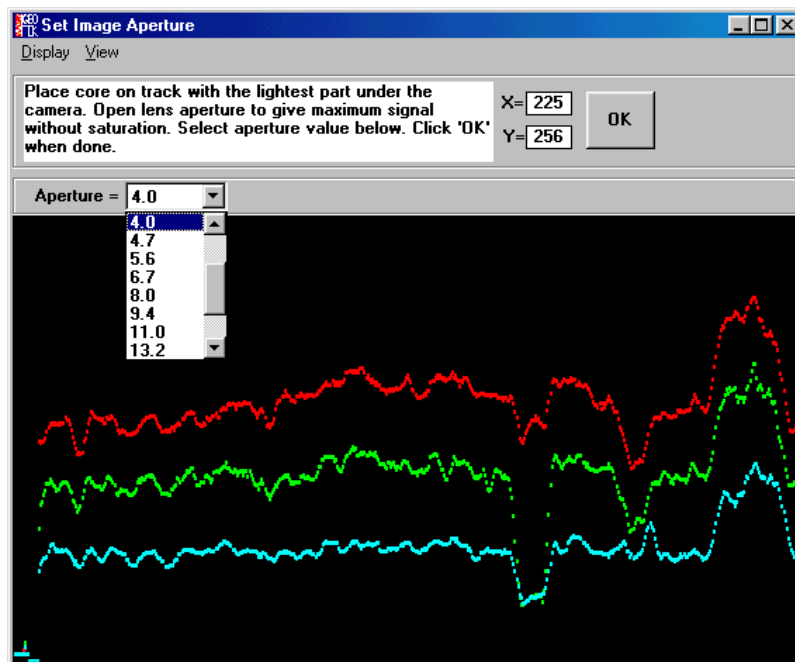


Figure 107. Image Aperture setup.

The aperture of the lens should be set so that the entire core can be imaged at the same setting. Because of this the lightest part of the core should be placed under the camera and the aperture adjusted such that the red, green and blue responses from the CCDs do not saturate, as shown in the scope display. The user should select the appropriate aperture setting in the option box at the top left of the scope window.

Convergence

The mechanical configuration of the CCDs within the camera head is set at the time of manufacture and the convergence values (alignment errors) are setup when the camera is installed. However, if the camera is

subjected to mechanical shock (accidental or during transportation) then the alignment of the CCD sensors should be checked using the **[Cross-core]** and **[Down-core]** buttons.

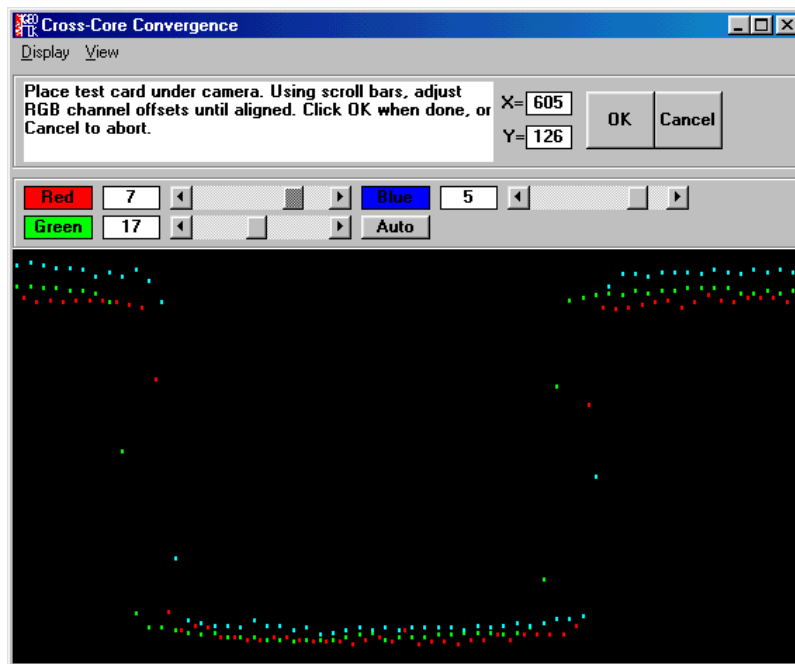


Figure 108. Cross-core Convergence Panel.

Cross-core

The cross-core convergence can be adjusted by placing a black to white boundary under the camera perpendicular the cross-core direction. The test card can be used for this and the user should focus the camera on the boundary change. The scope window that is spawned will display all three channels and the user can zoom in on the boundary and move the different profiles using the scroll bars at the top of the scope. The **[Auto]** button will perform an automatic convergence if the user prefers (see Figure 108).

Down-core

The cross-core convergence must be set before the down-core convergence can be set. The down-core convergence is a more complicated procedure as it requires moving a black to white or white to black boundary perpendicular to the down-core direction under the camera using the track. Again the testcard should be used for this. The logger control panel will start and the user will be prompted to put the testcard onto the track with the cross underneath the camera. When ready the user should select the required down-core resolution (the down-core convergence should be set for each down-core resolution used) and click on **[Acquire Data]**.

