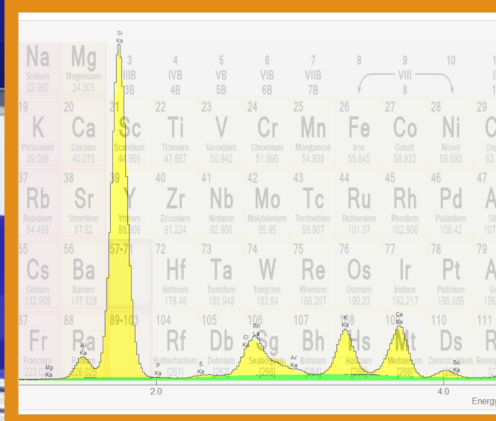




MSCL-XRF: MULTI-SENSOR CORE LOGGERS

PRECISE XRF CORE SCANNING FOR RESEARCH & INDUSTRY



IF CORE'S WORTH TAKING, IT'S WORTH LOGGING

GEOTEK MULTI-SENSOR CORE LOGGERS

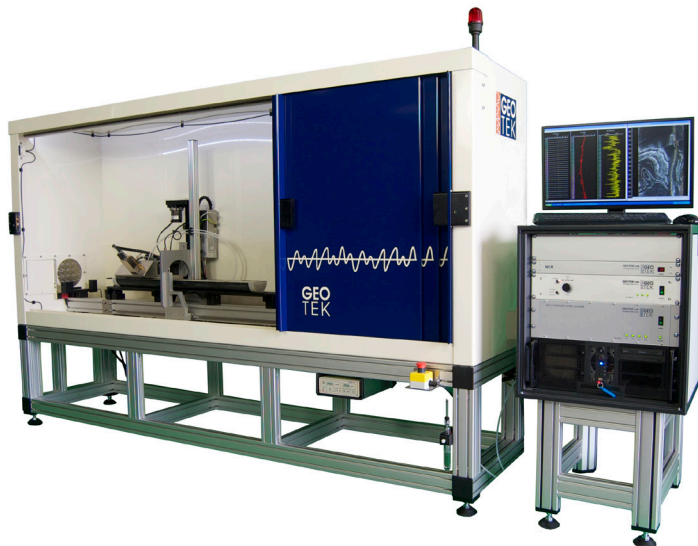
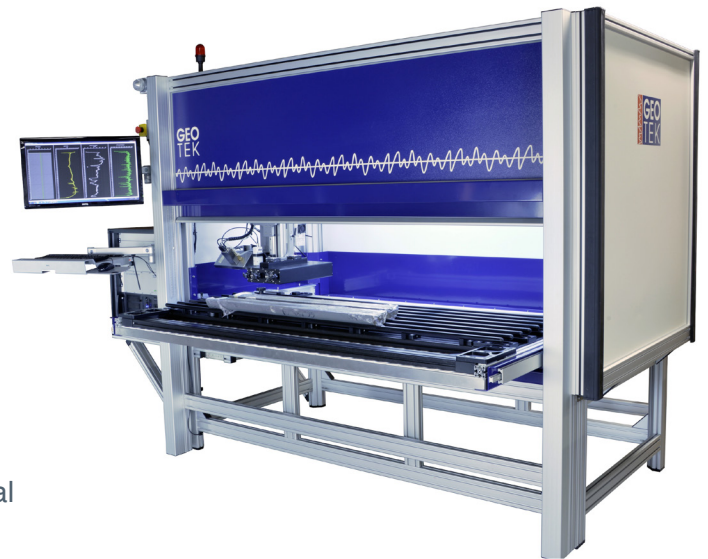
Geotek offer a range of specialised core scanning equipment that use XRF spectrometers to acquire elemental abundance from the surface of sediment and rock cores. The ability to continuously scan core samples using both petrophysical and spectroscopic techniques is a unique product to Geotek.

A MSCL is the perfect platform to acquire XRF data as it offers a stable and repeatable geometry with each measurement depth co-registered with other spectroscopy and petrophysical sensors. Geotek offer two XRF spectrometers: the high resolution and ultra-sensitive Geotek XRF, and the popular hand-held Olympus Delta, which are compatible with a range of different MSCL systems.

