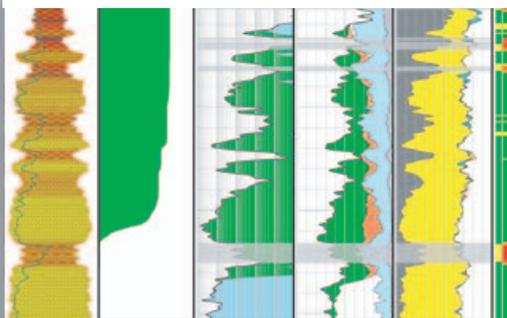


**Schlumberger**



# ECS Elemental Capture Spectroscopy Sonde



Fast, accurate  
lithology evaluation

## Applications

- Identify carbonate, gypsum, and anhydrite; quartz, feldspar, and mica; pyrite, siderite, coal, and salt fractions for complex reservoir analysis
- Estimate mineralogy-based permeability
- Determine well-to-well correlation from geochemical stratigraphy
- Determine sigma matrix for cased hole and openhole sigma saturation analysis
- Delineate coalbed methane
- Estimate producibility and in situ reserves

## Benefits

- Clay fraction values, independent of gamma ray, spontaneous potential, and density-neutron
- Advanced, integrated petrophysical evaluation and analysis
- Matrix density and neutron values for improved porosity values
- Robust petrophysical evaluation with minimal user inputs in sand-shale reservoirs
- Enhanced completion and drilling fluid recommendations
- Quantitative lithology for rock properties modeling and pore pressure prediction from seismic data

## Features

- Supports most geoscience disciplines
- Well-to-well data correlation for exploration and development projects
- Quantitative lithology for accurate determination of porosity, fluid saturation, and k-lambda permeability
- Lithology for rock-properties modeling, seismic calibration, and pore-pressure prediction from velocity data
- Better mechanical properties for fracture design and stimulation fluid selection

## Challenge: Fast petrophysical answers from elemental concentration logging

Formation parameters and formation-zonation levels can be defined by skilled interpreters or by referring to an established database. There are times though when neither is available.

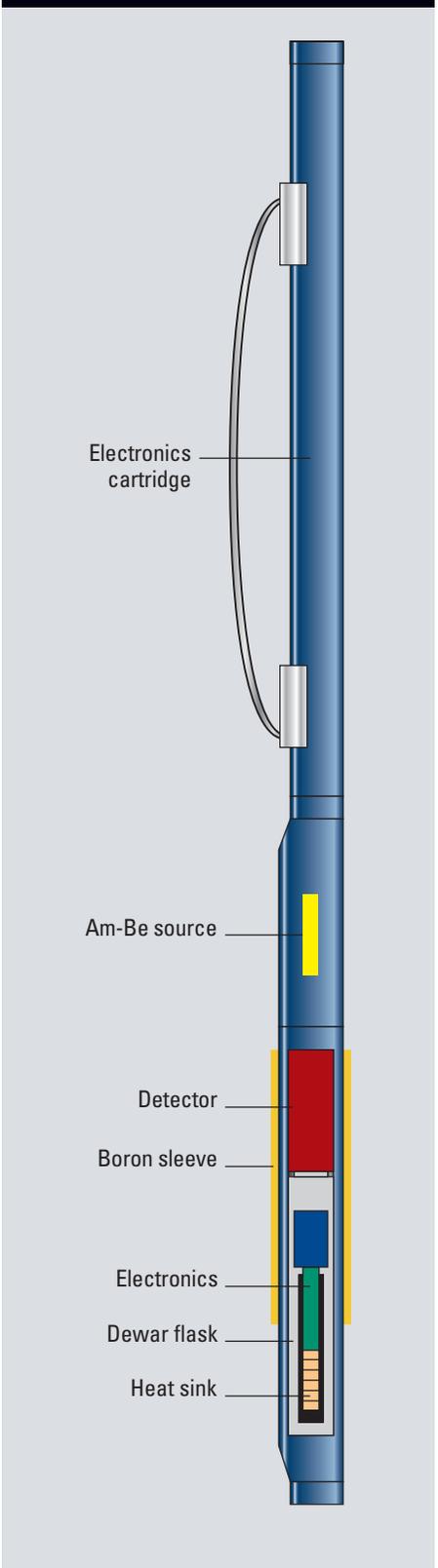
Geoscientists have long desired to provide a petrophysical answer from elemental concentration logging—comprising at least porosity and water saturation—in real time or within a few hours after logging a well. This information is essential to making decisions on running casing and completing wells.

