
WELLSITE GEOLOGY
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Topic:
Wellsite Geochemistry
Photo by author from the well of Tasbulat 324
in Aktau, Kazakhstan


Geochemistry
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Photo by author from the well of Tasbulat 324 in Aktau, Kazakhstan

Introduction to WS Geochemistry

Wellsite Geochemical analysis provides valuable information

- for the **understanding and evaluation** of **hydrocarbon systems**
- gives key insights necessary for implementing successful **exploration programs** and well-designed **operations** and well designed **completions** that maximize production.

Introduction to WS Geochemistry

History:

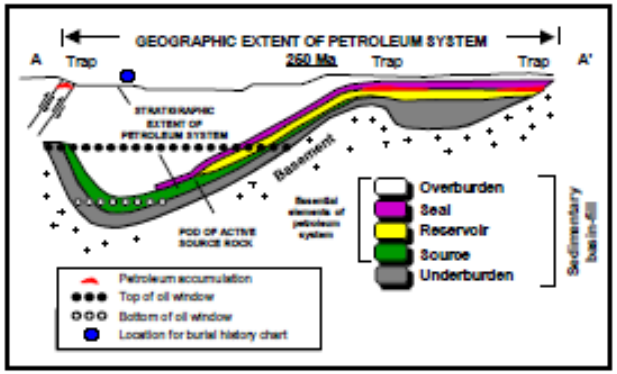
- XVI-XVII century was established like a science Geology and chemistry.
- In1838 Swiss scientist H.F. Sheinbane first proposed word GEOCHEMISTRY.
- In 1869 D.I. **Mendeleev** discovered periodic table of chemical elements.
- Frank Wigglesworth **Clarke** chemical distribution in the crust.

Clarke number: the relative abundance of a chemical element, typically in Earth's crust.

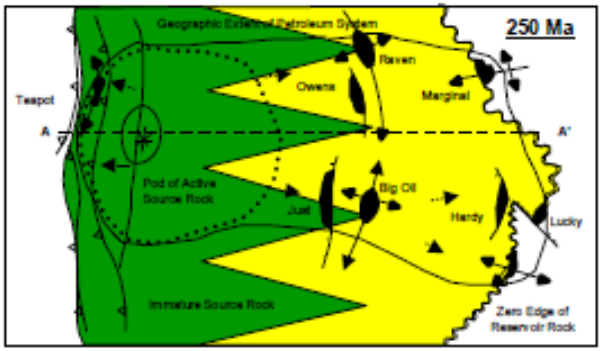
Origin of the oil and gas

- - Oil and gas are formed from the soft parts of microscopic organisms preserved in sediments.
- Mainly remains of marine plankton is converted to oil and gas.
- Land-derived plant material (including coal) generate pure natural gas (methane).

Petroleum System Folio Sheet Consists of Five Charts



Deer-Boar(.) Petroleum System Folio Sheet



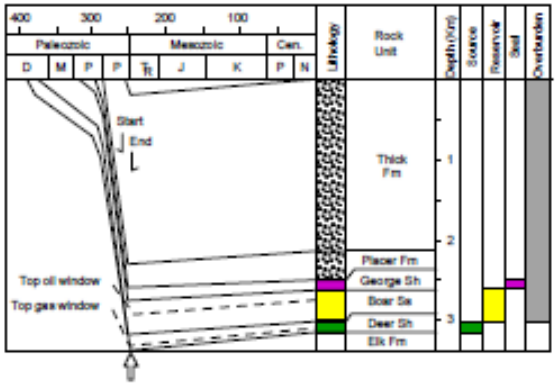
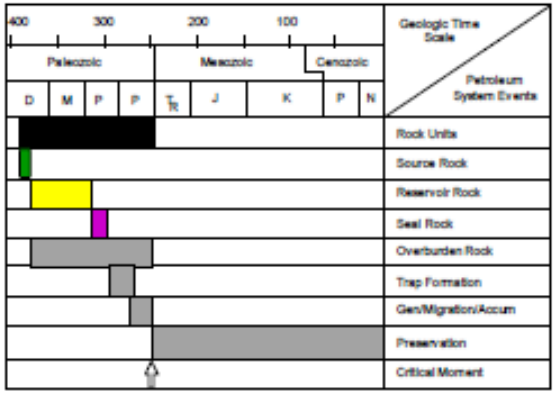


Table of accumulations for Deer-Boar(.) petroleum system.

Field Name	Date discovered	Reservoir rock	API Gravity (°API)	Cumulative oil production (x10⁶ bbl)	Remain reserves (x10⁶ bbl)
Big oil	1954	Boar Ss	32	310	90
Raven	1956	Boar Ss	31	120	12
Owens	1959	Boar Ss	33	110	19
Just	1966	Boar Ss	34	160	36
Hardy	1989	Boar Ss	29	85	89
Lucky	1990	Boar Ss	15	5	70
Marginal	1990	Boar Ss	18	12	65
Teapot	1992	Boar Ss	21	9	34



Magoon and Dow (1994)

