[PS]Characterization of the Porous System of Carbonate and Siliciclastic Sequences of Oligo-Miocene in the La Vela Offshore Field, Venezuela*

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Abstract

The offshore field "La Vela", in Venezuela, presents siliciclastic and carbonate deposits ranging from medium to condensed, arranged on an igneous metamorphic base. This research seeks to define petrophysical parameters and models, describe petrofacies, analyze rock quality and observe the distribution of isoproperties in the field, with the objective to characterize the porous system in deposits of interest of Oligo-Miocene age. An integrated petrophysical evaluation was applied, which focused on the interpretation of well logs in conjunction with electrical measurements and capillary pressure by mercury injection, based on a total of 80 samples analyzed demarcate into the sedimentary units within the seismoestratigraphic sequences.

As a result, the obtained parameter "m" allowed calculation of hydrocarbon saturation with a lower degree of uncertainty. This parameter with a value less than two is due with a poral system associated to fracture and the presence of authigenic minerals; these indications of secondary porosity were also evidenced from the detailed interpretation of well logs, including thin sections. Microfracturing of particles plays an important role within the field since it interconnects the poral system, which generally includes porosity intraparticle, interparticle, moldic, and micro vugular, although these last two are extremely localized.

Capillary pressure tests indicate diversity in petrophysical facies with poral radius ranging from nano to mega pores. It is then concluded that rock genesis and the diagenetic processes affected pore geometry and architecture. For this reason, the dominant petrofacies together with diagenetic processes, define and impact rock quality.

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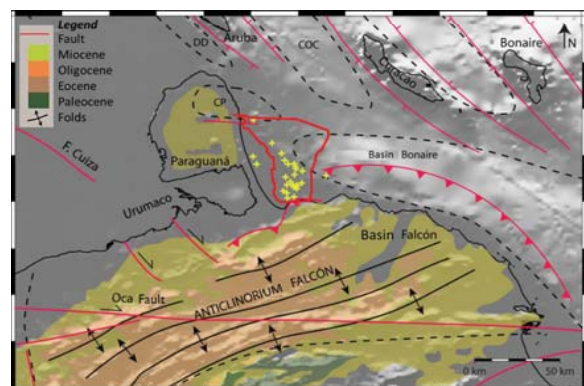
Yolimar Rojas –(yuli_rm@hotmail.com), Zureisy Marín- (zureisy24up@gmail.com), Ignacio Mederos (imederos30@gmail.com), María Gómez(gomezmc06@gmail.com)

Introduction

The Ensenada de La Vela field is located in territorial waters north of the Falconian coast and east of the Peninsula of Paraguaná, in Falcon state, Venezuela.

Silisiclastic and carbonate deposits saturated by hidrocarbons ranging from medium to condensed hydrocarbon, arranged on an igneous metamorphic base, were also proved.

Up to date, petrophysical evaluations were carried out previously, however, none of them responded to a characterization of petrophysical facies that integrated with seismic sequences, core analysis and detailed sedimentological studies, that contribute to defining zones with the best properties, as was suggested in 1980

