

High resolution geochemistry at well site, a new emerging tool

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INTRODUCTION

The recent impressive improvements in analytical chemistry, due on one side to the growing needs of environmental monitoring and on the other to fast developments in nanotechnologies, made possible to move part of geochemical lab activities to well site. New portable and more robust instruments, able to replace bulky and complex instruments used in the labs, have been adopted in mud logging units, to introduce geochemistry at well site. This trend is still ongoing and other analytical techniques will be moved soon, offering new opportunities to get in quasi-real time additional high value data, matching lab quality standards.

There are many benefits deriving from moving geochemical analyses to well site:

- **quick responses for optimization of well construction and of real time decisions,**
- **fresh samples availability for more accurate analyses,**
- **no need of complex procedures for exporting samples and shipping them,**
- **less costs or, even better, more data with the same budget,**
- **flexibility in sampling.**

Petroleum system modelling needs the largest possible amount of experimental data to properly constrain results of numerical simulations and well site geochemistry can supply very detailed profiles of different analytical data, crucial for appropriate calibrations.

One under evaluated benefit from geochemistry at well site is flexibility in sampling. Cutting samples are very often taken at regular intervals, defined in advance by well program: sampling frequency is sometimes similar in very homogeneous and less important sequences as well as in highly heterogeneous formations, such as reservoir and source rocks. By using geochemistry at well site and evaluating results in real time, sampling intervals can be adapted in the key formational intervals or where heterogeneities are evident.

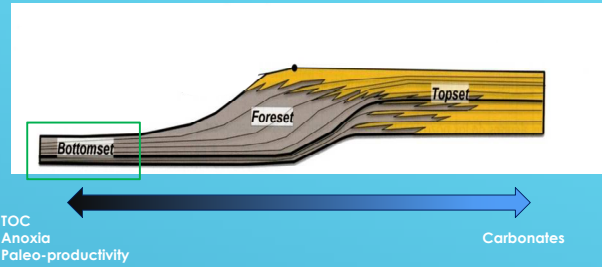
Thanks to lower cost and to the consequent possibility to get more samples and analyses, and to the flexibility in sampling, a high definition integrated picture of reservoirs and of source rocks, to be used as input to PSM exercises can be obtained. "Integrated" stands for a stringent integration of fluid compositions and rock properties, to investigate and to correlate fluid and rock heterogeneities.



Case History #1 – Well Site Source Rock Characterisation

Geological context:

- Complex stratigraphy of marine and continental succession, resulting from many relative sea-level changes at different scales
- Mixed siliciclastic-carbonate ramp (mid-distal), where TOC values range from 1 to 8%, and kerogen is mostly of type II/III.
- Both conventional and unconventional exploration.
- Variable kerogen maturity and complex charge mechanisms makes both light oil and gas interesting targets



Based on well-site acquisition:

- Portable XRD and XRF on cuttings
- Portable TOC and Pyrolysis
- C1-C5 mud logging

XRF, XRD and TOC data can give key information for reconstruction of source rock deposition.