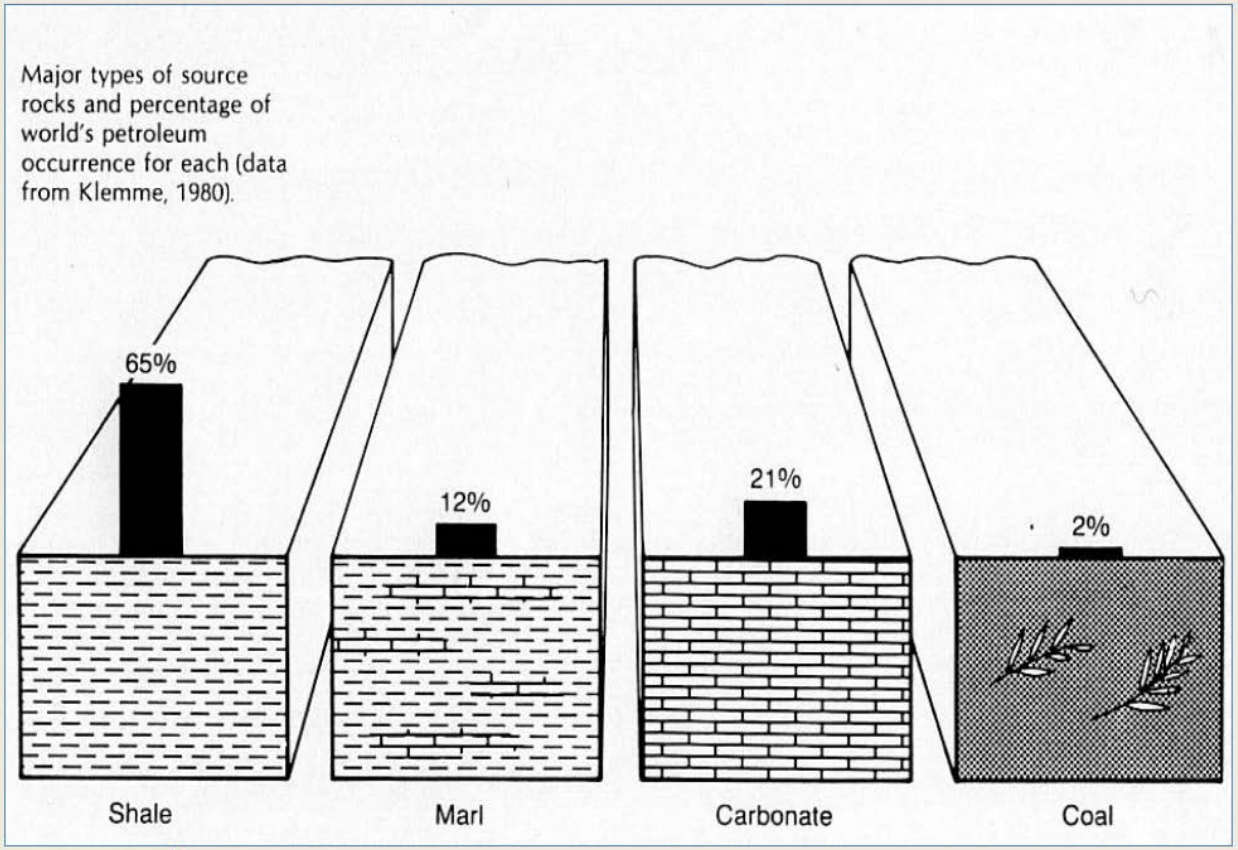
Source rocks

- To preserve this organic matter from early destruction we need an oxygen-free environment.



- Clay and mudstones (carbonate) are the most common source rocks.

Sourcerock Types



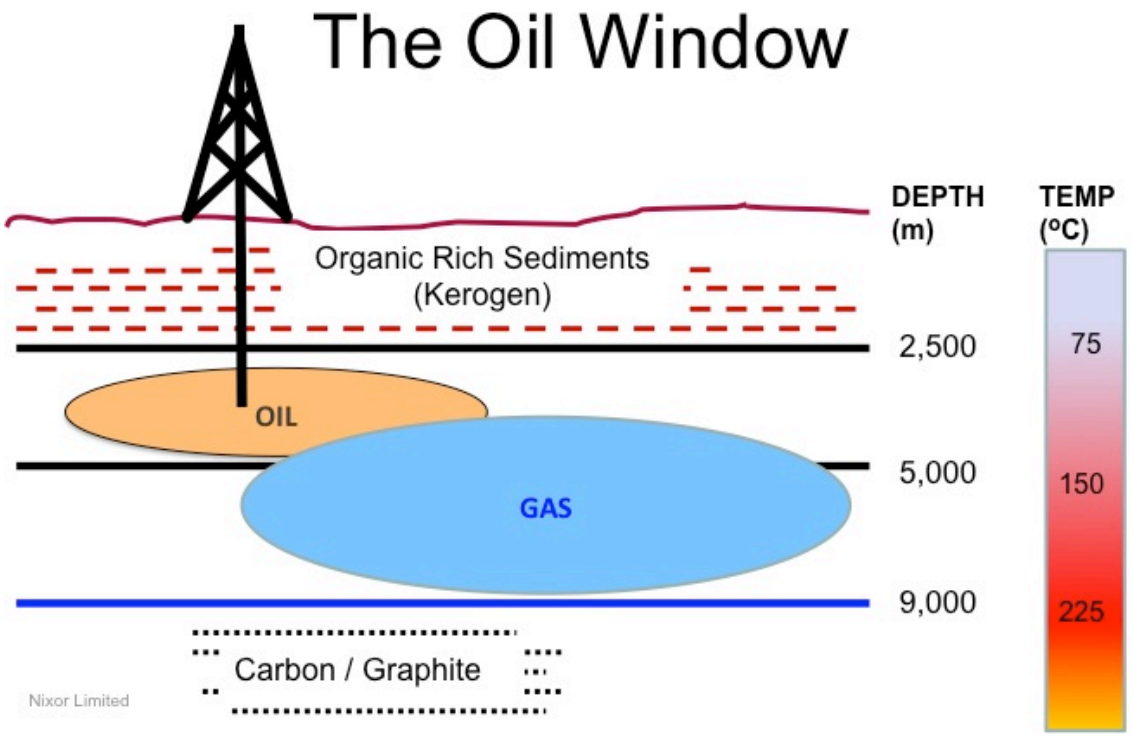
Gast Geological Consulting

The black colour of sedimentary rocks comes from the organic material.

Source rocks are shales (black shales), some carbonates, marl and coal.