MSCL XRF SYSTEM CONFIGURATIONS

MSCL-XYZ

- Multiple core workstation
- Accepts core boxes
- Surface core measurements with visible and UV linescan imaging
- Main use in core repositories and industrial laboratories

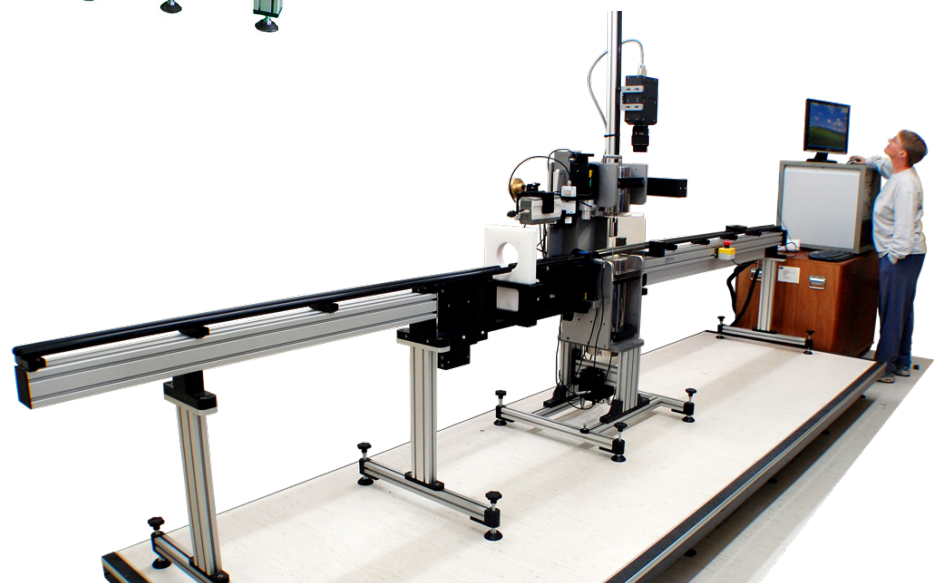


MSCL-XZ

- Small foot-print core logging platform
- Surface core measurements with visible and UV linescan imaging
- Main use for field-based measurements and smaller laboratories