Paleoenvironmental proxies

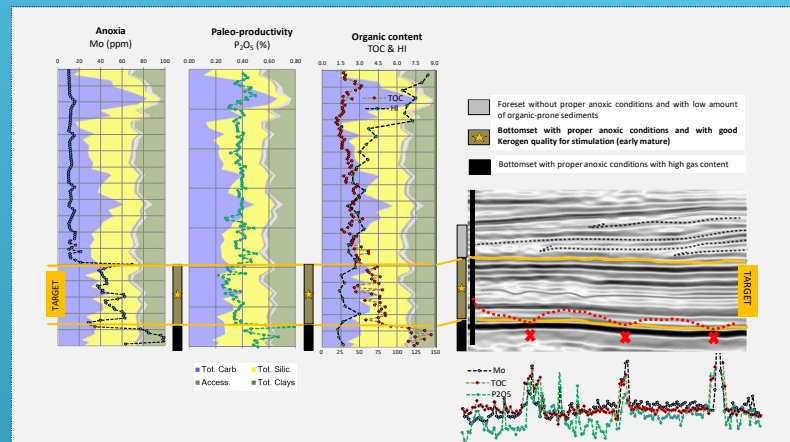
Mo concentration → Anoxia

P2O5 concentration → Productivity

Organic content proxies

TOC → Quantity of Organic Matter

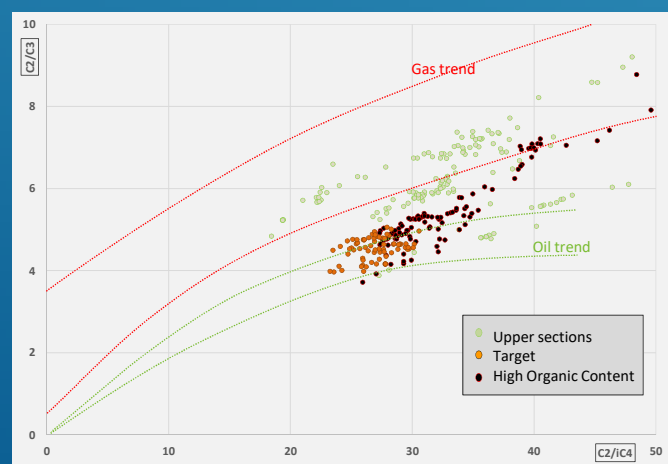
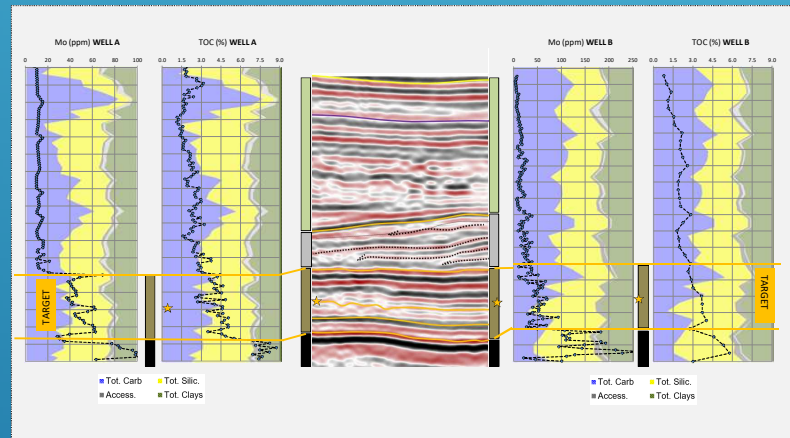
Hydrogen Index (HI) → Kerogen Quality



Well-well correlation

A better constrain of the basin geometrical evolution through time needs inter-wells correlations.

High resolution chemostratigraphy based on XRF and XRD can be fruitfully used at this aim. Concentrations and ratios between different chemical elements, due to specific paleo-environmental conditions limited in time, can differentiate homogeneous and uniform sedimentary sequences, allowing inter-well correlations using intra-formation horizons.

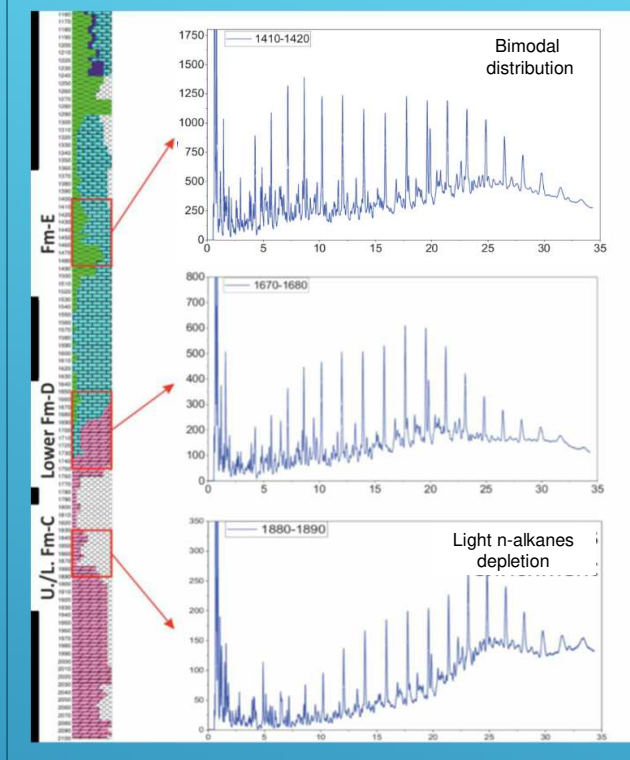


Fluid characterisation

Mud gas data from two wells indicates that:

- the target section is the most likely oil bearing interval;
- The shallow sections contains mostly gas, due to the poor quality of kerogen;
- the organic reach section at the bottom of the well can be both oil and gas bearing, probably depending on the local maturity and/or on gas charging from the deep.