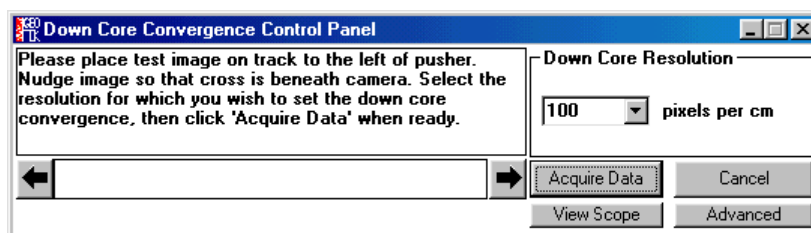


Figure 109. Logger Control Panel prompts the user to position the testcard prior to checking the down-core resolution.

The track will push the testcard beneath the camera and a scope like window will appear. This is, however, a static display using data collected as the testcard was pushed under the camera. The three channels will be displayed and the user should use the scroll bars at the top of the scope to align the three traces. The **[Auto]** button will perform an automatic convergence if the user prefers (see Figure 110).

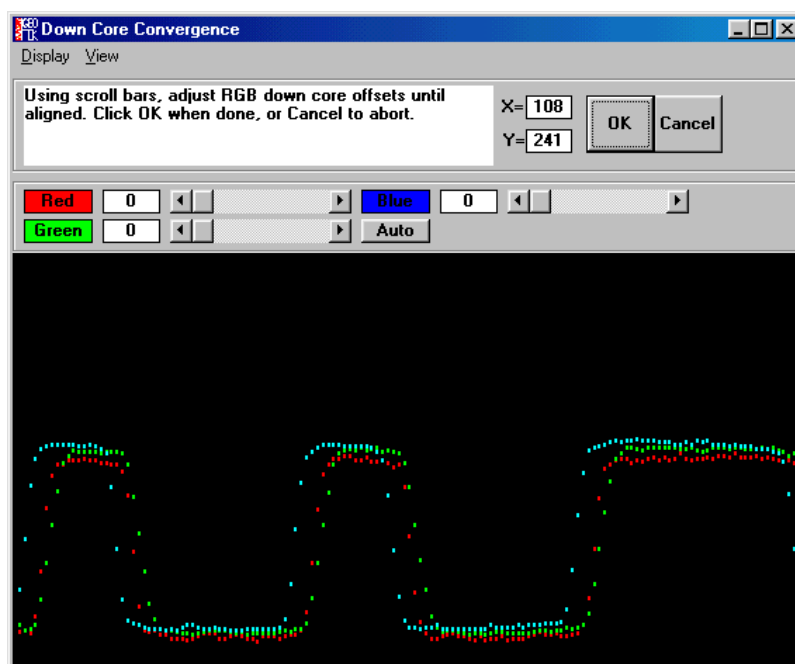


Figure 110. Down-core convergence panel.

View Scope

A scope is displayed with a variety of different viewing options (see Figure 97). The **[Display_All]** menu item displays all the channels (R, G and B) and each channel can be switched on or off using, for example, the **[Display_Red]** menu item. The user can zoom in on areas of the scope by drawing a box and clicking inside it. The view can be reset to the default by using the **[View_Reset]** menu item. The resolution of the scope can be changed using, for example, the **[View_Resolution_50%]** menu item that displays half of the available data across the scope screen, the default resolution is 25%. The type of data can also be changed. By default the data is displayed as convergence corrected, black correction applied and no white correction applied. All of these settings can be changed using the **[Data]** menu and sub menu items.

10.3 Image Data

The files created by the GEOTEK Digital Imaging software are in the Windows bitmap format. Additional information is included in the footer of the file that is used by the Geotek image replay software. This information includes calibration information (image aperture and white calibration aperture), resolution parameters (cross-core and down-core) and the relevant positional data (image top, length and width). Users should be aware that manipulating these images in other software and resaving them might cause some of this information to be lost. The Geotek replay software will not be able to show images that have lost the footer information. The file structure that is used for the data files as stored in the core directory is illustrated below:

```
im001_01.bmp, im001_02.bmp to im001_XX.bmp   for section 1
im002_01.bmp, im002_02.bmp to im002_XX.bmp   for section 2 etc.
```

There are no output functions available with the Geotek software but the widely used bitmap format allows cross platform manipulation of the data, whilst retaining all the relevant colour depth and resolution data intact.

The images can be viewed alongside the data collected with the other sensors on the Geotek MSCL system using the standard software. The user should load in the core data and then, in the processing panel, load the relevant core image (**[File_Load Image]**). The image will be displayed at the correct depth so that features and data can be compared. The profiles of red, green and blue reflectance can be extracted from the image (see section 5.2.5) and also displayed alongside the image and log data.