[PS]Quantification of Net-to-Gross and Oil Impregnation in Bioturbated Heterolithic Clastic Reservoirs using Core Photographs*

J. Iparraguirre[1,2], M. Arcuri[1,2], C. Zavala[2,3], V.H. Goitia Antezana[4], L.R. Arnez Espinosa[4], M. Di Meglio[3], and A. Zorzano[3]

Search and Discovery Article #42043 (2017)**
Posted March 27, 2017

*Adapted from poster presentation given at AAPG/SEG International Conference and Exhibition, Barcelona, Spain, April 3-6, 2016
**Datapages © 2017 Serial rights given by author. For all other rights contact author directly.

[1]Universidad Tecnológica Nacional, Buenos Aires, Argentina (j.iparraguirre@computer.org)
[2]Universidad Nacional del Sur, Bahía Blanca, Argentina
[3]GCS Argentina, Bahía Blanca, Argentina
[4]EUROTEK-YUGRA, Moscow, Russia

Abstract

Bioturbated heterolithic clastic reservoirs are often characterized by clean sandstones forming thin levels, small patches, and burrow infills. This scenario makes precise estimation of percentage of sandstone (net-to-gross) a very difficult task. At present, there are no tools available that allows a straightforward quantification of the sand content using core pictures. In this work, a novel technique that uses core photographs is presented. Using computer vision processing software it is possible to determine the composition of the analyzed cores. The method is based on an automatic segmentation of contrasted core photographs and the subsequent analysis through image processing. This methodology allows precise estimation of the sandstone percentage (ISA, image sandstone analysis) at a variable and fully customized sample rate. The results are continuous logs that can be fully integrated with other conventional core and well logs. A similar procedure was applied to the analysis and quantification of oil impregnation (IFA, image fluorescence analysis) through the processing of UV core photographs. The results were highly satisfactory. IFA was able to appropriately distinguish between impregnated and unimpregnated areas. Additionally, it was possible to successfully determine the degree of impregnation. This technique was successfully applied to the analysis of the Lower Cretaceous Leushinskaya and Vikulovo reservoirs in Western Siberia Basin, Russia. Three different logs were computed with sample rates of 1, 10 and 50 cm. In the case of ISA, the obtained logs proved to be useful tools for evaluating the location of sandier intervals, the precise calculation of net-to-gross for a desired interval, and the analysis of the internal cyclicity at different scales. IFA results were compared with other sophisticated well tools. The IFA log shows an excellent match with the oil saturation curve and provides a precise location of HC contacts. Both ISA and IFA logs also contribute to the precise estimation of core shift.

Quantification of net-to-gross and oil impregnation in bioturbated heterolithic clastic reservoirs using core photographs

Iparraguirre[1,2], J.; Arcuri[1,2], M.; Zavala[2,3], C.; Goitia Antezana[4], V.H; Arnez Espinosa[4], L.R.; Di Meglio[3], M.; and Zorzano[3], A.

1: Universidad Tecnológica Nacional; 2: Universidad Nacional del Sur; 3: GCS Argentina; 4: EUROTEK-YUGRA.

1. Introduction

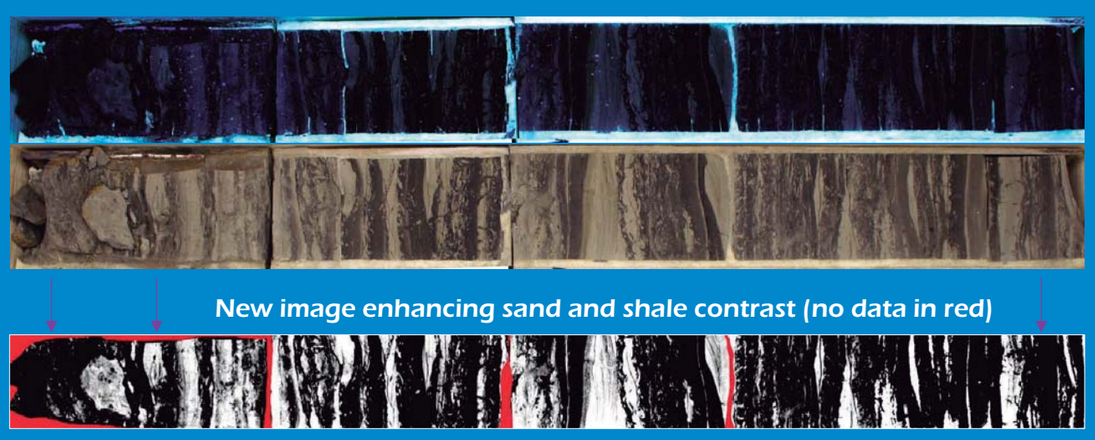
Bioturbated heterolithic clastic reservoirs are often characterized by clean sandstones forming thin levels, small patches, and burrow infills. This scenario makes precise estimation of percentage of sandstone (net-to-gross) a very difficult task. At present, there are no tools available that allows a straightforward quantification of the sand content using core pictures. In this work, a novel technique that uses core photographs is presented. Using computer vision processing software it is possible to determine the composition of the analyzed cores.