## Solution: ECS Elemental Capture Spectroscopy sonde

Pulsed neutron spectroscopy logging tools have been used in openhole formation evaluation since the late 1970s to measure elemental concentrations in rocks and estimate the major matrix properties from them. The early tools, however, were not widely used because they were physically long, costly to operate, and the data interpretation was complex.

The ECS sonde, which is a short, simple-to-use logging tool, measures and processes gamma ray spectra, or the number of gamma rays received by the detector at specific energy levels. These measurements allow for more accurately defining the clay content, mineralogy, and matrix properties of each potential zone.

*The 4.5-m [15-ft] ECS sonde emits high-energy neutrons into the formation, and a detector measures the gamma rays emitted by the reactions of neutrons with elements in the formation.*



## Results: Better measurements for better interpretation

Using the neutron-induced capture gamma ray spectroscopy principle, the ECS sonde determines relative elemental yields by measuring the gamma rays produced when neutrons bombard the formation and lose energy as they are scattered, primarily by hydrogen.

The primary formation elements measured by the ECS sonde in open and cased holes are the most commonly occurring elements: silicon, iron, calcium, sulfur, titanium, gadolinium, chlorine, barium, and hydrogen.

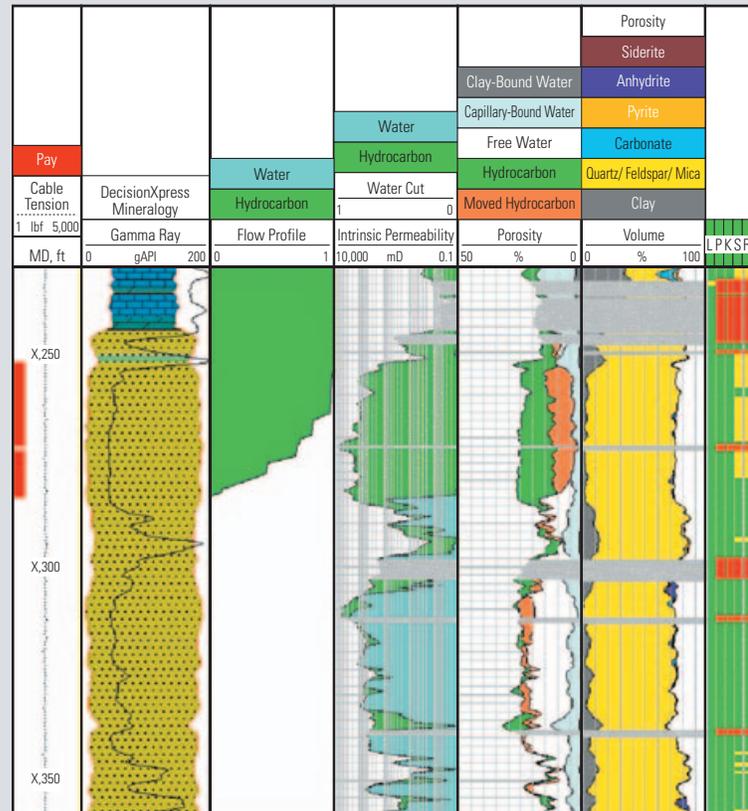
## Measuring yields with the ECS sonde

Lithologic fractions of total clay, total carbonate, and QFM (quartz, feldspar, and mica) are derived from the concentrations of silicon, calcium, and iron. Matrix density is calculated from silicon, calcium, iron, and sulfur, and it is combined with the measured bulk density to derive an accurate total porosity. In a similar way, the elemental concentrations of silicon, calcium, and iron are used to correct the neutron log for rock matrix effects, thereby yielding neutron porosity that is significantly closer to total porosity.

