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X-Ray Fluorescence While Drilling

Near-real-time evaluation of elemental composition at the wellsite

APPLICATIONS

- Formation evaluation using either the EcoFlex* multifactor cuttings evaluation-while-drilling service (conventionals) or LithoFlex* multifactor shale-cuttings evaluation-while-drilling service (unconventionals)
- 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 systems 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

X-ray fluorescence (XRF) determines the elemental composition of cuttings 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.

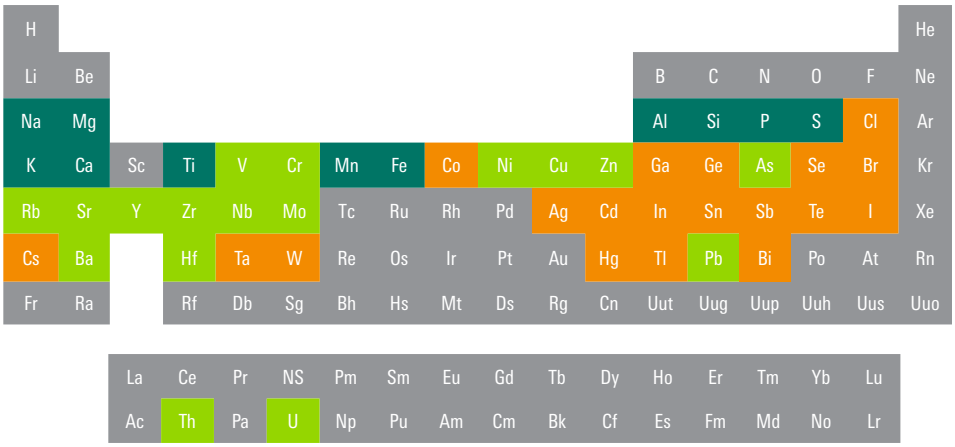
An XRF analysis can also be used to refine mineralogical evaluation of complex lithologies. Analysis of trace elements can provide key information to improve geological and petroleum systems models by providing proxies of paleodepositional and redox environments. Quantification of uranium, thorium, and 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 cuttings 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

Calibration is 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 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

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XRF Metrological Characterization		
Major element compounds	**Average absolute deviation, %**	**Limit of quantification, %**
Na_2O	±0.14	0.1300
MgO	±0.25	0.3600
Al_2O_3	±0.27	0.2100
SiO_2	±1.02	0.2500
P_2O_5	±0.19	0.0030
SO_3	±0.28	0.0040
K_2O	±0.08	0.0500
CaO	±0.32	0.0800
TiO_2	±0.01	0.0600
MnO	±0.0045	0.0042
Fe_2O_3	±0.1	0.1200
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	3.0
Zr	±12.3	7.0
Nb	±1.5	2.1
Mo	±1	0.7
Ba	±21	17.0
Hf	±3	3.0
Pb	±1	0.8
Th	±0.41	0.4
U	±0.78	0.4

XRF 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^2 [6.45 mm^2]
Beryllium window thickness	15 um
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

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