

# X-Ray Fluorescence

Component of the LithoFlex multifactor shale-cuttings evaluation-while-drilling service

**APPLICATIONS**

- Near-real-time chemostratigraphy at the wellsite
- Formation top identification
- Casing and landing point optimization
- Source rocks identification
- Paleodepositional environment identification

**BENEFITS**

- Obtains accurate, repeatable readings for greater consistency
- Enables well-to-well correlation and precise depth matching
- Improves lithofacies description from cuttings
- Provides additional information for geological basin and petroleum system modeling

**FEATURES**

- Customized calibration based on 40 reference powder samples
- Quantification of 28 inorganic elements (11 major and 17 trace elements)
- Qualitative evaluation of 19 trace elements
- Synthetic total and spectral gamma ray calculation
- 12-min analysis time
- Direct data storage in Schlumberger acquisition system
- Real-time data transmission

The LithoFlex\* multifactor shale-cuttings evaluation-while-drilling service uses X-ray fluorescence (XRF) analysis to determine the elemental composition of rock by quantifying major and trace elements. This technique provides measurements to parts per million and is highly useful for both organic and inorganic geochemical fingerprinting. With a geochemical fingerprint, you can accurately identify formation tops and casing points and conduct well-to-well correlation studies.

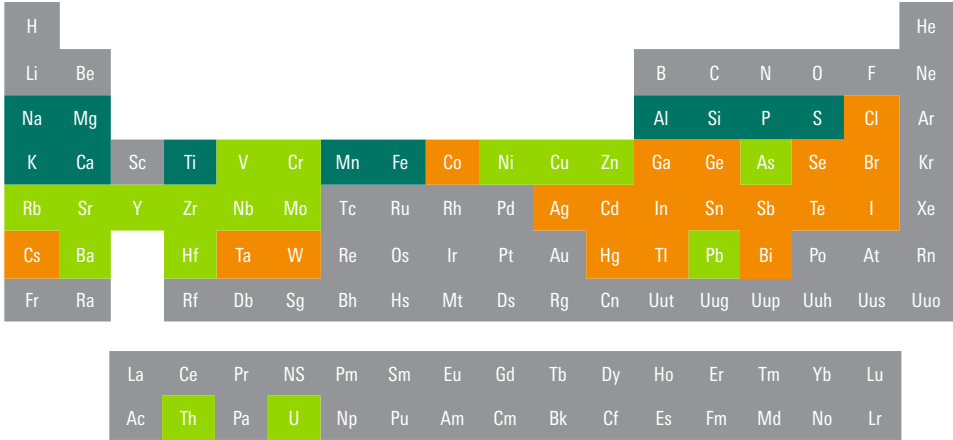
An XRF analysis can also be used to refine mineralogical evaluation of complex lithologies. Analysis of trace elements can provide key information to improve geological and petroleum system models by providing proxies of paleodepositional and reduction and oxidation (redox) environments. Quantification of uranium, thorium, and potassium provide a reconstructed synthetic spectral and total gamma ray, which can be compared with LWD or wireline gamma ray for verifying the depth of cuttings.

**Methodology**

Measurements are performed on drilled rocks that are cleaned, washed, dried, and ground with an automatic grinder to a grain size of approximately 80 um. The powder is then placed into plastic cups for analysis, which is performed under a small-vacuum environment. This lean process reduces overall workload because it does not require pellets (fewer consumables) or require the use of helium tanks, simplifying deployment.

**Quantification**

The LithoFlex service is calibrated based on 40 reference samples from a wide range of geological formations while maintaining measurement accuracy. This calibration method has been specifically designed to achieve the same performance as pellet samples. Accuracy and quantification limits have also been determined through extensive laboratory testing.



XRF analysis from the LithoFlex service provides quantitative measurements (dark and light green) and qualitative evaluation (orange) of the elements identified on the periodic table.

- Quantitative major elements
- Quantitative trace elements
- Qualitative evaluation

# X-Ray Fluorescence

## XRF Component of the LithoFlex Service Metrological Characterization

Major element compounds	Average absolute deviation, %	Limit of quantification, %
Na <sub>2</sub> O	± 0.14	0.13
MgO	± 0.25	0.36
Al <sub>2</sub> O <sub>3</sub>	± 0.27	0.21
SiO <sub>2</sub>	± 1.02	0.25
P <sub>2</sub> O <sub>5</sub>	± 0.19	0.003
SO <sub>3</sub>	± 0.28	0.004
K <sub>2</sub> O	± 0.08	0.05
CaO	± 0.32	0.08
TiO <sub>2</sub>	± 0.01	0.06
MnO	± 0.0045	0.0042
Fe <sub>2</sub> O <sub>3</sub>	± 0.1	0.12

Trace elements	Average absolute deviation, ppm	Limit of detection, ppm
V	± 5.6	7.9
Cr	± 6.9	9.3
Ni	± 3.9	2.6
Cu	± 2.2	1.1
Zn	± 2	1.4
As	± 1.2	0.8
Rb	± 1.7	0.9
Sr	± 7	17.3
Y	± 7	3
Zr	± 12.3	7
Nb	± 1.5	2.1
Mo	± 1	0.7
Ba	± 21	17
Hf	± 3	3
Pb	± 1.0	0.8
Th	± 0.41	0.4
U	± 0.78	0.4

## XRF Component of the LithoFlex Service Specifications

Operating voltage range	95–120 V or 200–240 V at 50–60 Hz
X-ray tube	Rhodium anode
Max. power	10 W
Max. tension	50 kV
Max. current	2 mA
Filter	Copper rhodium, molybdenum, or no filters
Analysis atmosphere	Vacuum
Detector	Silicon drift detector
Detector size	0.01 in <sup>2</sup> [9 mm <sup>2</sup> ]
Beryllium window thickness	15 μm
Sample preparation	Powder
Dimension	11.8 × 11.8 × 10.6 in [30 × 30 × 27 cm]
Weight	26.5 lbm [12 kg]
QC	Internal reference material for automatic QC

[slb.com/lithoflex](http://slb.com/lithoflex)