Case History #2 – Multiple generation events



Based on well-site acquisition:

- Electromagnetic Flowmeters for mud delta flow
- Portable XRD and XRF on cuttings
- Portable GC-FID on cuttings

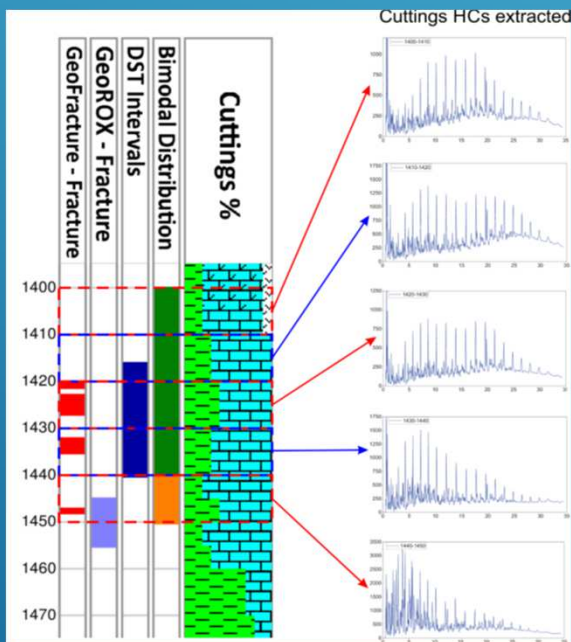
Oil becomes heavier with depth.

Incipient biodegradation in the bottom section: loss of the lighter n-alkanes and increasing UCM

Bimodal distribution in the shallow reservoir. A significant “hump” is still present

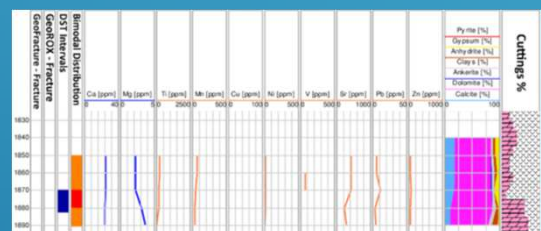
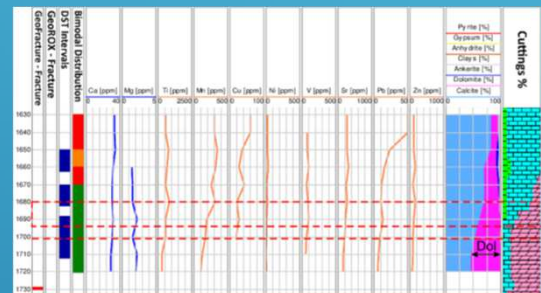
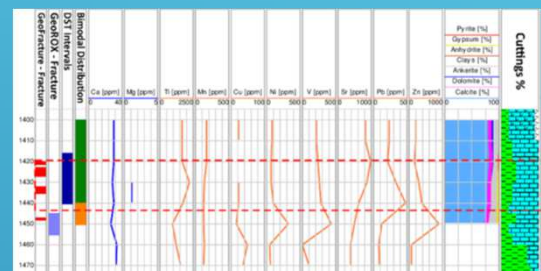
Detailed picture of the fractured interval

highly heterogeneous oil quality
mix of biodegraded + lighter/non-degraded fluid



Fractures detected only in the shallow reservoir

- changes of the mud flow
- possible cement precipitation (Sr, Pb, Zn)



Interpretation:

- Filling of the reservoirs by a first generation and migration event
- Slight biodegradation affecting the light fraction of the oil
- New filling of a more mature (lighter) oil through fractures

Final Remarks

- Labs activity can fruitfully and progressively move to wellsite.
- More data can be acquired at well site at lower costs, adding significant value.
- Data integration is crucial, adding huge value.
- New important progresses are still made possible by research activity.