2. Methodology

The method is based on an automatic segmentation of contrasted core photographs and the subsequent analysis through image processing. This methodology allows a precise estimation of the sandstone percentage (ISA, image sandstone analysis) at a variable and fully customized sample rate. The results are continuous logs that can be fully integrated with other conventional core and well logs. This metodology was also apllied to analyze the fluorescence images producing similar and usefull results.

3. ISA (Image Sandstone Analysis)

The first step consists on costumizing the entire set of photographs, enhancing the contrast between sands and shales and discarding non rock material. This processes should always be done by a geoscientists with any image processing software.



Color classification

White: count as positive (sandstone)
Black: count as negative (shale)
Red: discard

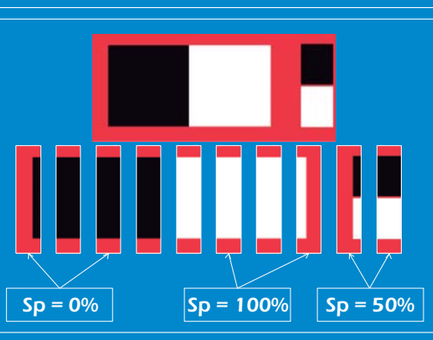
Metrics definition

Nwp: number of white pixels in the interest region
Nbp: number of black pixels in the interest region
Sp: sand percentage

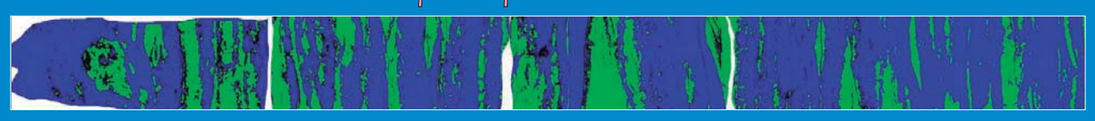
Sp = Nwp/(Nwp + Nbp)*100

Regional calculation

- Each pixel has 3 components: R(red), G(green) and B (Blue)
- Each component contains a value between 0 and 255
- White equals to RGB= 255,255,255
- Black equals to RGB= 0,0,0
- Pixels color is classified using the RGB values and a deviation paramenter DELTA



Output Sp=27.64 %

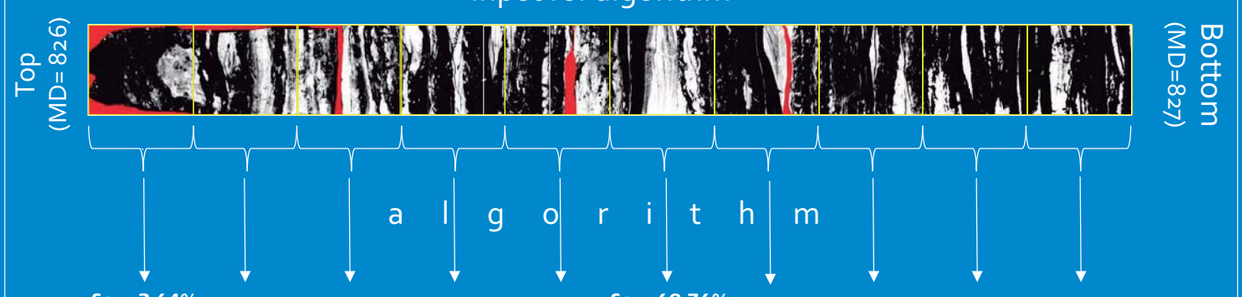


Unclassified: 10.09 % of total number of pixels

Samping intervals (customized)

x 1 cm x10cm (This example) x 50 cm x 35,5 cm?