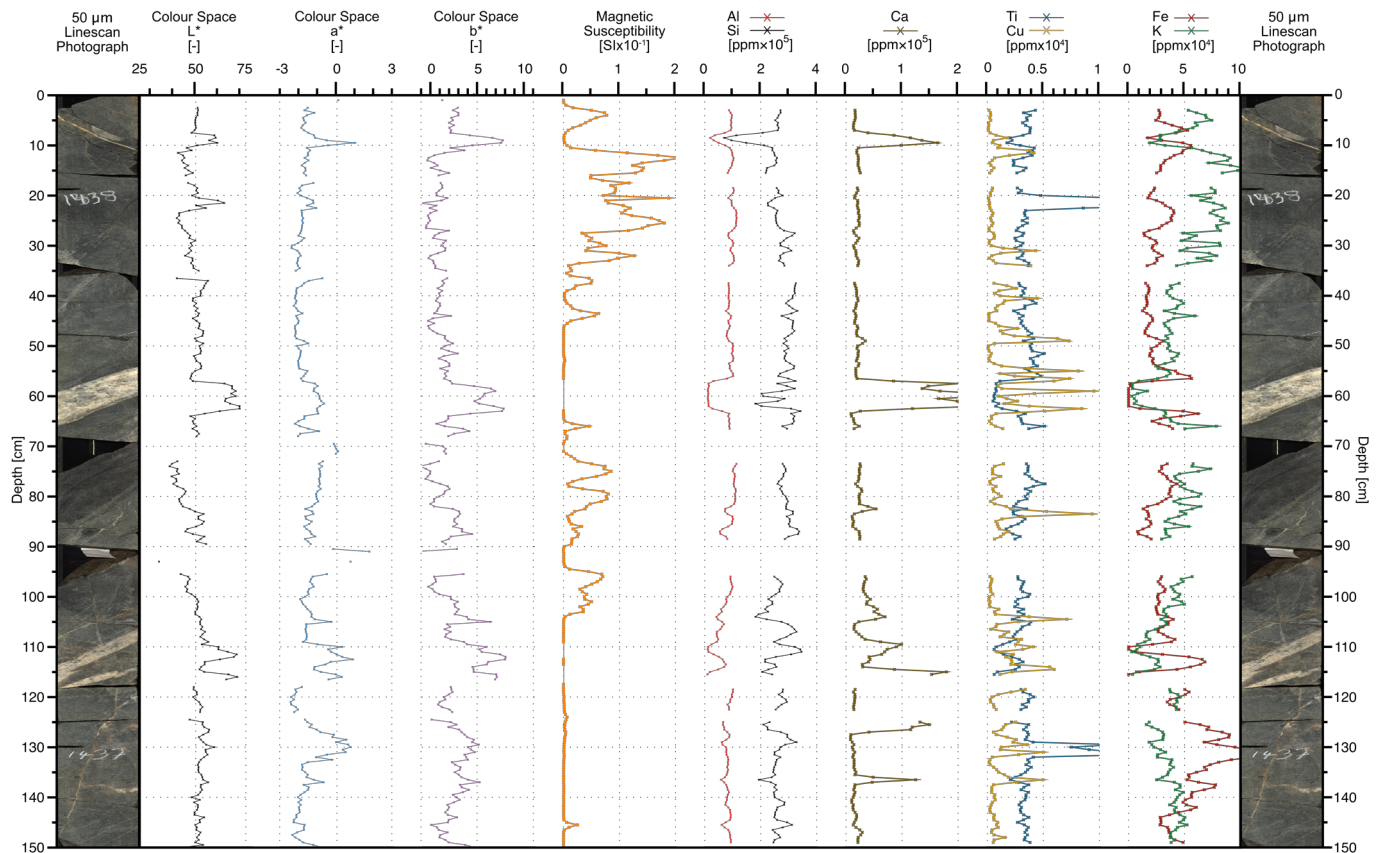
MSCL-S

- Accepts nearly any form of core material
- Spectroscopy and petrophysical sensors can be combined
- Continuous core logging
- Main use for field-based measurements and laboratories



APPLICATIONS OF XRF DATASETS

Nearly any geological, geochemical, or petrophysical application benefits from the ability to maximise data recovery from core material. Geotek's MSCL systems achieve this by uniquely combining continuous downcore XRF with other spectroscopy and petrophysical measurements.



Example X-ray fluorescence dataset acquired at a spatial logging resolution of 1 cm

OIL & GAS / UNCONVENTIONAL

- Corroboration of downhole log elemental concentration
- Core to log integration and correlation
- Interpretation of mineralogy and matrix properties
- Linking core gamma ray with elemental content and density

MINING

- Identification of trace metals and ore identification
- Elemental abundances automatically stored and exported as ascii file
- Depth co-registration of elemental data with physical and magnetic properties for resource assessment

GEOHAZARD

- Sediment provenance assessment
- Bed/unit correlation
- Characterisation of cement
- Derivation or proxy for mineral distribution
- Mass movement identification

RESEARCH

- Elemental abundances used as a proxy for environmental change
- Identification of volcanic ash, or ice-rafted debris
- Characterisation of palaeosols and sediment/rock core samples
- 100 µm downcore logging resolution for high resolution climate change studies