The source rock must be gradually and gently cooked (matured)

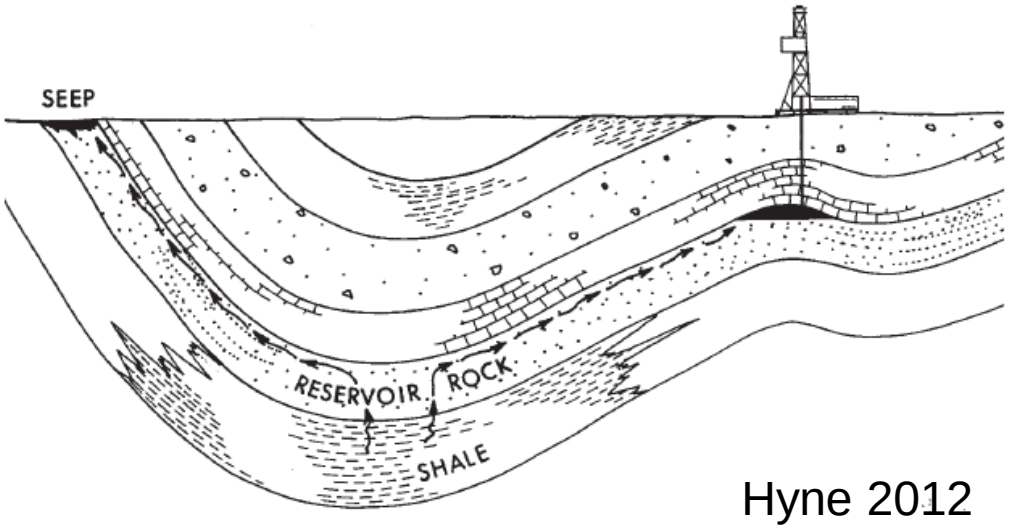
- The heat is obtained from the Earth by burial/subsidence of the source rock.



Primary migration

- At considerable depths oil and gas are formed and then slowly squeezed out of the source rock.

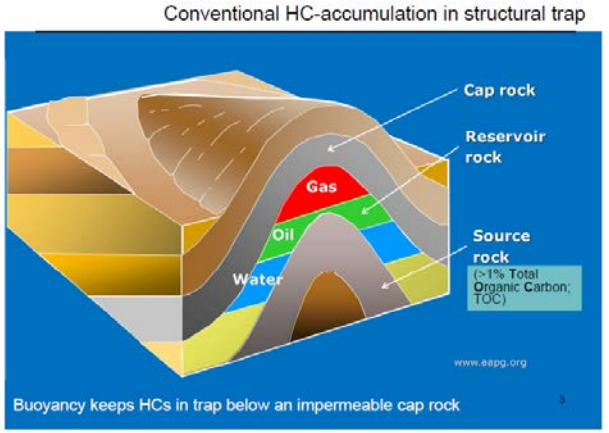
- 1. If they can, they will escape up to the surface of the Earth
- where th[redacted]t for ever.



Hyne 2012

- 2. The petroleum migrates until the upwards percolation (migration) is blocked (**trap**).
- The petroleum start to accumulate in the fine pores of the reservoir rocks (sandstones and carbonates).

Such a trap could be formed for example at the crest of an anticline.



Exploration Methods, Seeps

Dammholm Energy

Offshore Hydrocarbon Detection (Seeps)

- Seeps are direct evidence of hydrocarbon occurrences, and are associated with many major discoveries.
- Seeps provide significant targets for more intensive exploration efforts

