# Mineral Characterization in the Geological Research Industry: a Combined Method Using Techniques of Drill Cutting Descriptions, Chemical Tests and Petrophysical Measurements by Logging Tools

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## INTRODUCTION

Precise sample description is essential in geologic work. Subsurface research rests on a careful and methodic analysis of well samples, (Swanson, 1981). Samples are useful in well to well correlation and identifying source rocks, seal rock and potential reservoirs (to be used in oil, mineral exploration, underground storage facilities and geothermal energy). Well site descriptions and chemical tests, give a valuable clue to the petrophysicists for using the adequate log to determine the composition of the minerals forming the geological formations of interest at the well site. The mineral determinations described in the previous paragraphs are of capital importance for the identification of minerals through well log curves.
Driven by the strong oil and gas industry, researchers realize de importance of a good mineralogical interpretation; coring is very expensive and cuttings are collected each ten meters (more or less) while logging tools can record a given physical property of the rock each ½ Ft (0.124 m).
The objective, was originally oil, later gas, and recently any kind of resource that needs an accurate measurement of porosity, water saturation and permeability such as Deep aquifer exploration, geothermal energy, underground repositories (natural gas, waste, etc.).

## MATERIALS AND METHODS

Mineralogical properties often become visible when using binocular magnifying lenses either with transmitted or reflected light.
Calcite reacts immediately with Hydrochloric acid diluted at 10%, -' (López de Azcona and Mingaro Martín, 1967).
$CaCO_3+2HCl-CO_2+CaCl_2+2H_2O$

Dolomite crystals react slowly.

$(CO_3)_2CaMg+4HCl-CO_2+CaCl_2+MgCl_2+2H_2O$.

A more detailed compositional percentage may be obtained by using a manocalcimeter, (Geoservices, 1981) or by versenate analysis. Alizarin Red S staining solution provides clearly the mineral distribution.

Calcium sulphates such as gypsum and anhydrite may be observed by the reaction taking place (Fig.1) with barium chloride. With 2g. of grinded samples washed with acidulated hydrochloric water, and adding $BaCl_2$ to the filtrate, the reaction takes place (Geoservices, 1981):

$CaCO_3+BaCl_2-CaCl_2+BaSO_4$.

Chloride test takes 2g. of grinded sample, adding distilled water and in the obtained filtrate some drops of $AgNO_3$ at N/10; $NaCl+AgNO_3-AgCl+NaNO_3$.

Coal and Lignite differentiation occurs in a test tube when some grams of powdered sample are put into a nitric acid solution at 10% diluted.

Shaking and letting decant it.

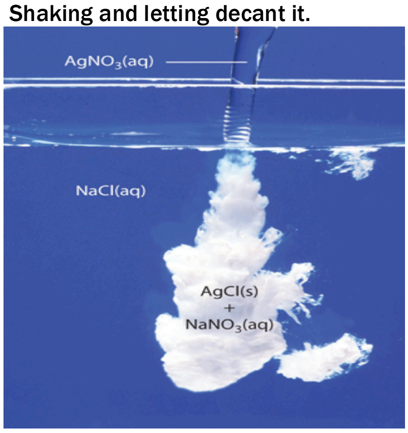


***fig 1*** *whitish milky precipitate.*

When working with log data, the equations for porosity calculations use mainly density log, sonic log and neutron log, modern tools such Nuclear Magnetic Resonance can solve directly for porosity and permeability, but the price of this technology far exceeds the budgets of the companies.

The equations using density, Sonic and neutron need an accurate knowledge of the minerals forming the rock (i.e. with the density equation, the petrophysicist or log analyst needs to use the correct grain density; for a given bulk density recorded by the logging tool, porosity will vary if we consider the rock formed by quartz grains, with a density of 2.65 g/cc or the presence of quartz and some carbonate cement, with a density that will vary between 2.65 g/cc and the density of a calcitic cement of 2.71 g/cc).
I.e. The equation for calculating porosity by density tool has the following formulae:

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(RhoMa-RHOB)/ (RhoMA-RhoFl) =DPHI
Where:

RhoMA is Matrix density
RHOB is the Bulk density (as recorded by the tool)
RhoFl is the fluid density
DPHI is the calculated porosity

By applying this calculation using the density of the mineral, we may obtain the porosity of the formation.
Thus, we have to provide the right mineral composition in order to obtain a precise calculation of the petrophysical parameters.