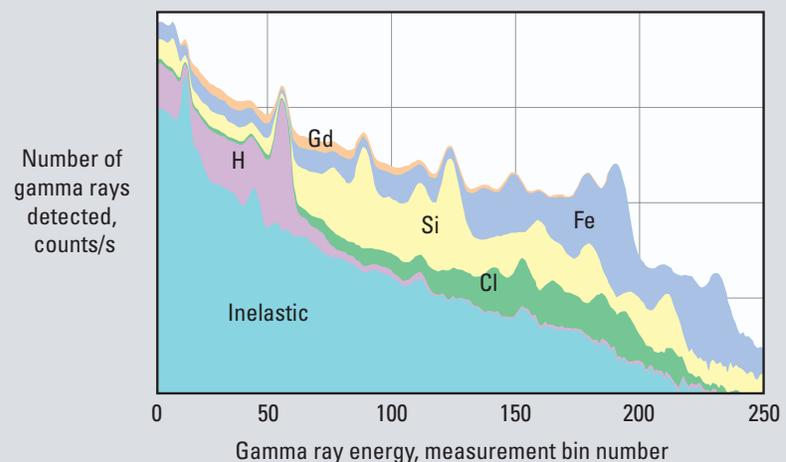
SpectroLith\* lithology processing of spectra from the ECS sonde is based on a technique in which measurements of silicon, calcium, and iron are used to produce an estimation of clay as accurate as that derived from a measurement of aluminum.

Carbonate concentrations are determined from the calcium concentration log with exceptional accuracy. The anhydrite volume is determined from the calcium and sulfur logs; thus, the remainder of the formation is composed of QFM. SpectroLith processing is used to compute pyrite, siderite, coal, and salt.

*DecisionXpress\* output for a log of a siliciclastic sequence. A light gray mask indicates log intervals in which the input data are of poor quality because of hole conditions or other problems. The porosity, permeability, and fluid saturations are summed and averaged over the pay interval using cutoffs on permeability and water cut selected by the user. These can also be presented in a table. Quality-control flags in the far right track indicate the interpretation description for lithology (L), porosity (P), permeability (K), saturation (S), and relative permeability (R). Green indicates favorable interpretation, yellow means a moderately favorable interpretation, and red reflects an unfavorable interpretation. The shale interval above X,240 ft is largely affected by poor hole conditions.*



*Typical gamma ray spectrum from the ECS sonde in a siliciclastic environment that has no calcium or sulfur. The thermal neutron capture gamma rays are shown divided into the contributions of the different elements present. Gamma rays from inelastic neutron reactions are also present, but are not used quantitatively. The capture yields of iron (Fe) and calcium (Ca) include small signals from aluminum and sodium. This contamination is taken into account during further processing.*



## Complementary technologies

The DecisionXpress petrophysical evaluation system integrates data from the ECS sonde and the Platform Express\* integrated wireline logging tool to provide rapid data visualization and reprocessing capabilities at the wellsite or in a client's office. This combination provides a robust petrophysical evaluation with minimal user inputs in sand-shale reservoirs for planning of coring and sampling operations; decisions for casing, drilling ahead, or sidetracking; and the design of completion strategies.

Accurate measurement of relative elemental yields with the ECS sonde, coupled with SpectroLith processing and DecisionXpress petrophysical evaluation, can help improve production, reduce costs, and minimize risks.