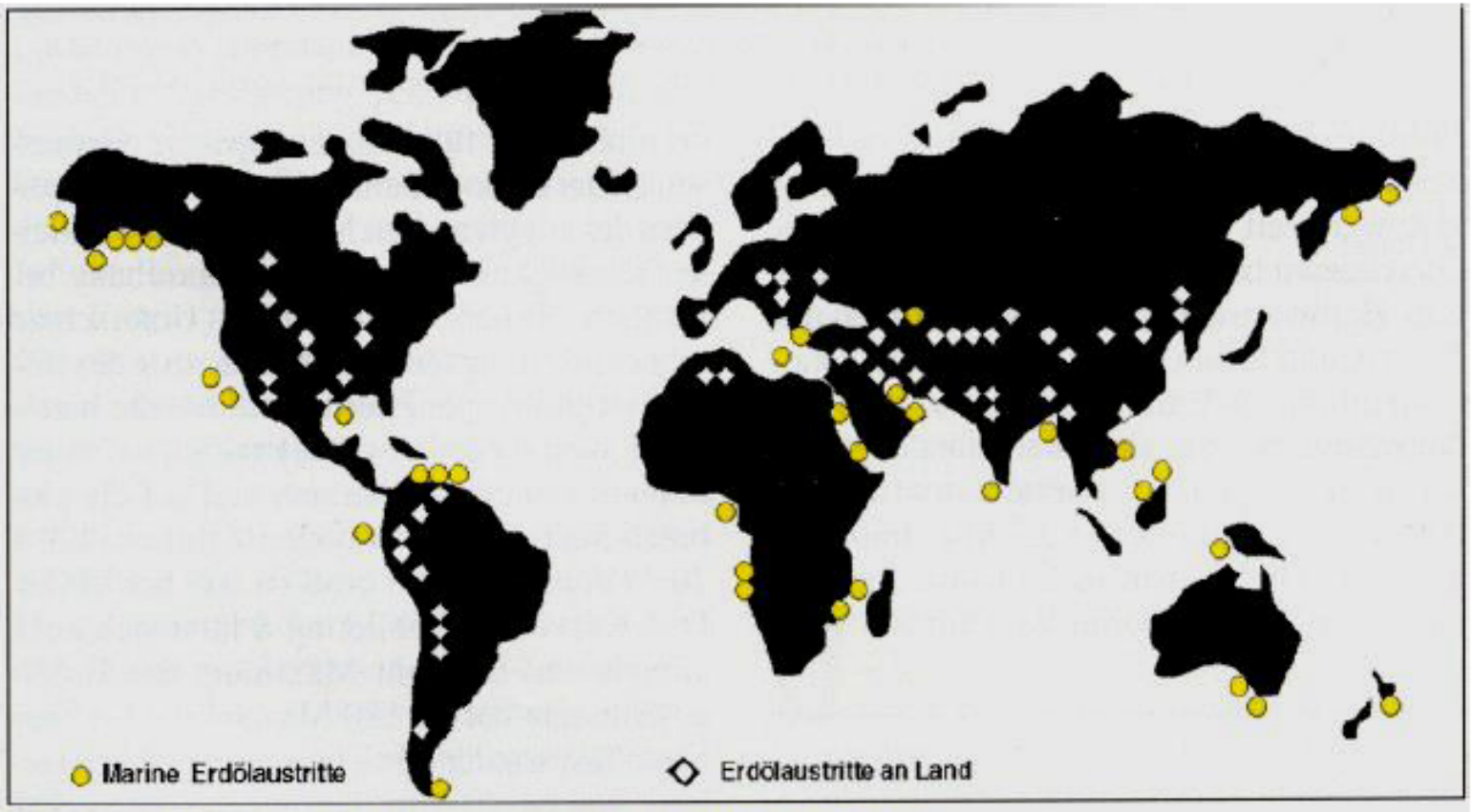


Abb. 2 Lokationen von Erdölaustritten an der Erdoberfläche [2, 3]

„Magic fives”

- Five requirements that lead to accumulation of oil and gas.

- Successful exploration: all five factors have to come together and in the correct sequence. If one fails, than we cannot expect there to be any oil or gas.

- **1. Source rock**
- Shale (black shale) or very fine grained limestone, with a minimum of 0,5 % of organic matter.
- **2. Heat**:
- Obtained from the Earth by burial of the source rock.
- **Oil window**: oil generation: between 60 - 120 °C
- **Gas window**: 120 - 225 ° C.
- Above 225 ° C, the kerogen is inert, having expelled all hydrocarbons; only carbon remains as graphite.

- **3. Reservoir**

A layer or formation of rock that is both porous and permeable, usually sandstone of limestone.

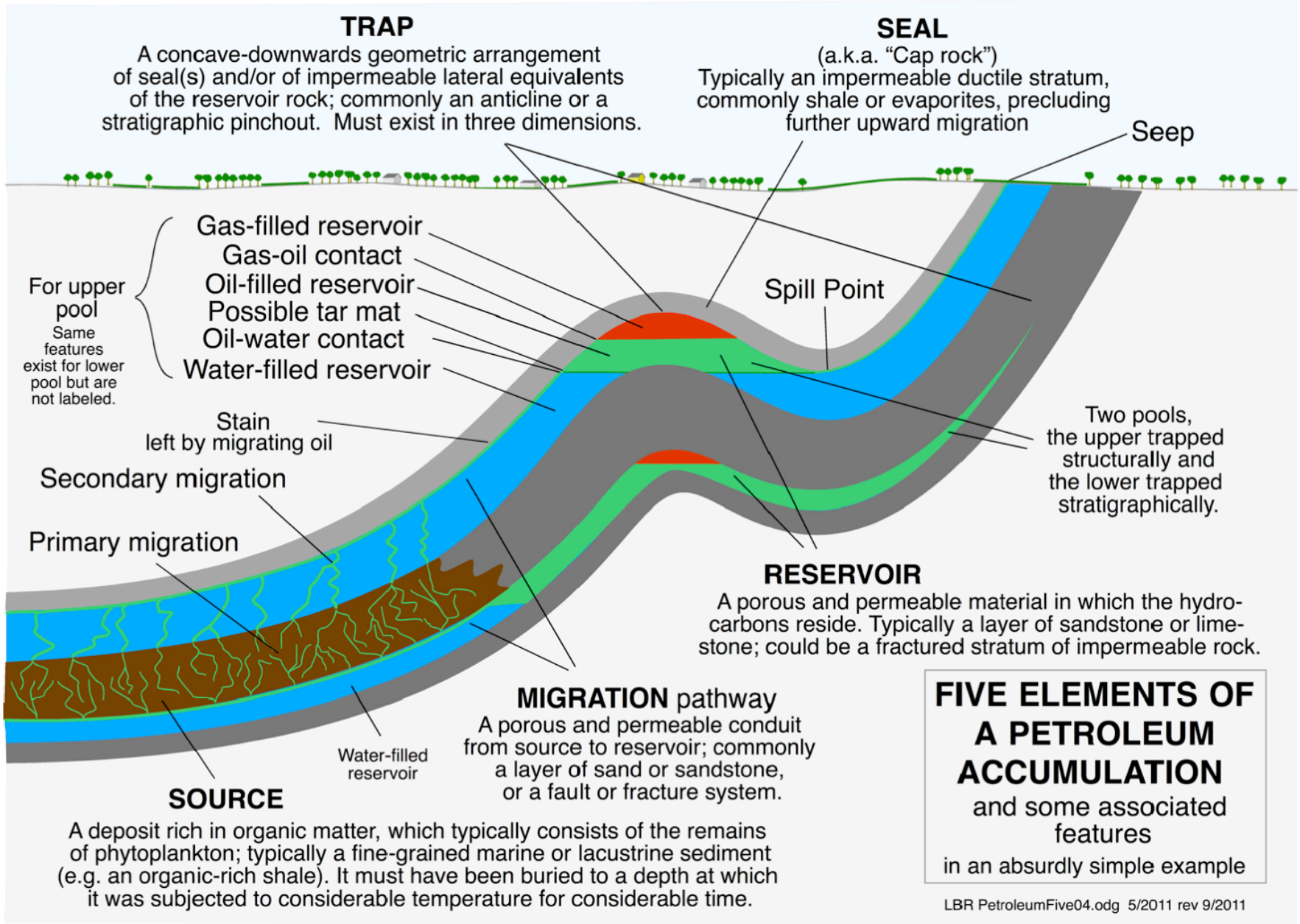
4. Cap rock or seal

An impermeable layer above the reservoir to retain the petroleum within it: in most cases shale or evaporite.

5. Trap

- A subsurface environment, formed by structural or stratifraphic control, where the petroleum is barred from migration.