## RESULTS

Calcite Dolomite ratios may be well determined by using either a manocalcimeter or versenate analysis. Adequate tables provide the accurate readings for percentage evaluation. A deep red color takes place in the calcite crystals when using Alizarin Red S staining technique (Dickson, 1965, 1966).

A whitish milky precipitate occurs in either the sulphate or chloride samples when tests are performed.

The occurrence of a brown colored solution takes place if lignite is present in the sample. A colorless, transparent solution if coal is present. The presence of other minerals, such pyrite, glauconite, (Fig.2) and conductive clays can affect significantly the log responses.

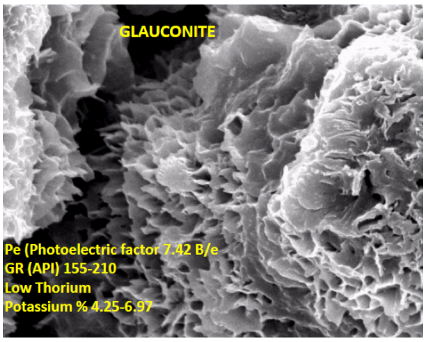


**fig 2.** BSE image of glauconite

Regarding the well log response of the minerals described in the well cuttings and chemical tests, we use different tools and the appropriate cross plots and tables for a precise mineralogical determination.

The presence of pyrite in a rock increases density and conductivity; in the first case, affects porosity calculation (pyrite is a dense metallic mineral) and the results of the calculations will leave low porosities.
Pyrite, glauconite (Fig.3) and shales are very conductive and consequently resistivity will be low; indicating a "fictitious" presence of salt water in a reservoir and low volume of hydrocarbons. In extreme cases, log response is unreliable, and in most cases correction is needed, having an electronic microscope and diffractometer at the well site is expensive and can be considered near impossible.

## DISCUSSION

Late generation logging tools such Elemental Capture Spectroscopy (Mark of Schlumberger) measure the atomic weights of the elements giving a very accurate mineral identification, but, this technology is again expensive, only available for large budgets, far from the budgets of small companies, ,in

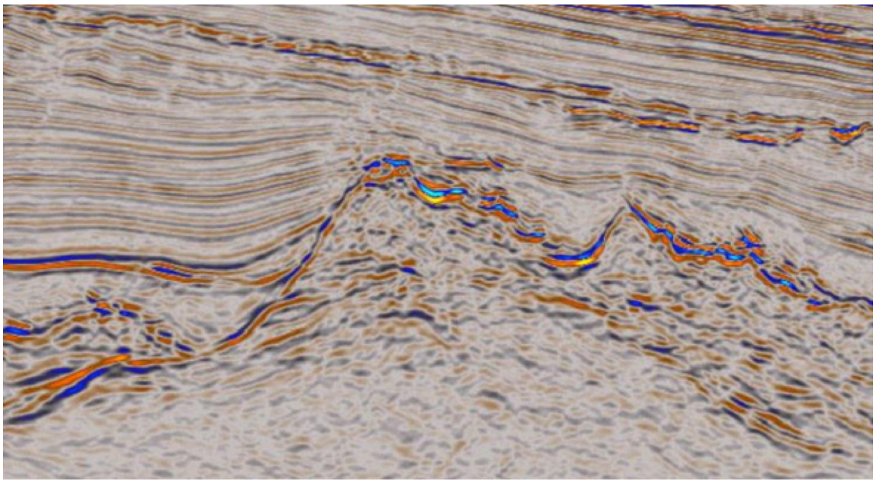

***fig 3.*** *Glauconite occurrence as a marker of the seal location between the Cenozoic-Mesozoic unconformity. Formation Tops at Casablanca oil field.*