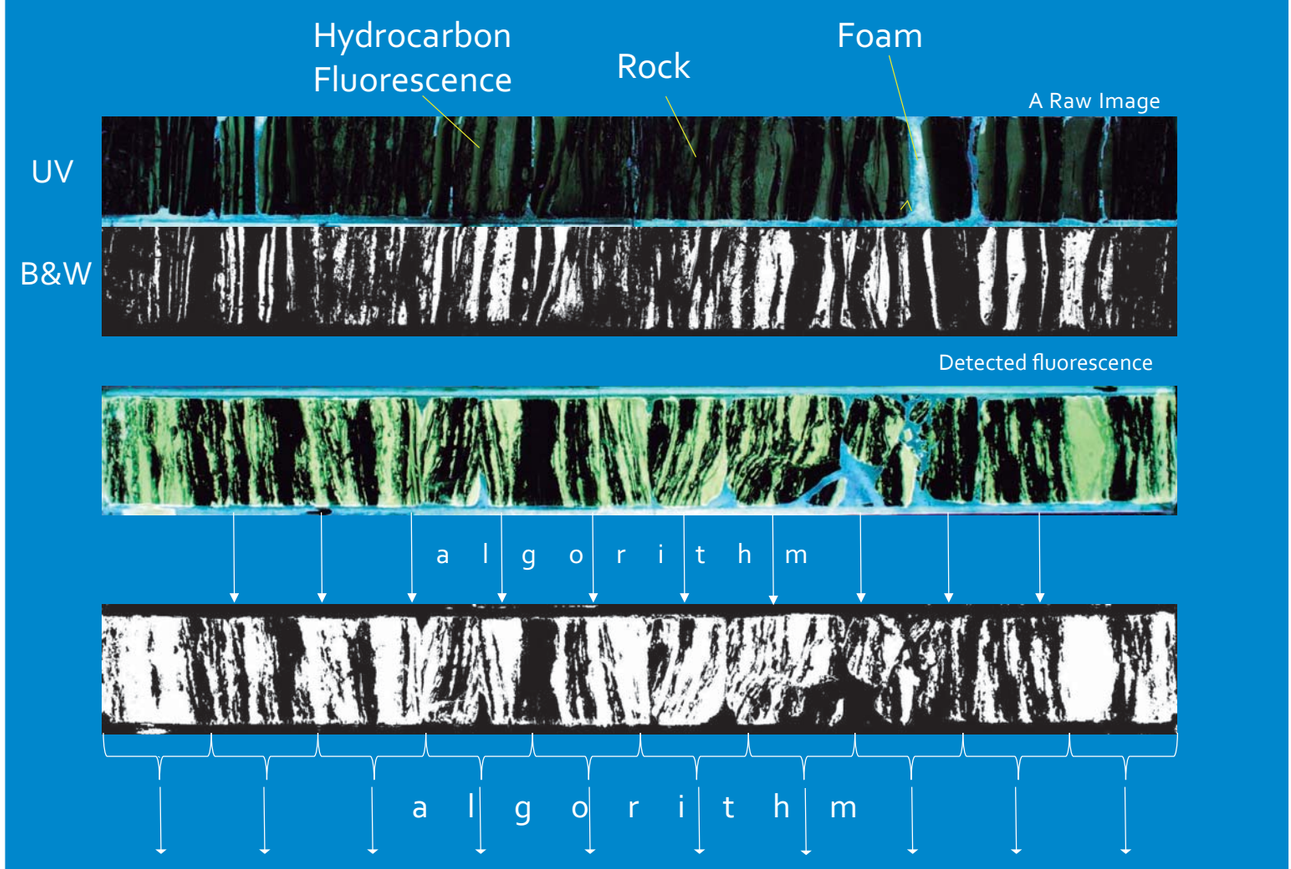
Input for algorithm



MD: Automatically calculated at the middle of the measured interval

4. IFA (Image Fluorescence Analysis)

A similar procedure was applied to the analysis and quantification of oil impregnation (IFA, image fluorescence analysis) using UV core photographs. The results were highly satisfactory. IFA was able to appropriately distinguish between impregnated and unimpregnated areas. Additionally, it was possible to successfully determine the degree of impregnation.