- The trap must have been there before the oil/gas migration starts.
- The petroleum must be preserved in the trap. Later tilting or faulting could allow it to escape.
- Further deep burial can lead to petroleum destruction.


TRAP
A concave-downwards geometric arrangement of seal(s) and/or of impermeable lateral equivalents of the reservoir rock; commonly an anticline or a stratigraphic pinchout. Must exist in three dimensions.
SEAL
(a.k.a. "Cap rock")
Typically an impermeable ductile stratum, commonly shale or evaporites, precluding further upward migration
Seep
Gas-filled reservoir
Gas-oil contact
Oil-filled reservoir
Possible tar mat
Oil-water contact
Water-filled reservoir
For upper pool
Same features exist for lower pool but are not labeled.
Spill Point
Stain
left by migrating oil
Secondary migration
Primary migration
Two pools, the upper trapped structurally and the lower trapped stratigraphically.
RESERVOIR
A porous and permeable material in which the hydrocarbons reside. Typically a layer of sandstone or limestone; could be a fractured stratum of impermeable rock.
MIGRATION pathway
A porous and permeable conduit from source to reservoir; commonly a layer of sand or sandstone, or a fault or fracture system.
Water-filled reservoir
SOURCE
A deposit rich in organic matter, which typically consists of the remains of phytoplankton; typically a fine-grained marine or lacustrine sediment (e.g. an organic-rich shale). It must have been buried to a depth at which it was subjected to considerable temperature for considerable time.
FIVE ELEMENTS OF A PETROLEUM ACCUMULATION
and some associated features
in an absurdly simple example
LBR PetroleumFive04.odg 5/2011 rev 9/2011

Advantages

Source and **reservoir** rocks analysis provide following measurements and applications:

1. Providing measurements of **Organic Carbon content, Oil content, Remaining hydrocarbon, Thermal maturity and Organic CO_2 in unconventional reservoir and on source rocks**;

2. Providing measurements of Oil yields, Viscosity and API prediction, Tar, bitumen and pyro-bitumen content and Pay zone identification;

Oil yield: the oil what remains in the mud after coming out from the mud shaker. The number of the yield give information on the quality of the oil. In productive reservoir we can detect the pay zone.

Advantages

3. **Identifying bypassed pay zone** by analyzing cuttings while drilling and assessing reservoir potential earlier in the development process by providing an estimate of how much oil residues in the reservoirs for all type of reservoirs;

4. **Optimizing hydraulic fracture placement** by pinpointing the location of oil in shale plays and tight sand;

5. **Identifying sweet spot** to determine the best location in the heavy oil column for heavy oil reservoir.

Sweet spot: stain on the cutting.

Equipment package

Wellsite Geochemistry Logging (WGL) service brings advanced, lab-based formation and resource evaluation technologies to the wellsite, enable us **faster** and more **informed exploration** and **reservoir development decisions**.

WGL service mainly includes

- source and reservoir rock thermal extraction and **pyrolysis analysis**,
- **XRD mineralogy analysis** and
- Quantitative **Grain Fluorescence (QGF**) and
- Quantitative **Grain Fluorescence on Extract** Fluorescence (QGF-E) analysis.

These analysis could provide fast and depth-profile results which indicate *properties of source rocks* and *reservoir rocks*.

Equipment package

Wellsite Geochemistry Logging equipment package:

1. Trailer （WLT20-G）for holding on equipment which include UPS power and safety monitoring;



Equipment package

2. **Shale Analyzer** for **organic geochemistry logging** which provide **measurement of TOC**, as well as other related parameters;



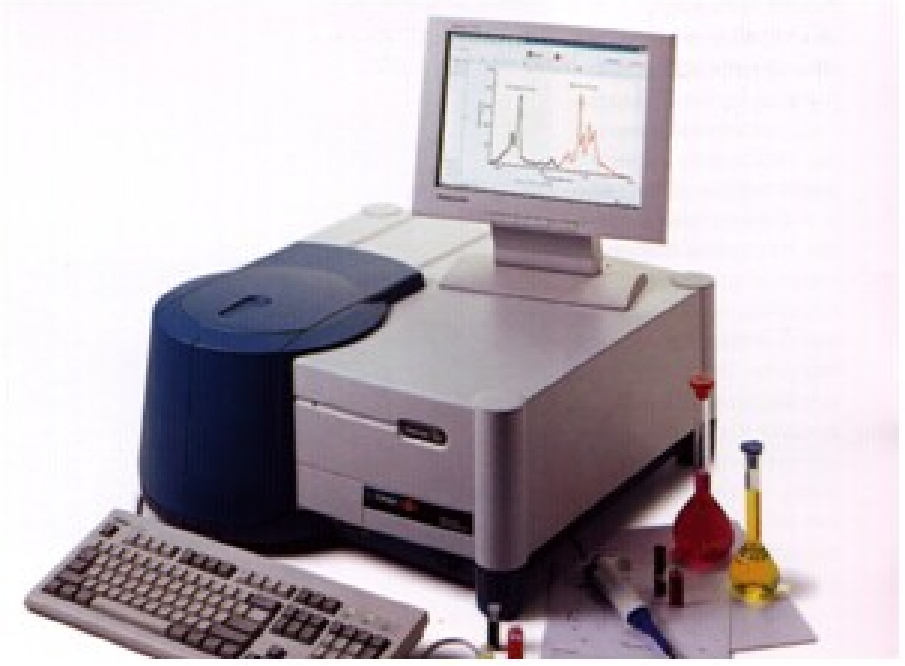
Equipment package

3.**Terra XRD mineral analyzer** for **mineralogy logging** which provide measurement of minerals in rocks;



Equipment package

4. **Cary-Eclipse spectrophotometer** for measurement of **fluid inclusion** and extraction fluorescence in rocks which provide QGF (Quantitative Grain Fluorescence) and QGF-E (Quantitative Grain Fluorescence on Extract) Fluorescence parameters.
In the case of oil based mud we can differentiate between the oil in the rock and in the mud.