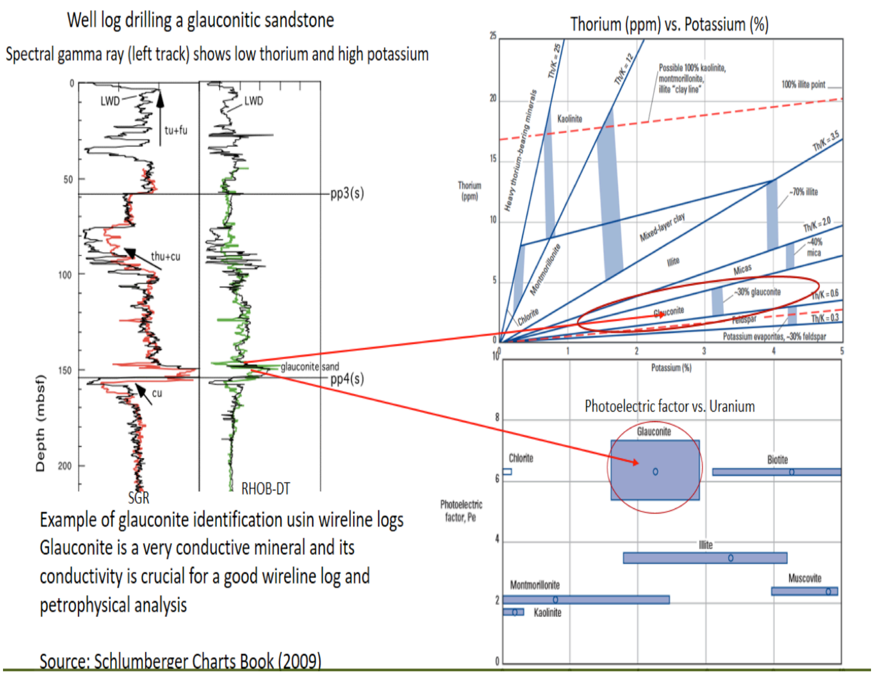


***fig 4.*** *Graphical determination of mineralogical content using well-log and cross plotted tables (extracted from Schlumberger Chart Book (2009) and Element Mineral Rock Catalog (Schlumberger, 1999); compiled by Oberto Serra).*

environmental studies and underground storage, etc.

This presentation will show the methods for mineral identification using classic logging tools such gamma ray spectroscopy gamma ray (Thorium, Uranium, Potassium), photoelectric factor, charts (Density vs. Neutron, Thorium versus potassium, Photoelectric factor vs. Potassium, Matrix volumetric factor vs Grain density and others) combining different measurements and the tables commonly used in the petrophysical interpretation, determining specific mineralized intervals, such as glauconitic sands.

## CONCLUSIONS

An adequate consideration of sample cutting descriptions and chemical tests performed in the mud-logging unit, provide the correct election of the logging tools to be run into the open hole.
Mineralogical composition of the drilled rocks, affect the primary petrophysical properties of the formation, permeability and porosity.

Reducing or increasing porosity by chemical precipitation can be determined by the logging tools (Fig. 4 y 5).

Determining specific mineralized intervals, such as glauconitic sands are of valuable help while drilling in the Mediterranean Oil fields.

The occurrence of glauconite and high gamma ray readings are indicative of the proximity of the unconformity at the Mesozoic formations, separating seal rock from reservoirs.

Such considerations must be carefully observed, to avoid any potential damage to the oil reservoir.

The occurrence of glauconite is a clear stratigraphical key horizon.

## ACKNOWLEDGEMENTS

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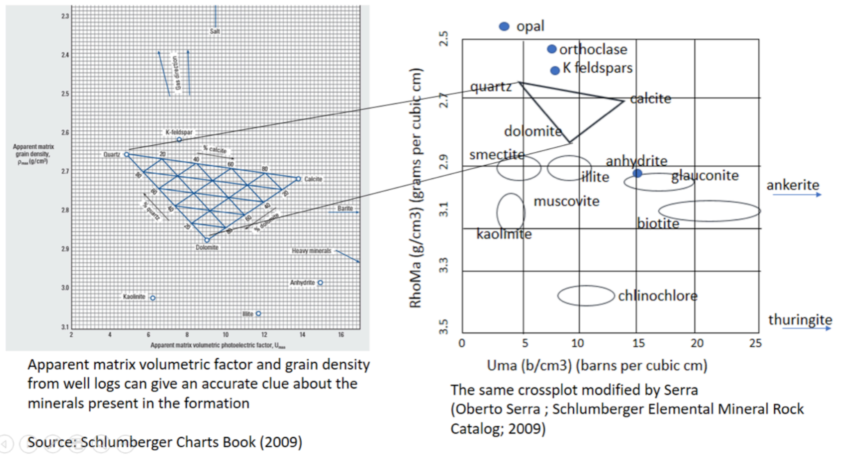


***fig 5.-** Apparent matrix volumetric factor and grain density from well logs can give an accurate clue about the minerals present in the formation. Source: Schlumberger Charts Book (2009) and Elemental Mineral Rock Catalog (O. Serra, Schlumberger 1999)*

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