Geologically it is a monocline with dip at the southeast, cut by normal faults of northeasterly heading.
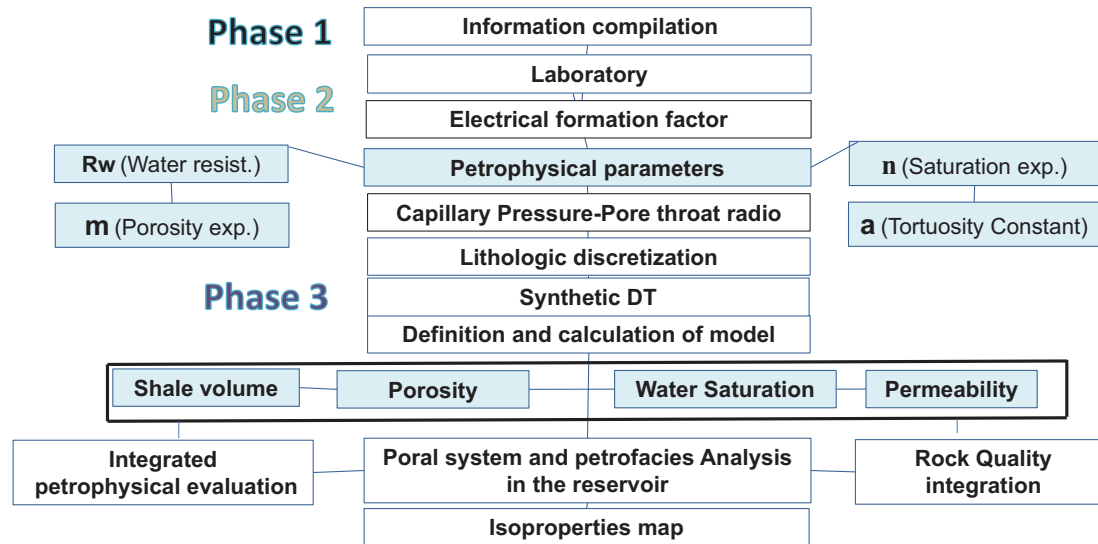
General objective:
To characterize the porous system in deposits of interest of the Oligo-Miocene age.
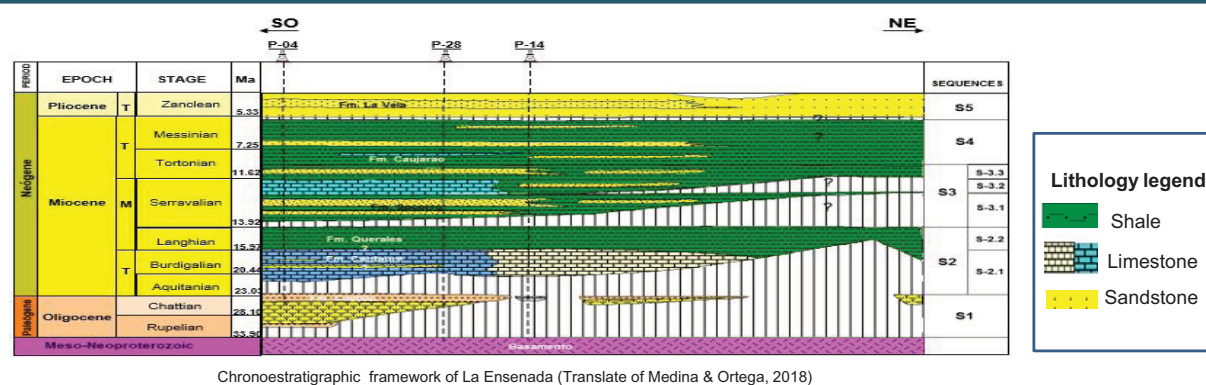This research seeks to:
• Define the petrophysical parameters and models.
• Describe pore throat radius and petrofacies.
• Analyze quality of rocks and observe the distribution of isoproperties in the field.

Location of the area and main structures (Modified of Gorney , 2007).

Area: 978 Km2 · seismic volume 3D · 26 wells

Methodology

WORKFLOW TO CHARACTERIZE POROUS SYSTEM

Phase 1 — Information compilation · Laboratory · Electrical formation factor

Phase 2 — Rw (Water resist.) · Petrophysical parameters · n (Saturation exp.)
m (Porosity exp.) · Capillary Pressure-Pore throat radio · a (Tortuosity Constant)

Phase 3 — Lithologic discretization · Synthetic DT · Definition and calculation of model

Shale volume · Porosity · Water Saturation · Permeability

Integrated petrophysical evaluation · Poral system and petrofacies Analysis in the reservoir · Rock Quality integration

Isoproperties map

Chronoestratigraphic framewok

Chronoestratigraphic framework of La Ensenada (Translate of Medina & Ortega, 2018)