Equipment package

5. Digital microscope photography with white and UV light;



6. Other integration with customer requirement.
7. Chemical reagents: HCL, $C_6H_6O_3$

Equipment package

X-Ray Diffraction (XRD) analysis provide direct measurement of formation mineralogy and following applications:

- Direct measurement of mineralogy for **accurate lithologic assessment** and more informed **stratigraphic correlations**;
- **Optimizing vertical completions** or lateral drilling target by **identifying the most brittle interval** which is most closely associated with hydrocarbon bearing intervals for unconventional resources;

Equipment package

- **Determination of feldspars, total clay and carbonate minerals in sandstones**, allowing better **understanding** of **provenance**, diagenetic history, porosity evaluation and reservoir quality;
- **Determination of calcite, dolomite and siderite in carbonates,** permitting better understanding of **diagenesis** and reservoir quality, as well as constraining log interpretations;
- Direct **measurement of mineralogy from cuttings** samples requires no downhole tools to provide **accurate lithologic assessment and brittleness**, in near real-time, with no capital risk.

Equipment package

Quantitative Grain Fluorescence (QGF) and Quantitative Grain Fluorescence on Extract Fluorescence (QGF-E) provide both UV and visible spectral information of samples and direct **detect current and palaeo-oil zones** by measuring the intensity of fluorescence from ultraviolet light-excited hydrocarbons sealed in fluid inclusions and at the surface of siliciclastic rocks.

QGF and QGF-E could be used **to investigate oil migration** and **petroleum charge** history using core and cutting samples from petroleum exploration wells.

Equipment package

Uses of QGF-E (Quantitative Grain Fluorescence on Extract in the case of siliclastics and carbonates) **detecting current oil zones** where oil-based drilling muds have been used or where there are indeterminate oil shows and delineating oil-water contacts.

Uses of **QGF** (Quantitative Grain Fluorescence in the case of siliclastics) detecting **palaeo-oil zones** and **delineating palaeo oil-water contact**.

Equipment package

Geochemical Mudlogging uses:

- **mass spectrometry mudgas detection** of the drilling mud, and
- **X-ray diffraction** (XRD) to analyze the rock cuttings from the wellbore.

Together, they provide a semi-empirical measurement of **both chemistry and mineralogy of the wellbore**. Both mass spectrometer and XRD machines are used right on the drilling location in real time allowing for instant analysis.

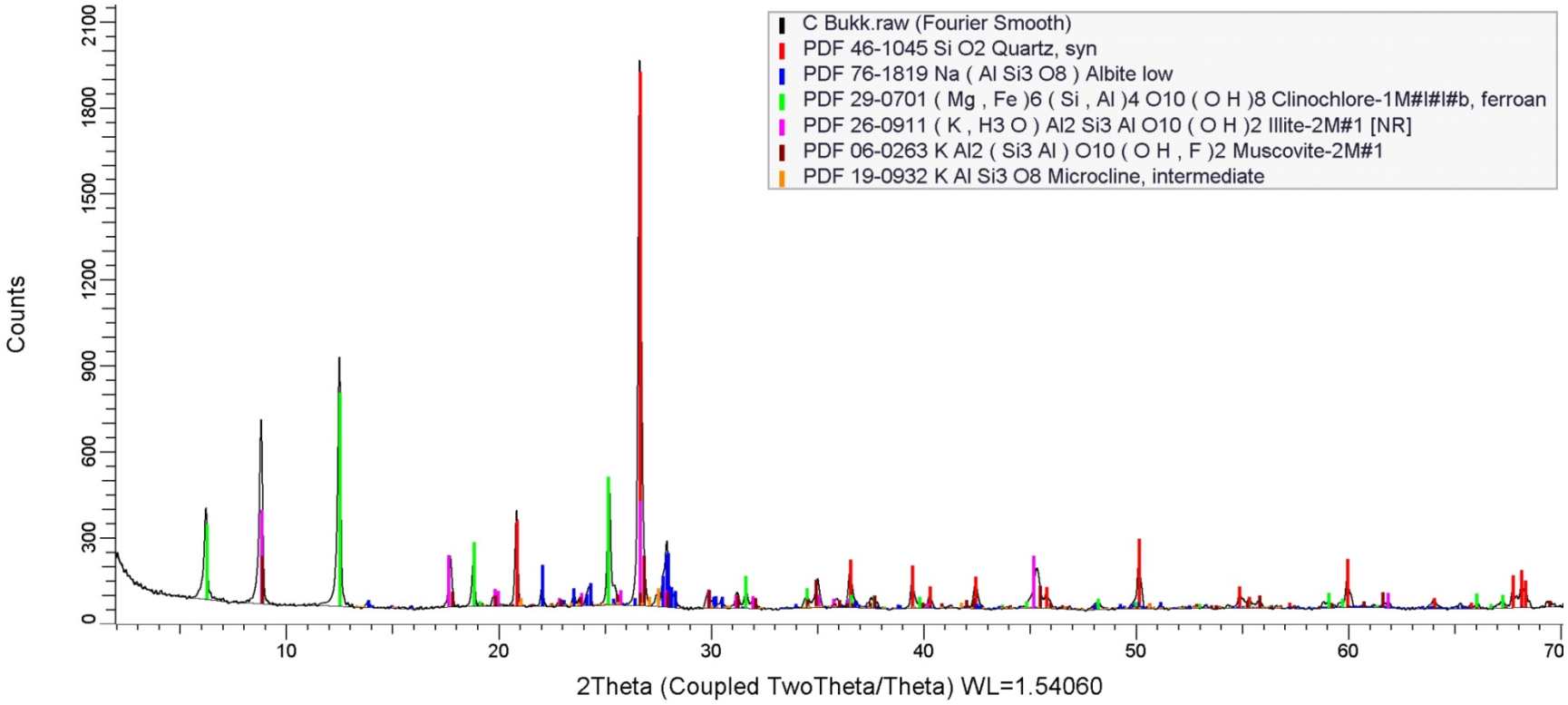
Equipment package

Both the mass spectrometry and XRD machines have been extensively field tested for decades. Comprehensive analysis is given after every well finishes to evaluate and understand how the geologic and petroleum systems behave in relation to one another. From **mineral** and chemistry compartments, to **fluid properties**, **water analysis, thermal maturity** tracking and much, much more.