Metrics used for detecting hydrocarbon fluorescence

Nhp: number of pixels with fluorescence
Nbp: number of black pixels
Hp: hydrocarbon presence

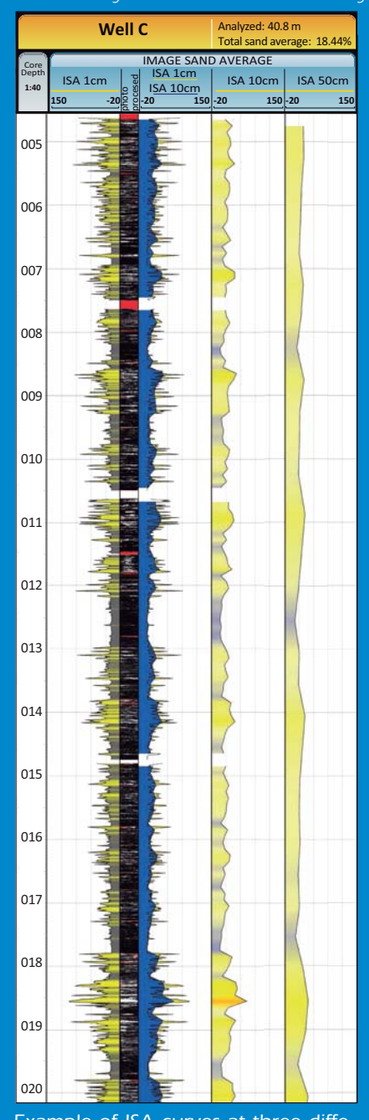
Hp = Nhp/(Nhp + Nbp)*100

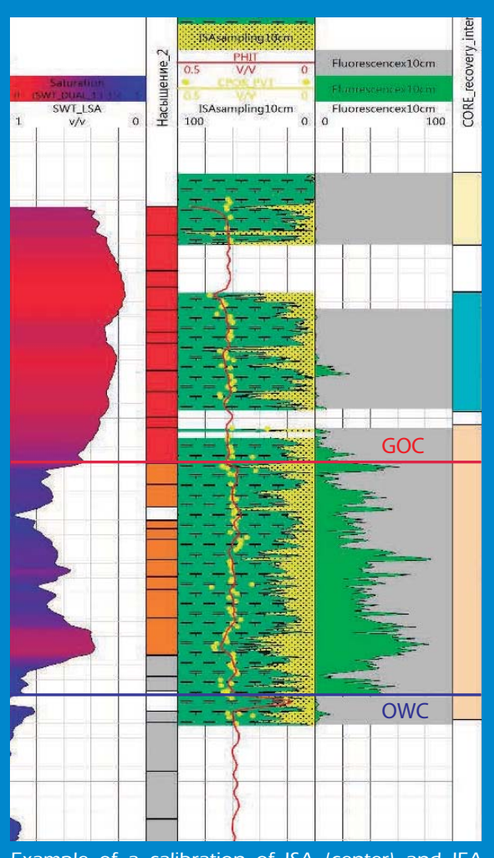
5. Application development

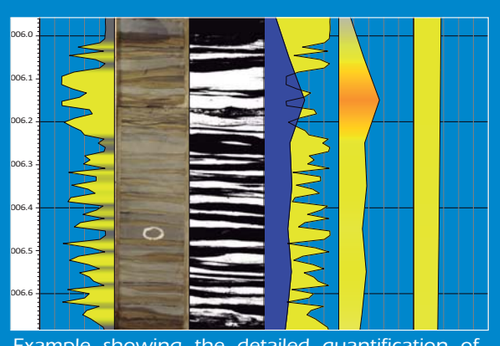
A new application was developed in order to properly process a large database. The application requires a set of core photographs, with indication of the base depth, the top depth, and sampling window. Is is possible to process pictures to obtain either ISA or IFA results. The output consist on a CSV file that contains depth and S or H values that it can be imported into any current tool that supports CSV format