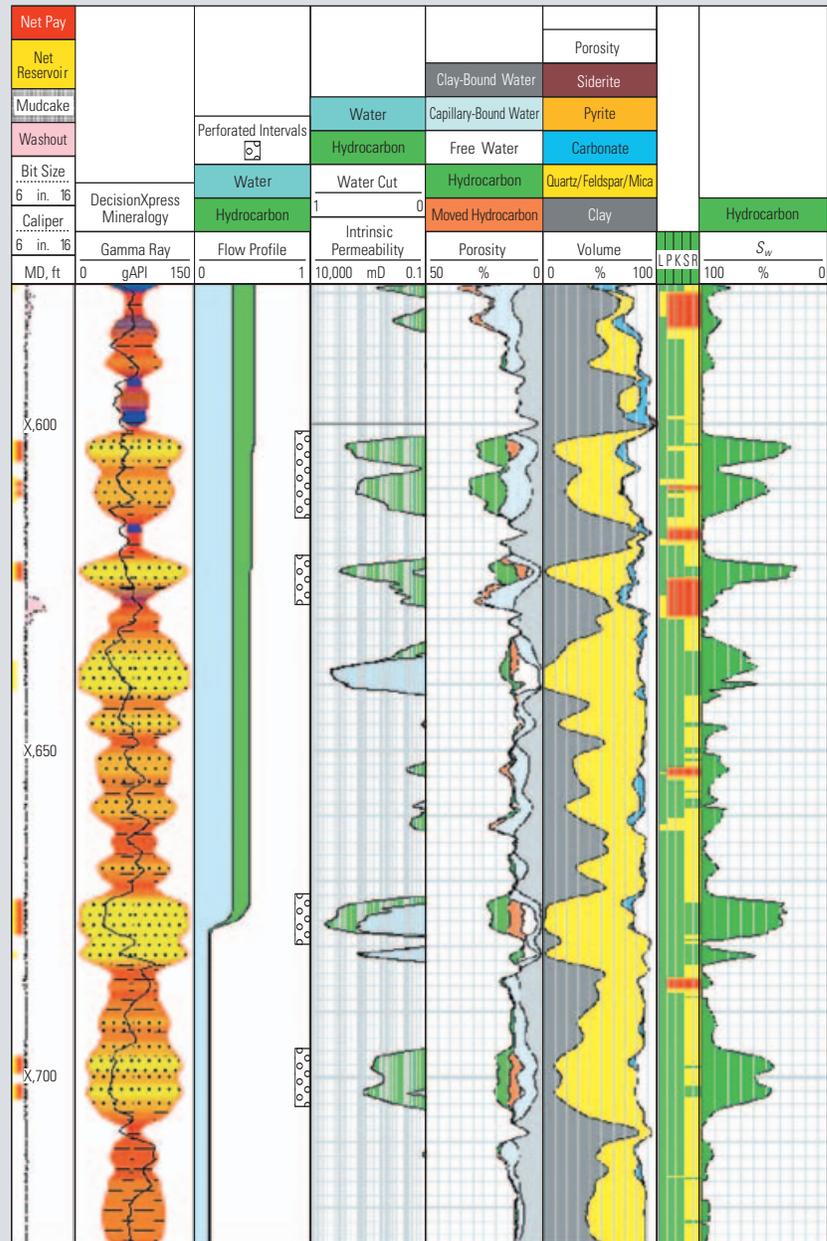
## Rapid evaluation of complex lithologies

A Middle East operator drilling with two rigs needed rapid petrophysical wellsite analysis to help minimize the impacts of geological uncertainty and abrupt changes in formation-water resistivity on operations.

Prospective sandstones tended to be thinly bedded and varied widely in grain size. A complex mineralogy, including glauconite, complicated log interpretation. The operator selected the DecisionXpress service because it integrates data from the Platform Express tool and the ECS sonde to determine mineralogy. This combination also provides a continuous matrix density measurement that can be used in subsequent log processing. The ECS data helped to identify zones containing significant amounts of calcite. This was not possible using standard logs, which are affected by barite in the drilling mud.