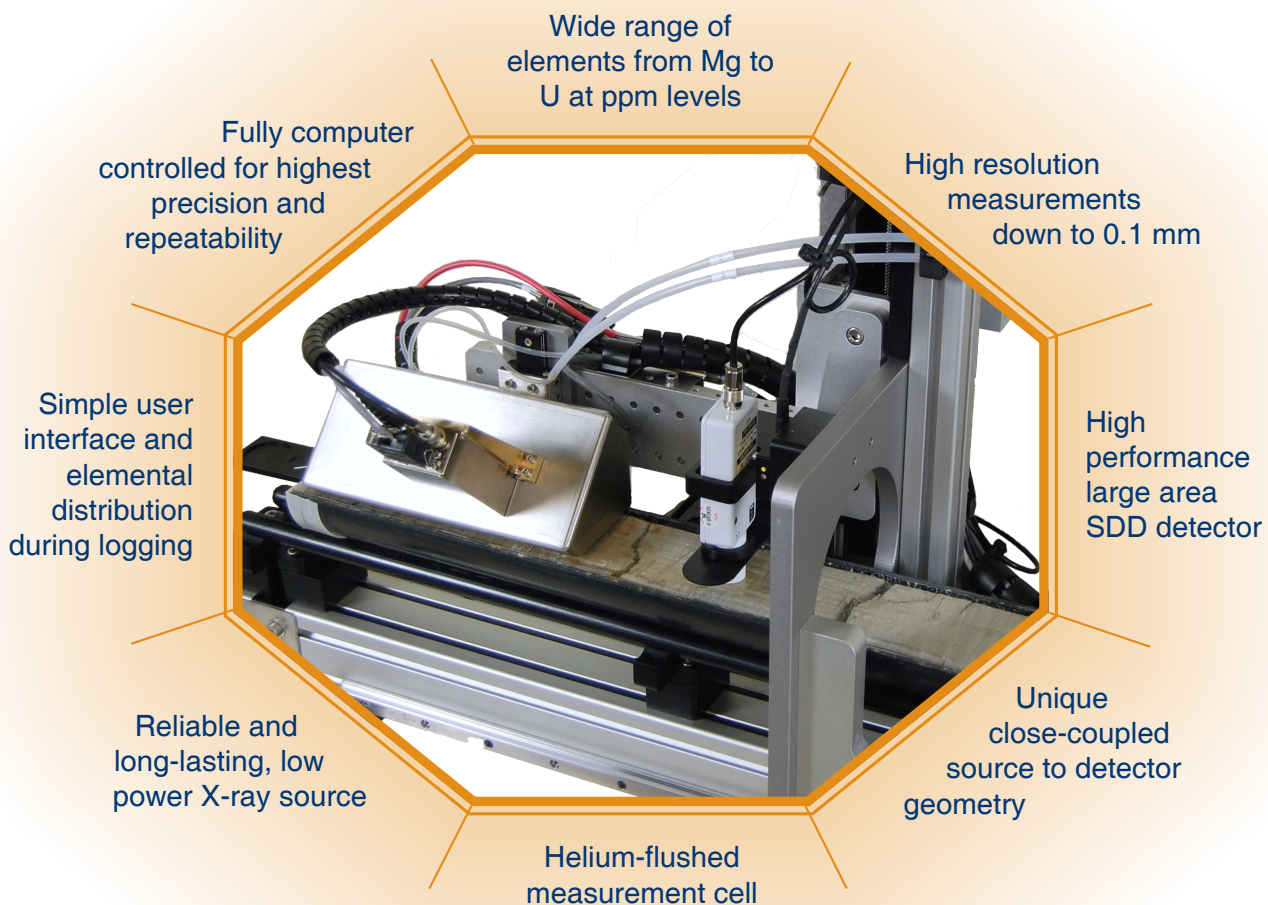
ENVIRONMENTAL

- Identification of heavy metals
- Can be integrated with ultraviolet linescan imaging for hydrocarbon identification
- Field-based measurements

HIGH RESOLUTION GEOTEK XRF SPECTROMETER

The ultra-sensitive Geotek X-ray fluorescence (XRF) spectrometer acquires precise elemental abundances from the surface of sediment and rock cores, and offers superior sensitivity for light elements.

- High performance large area silicon drift detector (SDD) with a helium-flushed measurement cell dramatically improves sensitivity, especially for the light elements such as Mg, Al, and Si
- Widest range of elements from Mg to U at ppm levels
- Motorised X-ray slits enable a downcore spatial resolution of 100 μm or less
- Sophisticated filter slide to lower detection limits across a wide range of elements, and allows different cross-core areas to be illuminated – perfect for high-resolution studies of dipping laminae
- Low-power sealed X-ray source for long life (>10 000 hours) with no maintenance
- A unique close-coupled geometry for high efficiency at low X-ray tube power
- Simple to use custom-designed software automatically communicates with the logger to acquire, interpret, and display the fluorescence spectra with element abundance during acquisition
- Precise measurements are assured through a combination of peak fit and deconvolution algorithms using a proprietary quantitative analysis suite