Practical experiments

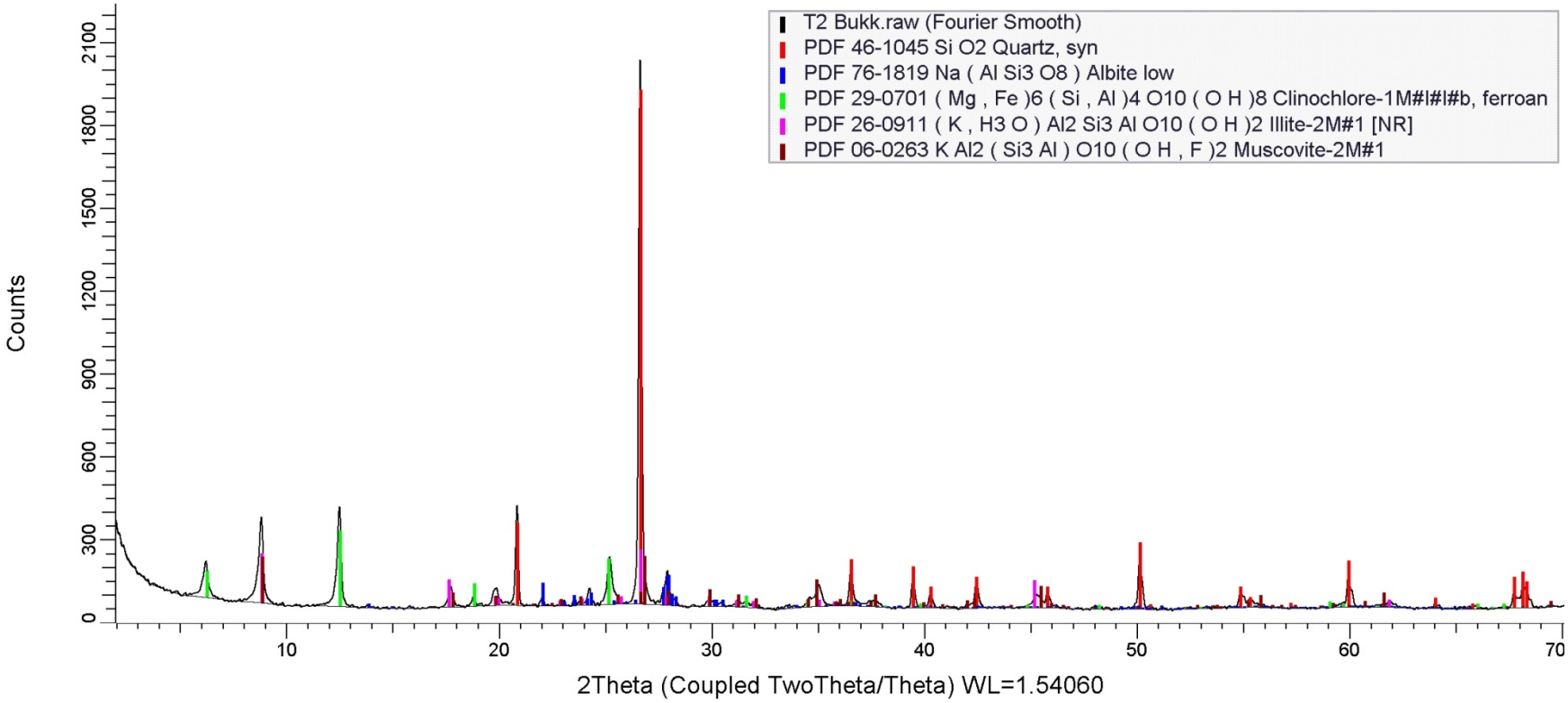


Practical experiments



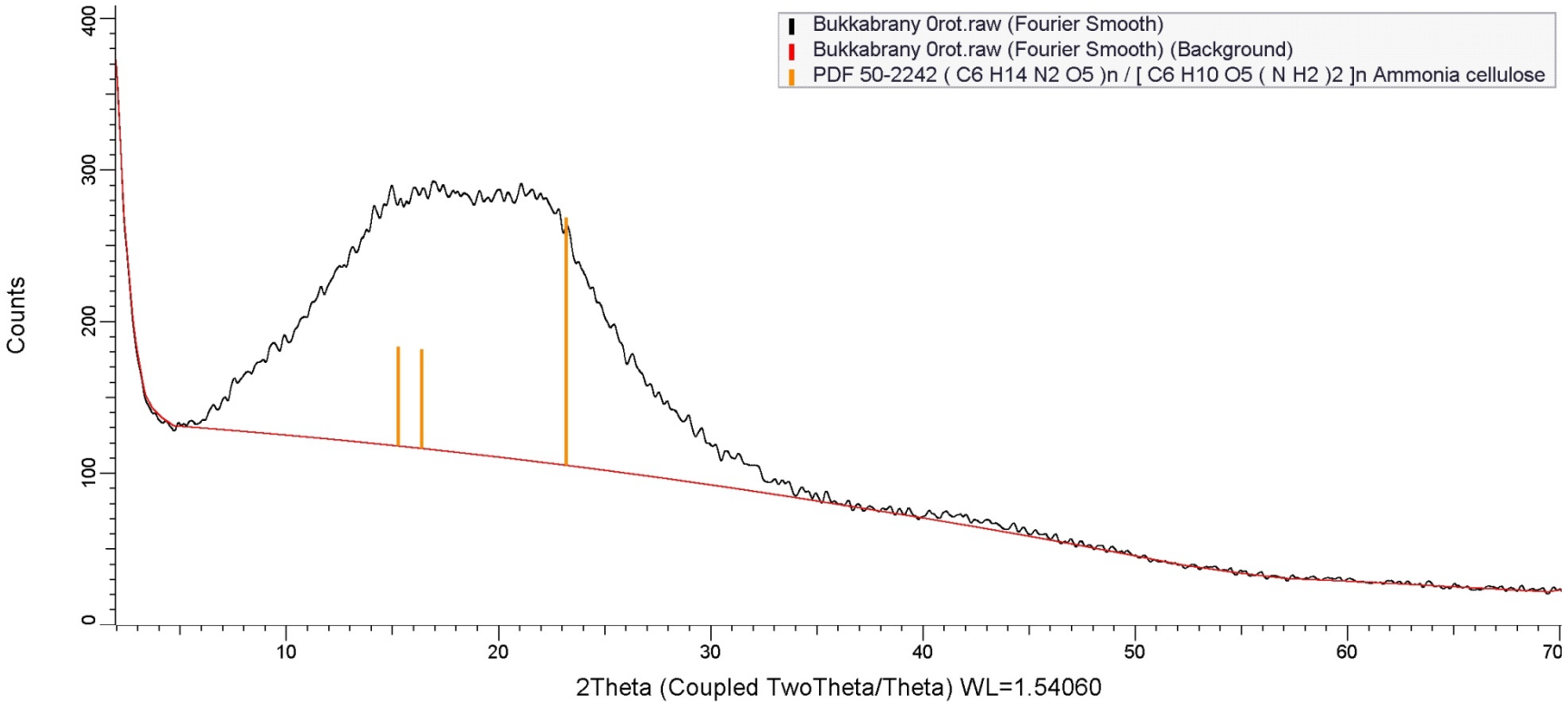
Shale rock sample , Carboniferous age, BÜKK MTS.
Measured by the portable Terra XRD mineral analyzer