Prompt, robust interpretations based on the DecisionXpress system were made to help the operator plan formation testing and fluid sampling operations for formation evaluation.

Data from the Platform Express tool and the ECS sonde are integrated to determine mineralogy. This presentation shows borehole and depth information, red net pay flags, and yellow net reservoir flags in the depth track. Track 1 shows lithology from the Platform Express tool. Perforations in four zones and the flow profile are shown in Track 2. However, the water cut information in Track 3 reveals a zone near X,675 ft that ultimately produced water. Fluid interpretations in Track 4 suggest that the best oil potential exists just below X,600 ft and around X,700 ft. The dominant minerals, shown in Track 5, include quartz, feldspar and mica (yellow), and clay (gray), with minor amounts of carbonate minerals (blue). Summarized in quality-control Track 6 are lithology (L), porosity (P), permeability (K), saturation (S), and relative permeability (R); where green reflects a favorable interpretation, yellow a moderately favorable interpretation, and red an unfavorable interpretation. Track 8 shows hydrocarbon volumes.



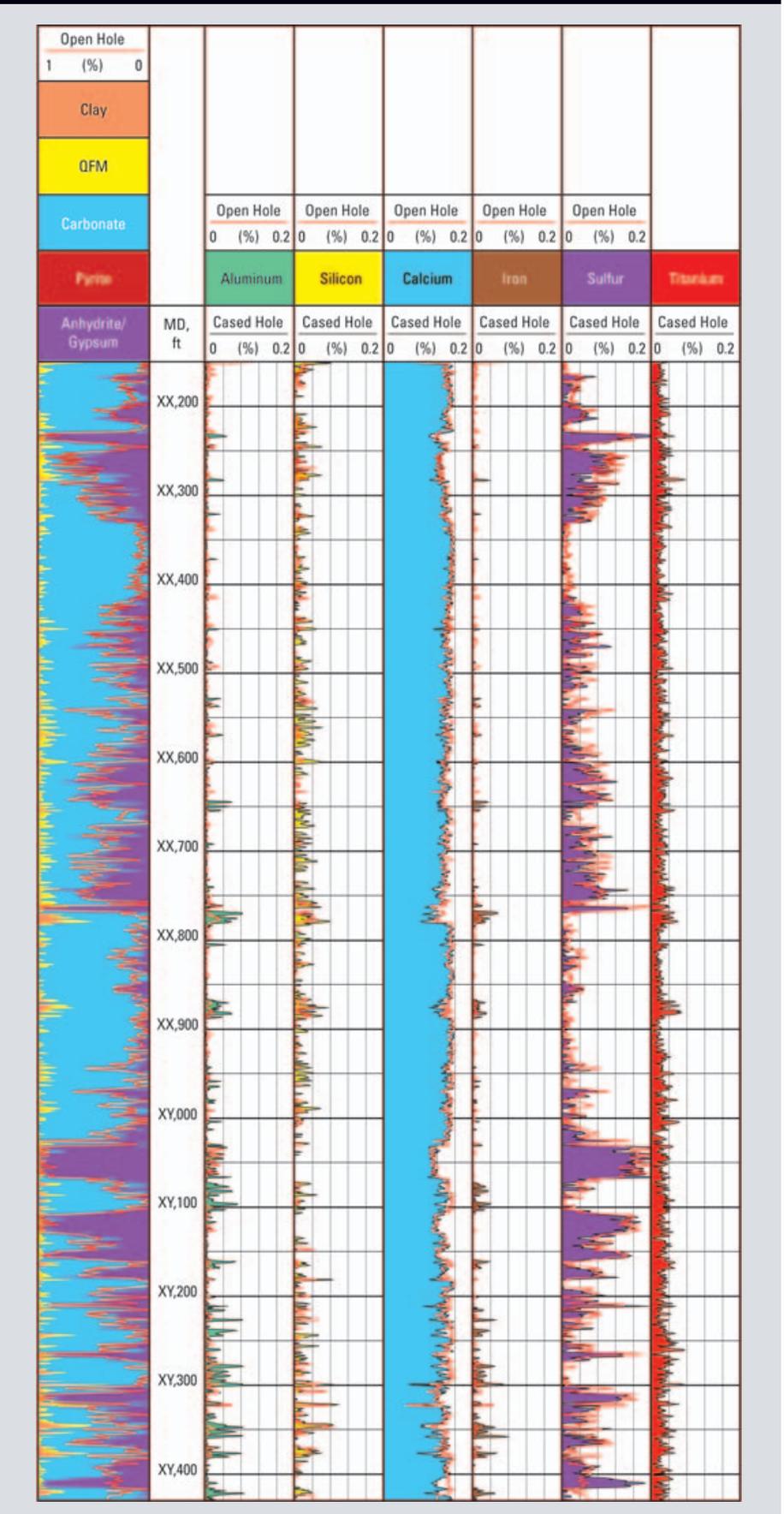


### Using the ECS sonde in cased holes

In old cased wells with limited information available or in new wells where conditions of wellbore instability made it necessary to set casing before all of the zones of interest had been logged, elemental spectroscopy data can be acquired with the ECS sonde behind casing.

SpectroLith results from a Middle East well are shown after applying the selected offsets on the iron, silicon, calcium, and sulfur yields. The red curves are the corresponding results from the openhole ECS log overlaid on the same interval. The match between the openhole and cased hole results is excellent as indicated in the mineralogy track and on the individual yields themselves. The few discrepancies are due to the presence of casing collars and some hole enlargement over the upper portion of the interval.