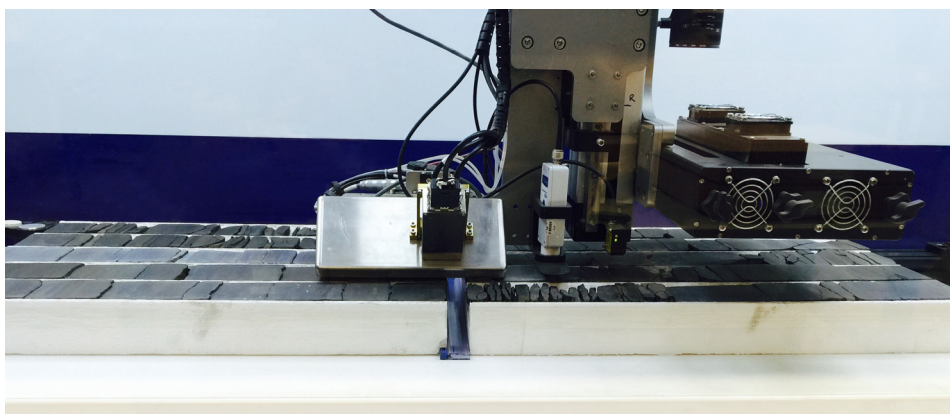


Geotek MSCLs use a counter-balanced vertical axis to carefully lower the sensor onto the core surface offering a stable and repeatable measurement geometry. The depth is precisely measured (± 0.01 mm) and co-registered with other sensor parameters. The Geotek XRF sensor can be installed on a variety of different multi-sensor core loggers which are suitable for logging sediment or rock core that is split/slabbed, or core in boxes.

XRF LOGGING WORKSTATIONS (MSCL-XYZ)

The MSCL-XYZ is fully automated 3-axis (XYZ) workstation designed for laboratories or core repositories with large volumes of core, and core boxes.

The system is compatible with various spectroscopic techniques and high resolution visible and ultraviolet linescan imaging. Typically, one MSCL-XYZ system with one operator can log up to 9 m of core, or two 3 ft core boxes per acquisition set-up. This is therefore the perfect instrument for clients wishing to log on a 24/7 basis with limited technician input.



GEOTEK XRF SPECTROMETER SPECIFICATIONS

TYPICAL ELEMENT / DETECTION LIMIT, PPM

Mg	3000
Al	800
Si	300
P	500
S	1000
K	100
Ca	40
Ti	60
Mn	15
Fe	10
Br	7
Sr	2
Mo	6
Ba	27
Pb	4.5
U	3

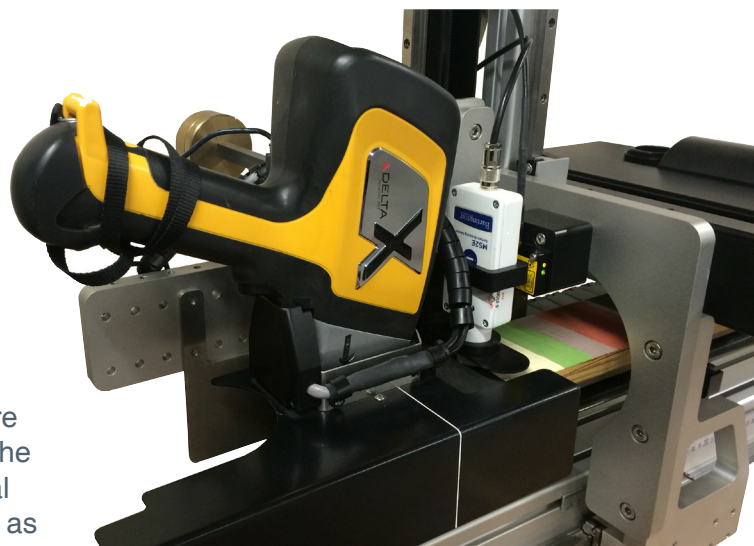
X-ray source	15W/50kV, Rh anode allowing sulfur detection, air-cooled, 50 μ m Be window
X-ray detector	Canberra Silicon Drift Detector, 15 mm ² , FWHM: down to 145eV Mn K α , 0.5 mil (12.7 μ m) Be window
Spectral analysis	bAxil (next generation version of WinAxil)
Elements detected	Mg to U
Downcore resolution	10 to 0.1 mm
Crosscore resolution	5, 10, or 15 mm
Core accepted	Diameter: 55 to 150 mm; Length: up to 155 cm
Radiation shielding	3 mm of stainless steel on all sides with safety interlocks on doors
MSCL-XZ scanner dimensions	270 cm x 70 cm x 170 cm (L x W x H)
MSCL-XYZ scanner dimensions	307 cm x 137 cm x 210 cm (L x W x H)
Electronics rack	55 cm x 60 cm x 60 cm (L x W x H)
Weight MSCL-XZ	450 kg
Weight MSCL-XYZ	800 kg
Services required	Power: 1.5 kW @ 220-240 V; Helium: 5-10 ml/min, 99.5%