Lithology legend: Shale · Limestone · Sandstone
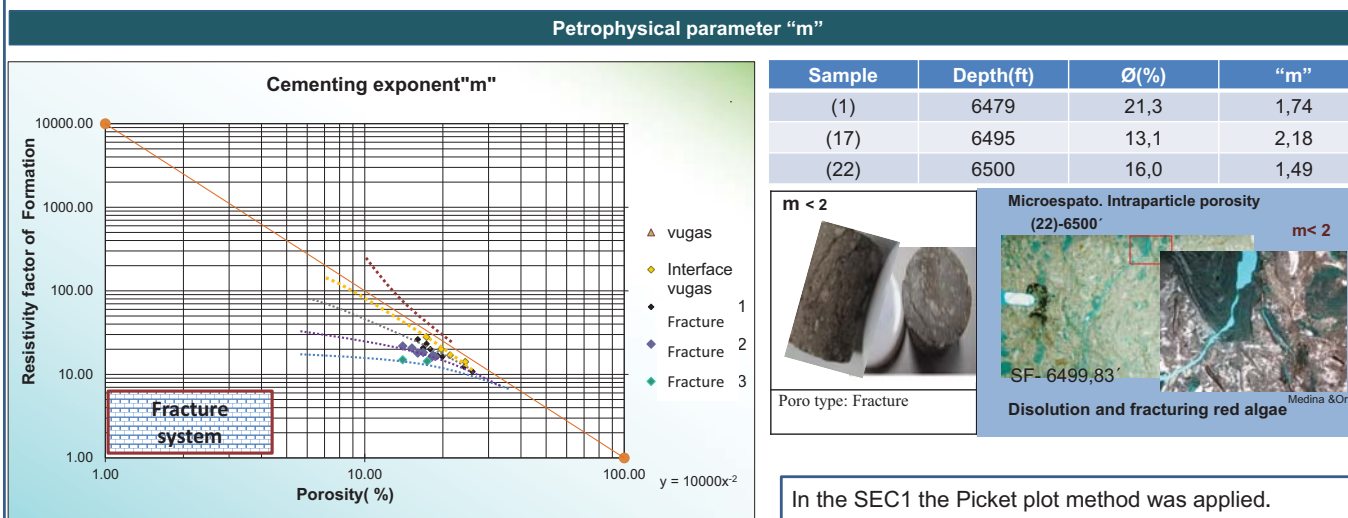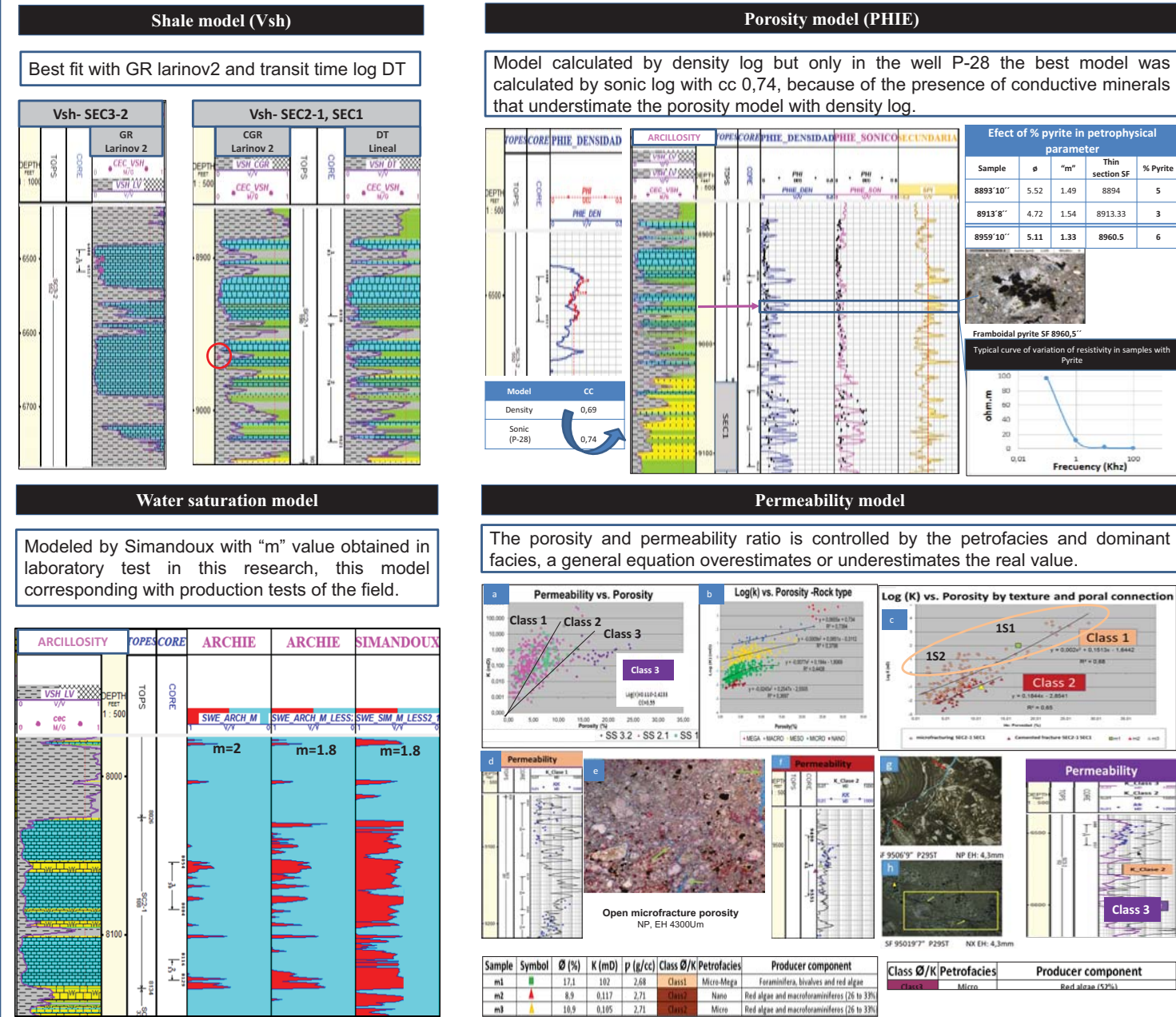
Results