6. Some examples and results

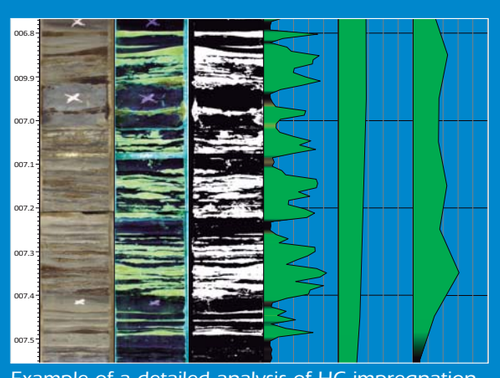
This technique was successfully applied to the analysis of heterolithic Lower Cretaceous reservoirs in the Western Siberia Basin, Russia. Three different logs were computed with sample rates of 1, 10 and 50 cm. In the case of ISA, the obtained logs proved to be useful tools for evaluating the location of sandier intervals, the precise calculation of net-to-gross for a desired interval, and the analysis of the internal cyclicity at different scales. IFA results were compared with other sophisticated well tools. The IFA log shows an excellent match with the oil saturation curve and provides a precise location of HC contacts. Both ISA and IFA logs also contribute to the precise estimation of core shift.



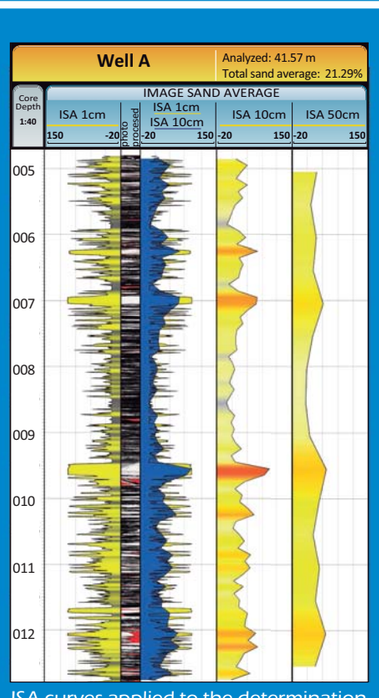




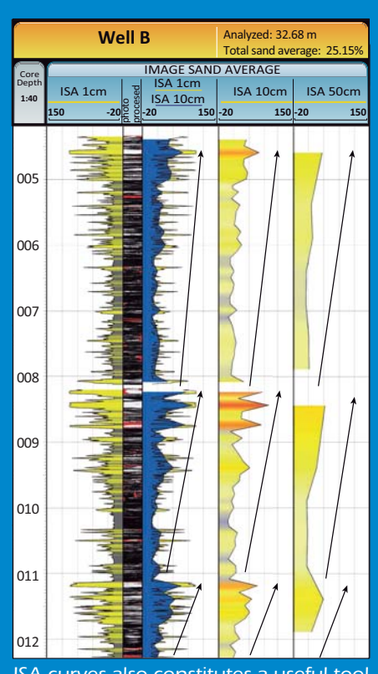
Example showing the detailed quantification of small sandstone levels and patches (ISA). Two sample rates are shown (1 cm and 10 cm)



Example of a detailed analysis of HC impregnation using the IFA curve (sample rate 1cm)



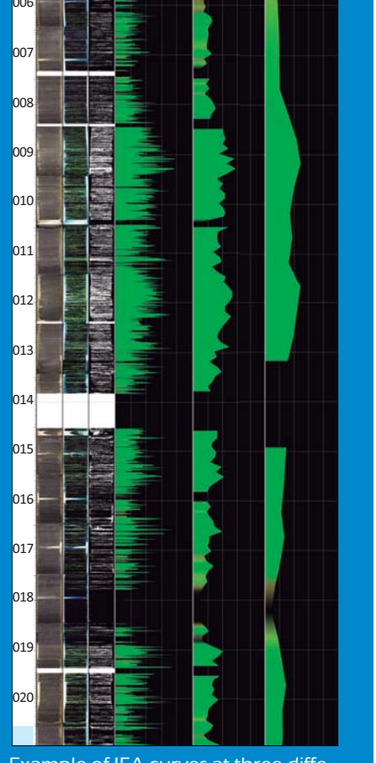
ISA curves applied to the determination of sandstone content at three different sample rates (1, 10 and 50 cm). Note the perfect match between core and ISA curves



ISA curves also constitutes a useful tool to recognize internal cycles of different hierarchical orders. In the example 1cm and 10 cm sample curves clearly define m-scale thickening upward cycles.

Example of a calibration of ISA (center) and IFA (right) curves with the saturation curve (left). Note the good match of IFA curves with OWC and GOC contacts.

Example of ISA curves at three different sample rates (1, 10 and 50 cm) on heterolithic deposits.



Example of IFA curves at three different sample rates