Practical experiments



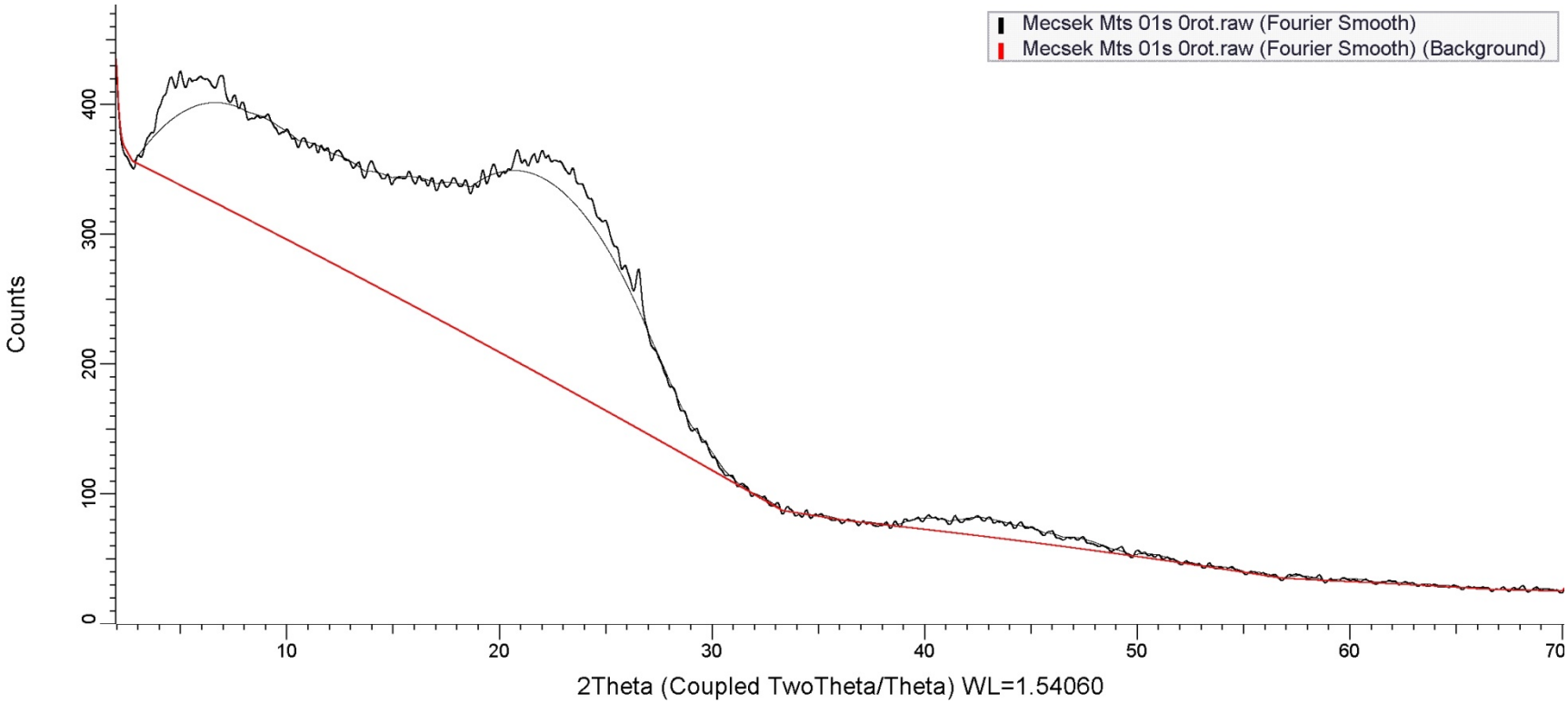
Shale rock sample , Triassic age, BÜKK MTS.
Measured by the portable Terra XRD mineral analyzer.

Practical experiments



Bükkábrány area, coal sample

Practical experiments



Mecsek MTS, coal sample

Discussion

Wellsite Geochemistry is a modern scientific direction characterized by a high transdisciplinarity and located at the edge of chemistry, environmental sciences, geology and biology.

It is the intention to introduce (i) clearly structured and comprehensible knowledge, (ii) process orientated learning and (iii) the complexity of natural geochemical systems.



THANKS FOR THE ATTENTION