Limits of detection for the Geotek XRF sensor were acquired on dry reference materials with a 30 second count time, a 15 x 10 mm illumination area, and a helium-flush.

OLYMPUS DELTA PROFESSIONAL XRF SPECTROMETER

Geotek have integrated one of the most popular hand-held XRF spectrometers on the market onto our MSCL systems: The Olympus Delta Professional (Delta XRF). MSCL systems offer a stable and repeatable measurement geometry that is automatically controlled through software.

Through limited operator involvement, custom-designed software seamlessly communicates with the Delta XRF to provide depth co-registered XRF data during logging acquisition. Geotek utilise Olympus's interpretation software to present the acquired spectra and automatically display the results during logging along side other chemical or physical property datasets. These data can then be easily exported as an ascii file for further analyses. Furthermore, the sensor can be detached, and used as a standard hand-held if required.



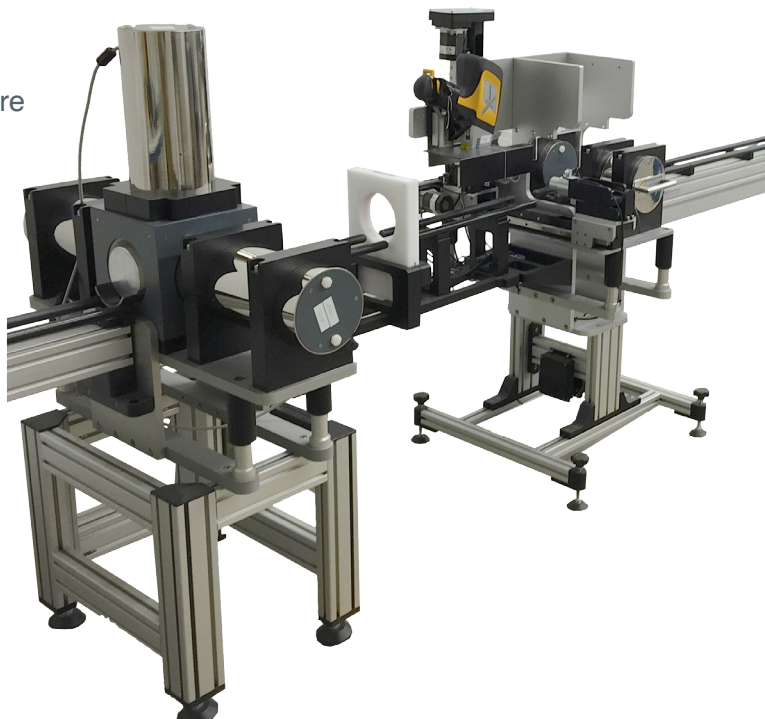
Olympus Delta Professional XRF installed onto a MSCL-XZ

INTEGRATION OF CHEMICAL & PHYSICAL PROPERTY LOGGING

The standard multi-sensor core logger (MSCL-S) combines both spectroscopy measurements like XRF or visible and near-infrared with a wide-range of petrophysical measurements such as attenuated gamma density or spectral/total natural gamma. Data from all sensors are acquired simultaneously and at co-registered depths downcore for easy cross-sensor data correlation. The ability to continuously scan core samples using both petrophysical and spectroscopic techniques is a unique product to Geotek.

The sensors offered on the MSCL-S include:

- XRF spectrometry
- Visible and near-infrared spectrometry
- Colour spectrophotometry
- Attenuated gamma density
- P-wave velocity
- Non-contact electrical resistivity
- Magnetic susceptibility
- Spectral and total natural gamma
- Visible and ultraviolet 5K linescan imaging



Standard multi-sensor core logger (MSCL-S) with Delta XRF, attenuated gamma density, P-wave velocity, magnetic susceptibility, and spectral natural gamma