*ECS mineralogy and normalized yields recorded in open and cased hole over the same section of the reservoir. Openhole results are shown in red. Offsets were applied to cased hole yields prior to mineralogy computation.*



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**ECS Measurement Specifications**

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Output	Elemental yields, dry-weight elemental fractions, dry-weight SpectroLith lithology, and matrix properties
Logging speed, standard	549 m/h [1,800 ft/h]
Range of measurement	600 keV to 8 MeV
Vertical resolution	45.72 cm [18 in]
Accuracy <sup>†</sup>	2%-coherence to standards computed
Depth of investigation	22.86 cm [9 in]
Mud type or weight limitations <sup>‡</sup>	None
Combinability	Combinable with most tools
Special applications	Automatic wellsite petrophysical interpretation <sup>§</sup>

<sup>†</sup> Elemental statistical uncertainty at nominal conditions (549 m/h [1,800 ft/h] logging speed, resolution degradation factor of 5 to 16,000 counts/s count rate, and closure normalization factor of 3); Si, 2.16%; Ca, 2.19%; Fe, 0.36%; S, 1.04%; Ti, 0.10%; Gd,  $3.48 \times 10^{-6}$ .

<sup>‡</sup> Calcium carbonate used in large quantities as lost-circulation material may be detected by the tool.

<sup>§</sup> Magnesium yield is measured by the tool and can be used to split carbonate fractions in some cases.

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**ECS Mechanical Specifications**

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Max. temperature	177 degC [350 degF] 260 degC [500 degF] with internal flask, CO <sub>2</sub> cooling
Max. pressure	138 MPa [20,000 psi] 172 MPa [25,000 psi] with high-pressure housing
Borehole size	
Min.	16.51 cm [6.5 in]
Max.	50.80 cm [20 in]
OD	12.70 cm [5 in] 13.97 cm [5.5 in] with high-pressure housing
Length	3.09 m [10.2 ft]
Weight	138 kg [305 lbm]
Tension	222,410 N [50,000 lbf]
Compression	88,960 N [20,000 lbf]

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