Petrophysical parameters ; Estimation of Electrical formation factor to sample core.

Laboratory results "m" by sequences.

SEQUENCES	POROSITY	"m"
SC3-2	Microfracture porosity	1.7
SC2-1	Porosity by particle microfracturing with interparticle porosity tendence	1.8
SC1	(Interparticle) cemented rocks	2
	(Interparticle) moderately cemented rocks	1.8

Petrophysical parameter "m"

Cementing exponent"m"

Sample	Depth(ft)	Ø(%)	"m"
(1)	6479	21,3	1,74
(17)	6495	13,1	2,18
(22)	6500	16,0	1,49

m < 2 · Microespato. Intraplatclip porosity (22)-6500' · m< 2

vugas · Interface vugas · Fracture · Fracture 1 · Fracture 2 · Fracture 3

Poro type: Fracture · SF-6499,83' · Dissolution and fracturing red algae

y = 1000a⁻²

In the SEC1 the Picket plot method was applied.

Results

❖ Petrophysics models.

Shale model (Vsh)
Best fit with GR larinov2 and transit time log DT

Vsh- SEC3-2 · Vsh- SEC2-1, SEC1

Porosity model (PHIE)
Model calculated by density log but only in the well P-28 the best model was calculated by sonic log with cc 0,74, because of the presence of conductive minerals that underestimate the porosity model with density log.

Effect of % pyrite in petrophysical parameter

Sample	#	"m"	Thin section SF	% Pyrite
8893'10''	5.52	1.49	8894	5
8913'8''	4.72	1.54	8913.33	3
8959'10''	5.11	1.13	8960.5	6

Framboidal pyrite SF 8960,5'

Typical curve of variation of resistivity in samples with Pyrite

Model	CC
Density	0,69
Sonic (P-28)	0,74

Water saturation model
Modeled by Simandoux with "m" value obtained in laboratory test in this research, this model corresponding with production tests of the field.

ARCHIE · ARCHIE · SIMANDOUX · m=2 · m=1.8 · m=1.8

Permeability model
The porosity and permeability ratio is controlled by the petrofacies and dominant facies, a general equation overestimates or underestimates the real value.

Permeability vs. Porosity · Log(k) vs. Porosity-Rock type · Log (K) vs. Porosity by texture and poral connection

Class 1 · Class 2 · Class 3

Open microfracture porosity NP, EH 4300Um

❖ Petrofacies definition

Heterogeneity in the pore throat radio. Graphical apex shows 35% of displacement and R35 dominant radio. The Pittman equation reproduces poral throat radio in conventional core data.

Pittman equation with conventional core data shows in general dominant microporosity poral throat radio.

Carbonatic rocks – small poral throat radio- high pressure. Siliciclastic rocks – big poral throat radio - low pressure.

Apex · Incremental Hg saturation · B... Pc Vs. R... of Pittman

y = 0.8866x + 0.0216 R² = 0.9648

SEC3-2 (Carbonatic) · SEC2-1 (Siliciclastic) · SEC1 (Siliciclastic)

Capillary Pressure SEC2-1 · Capillary Pressure SEC1
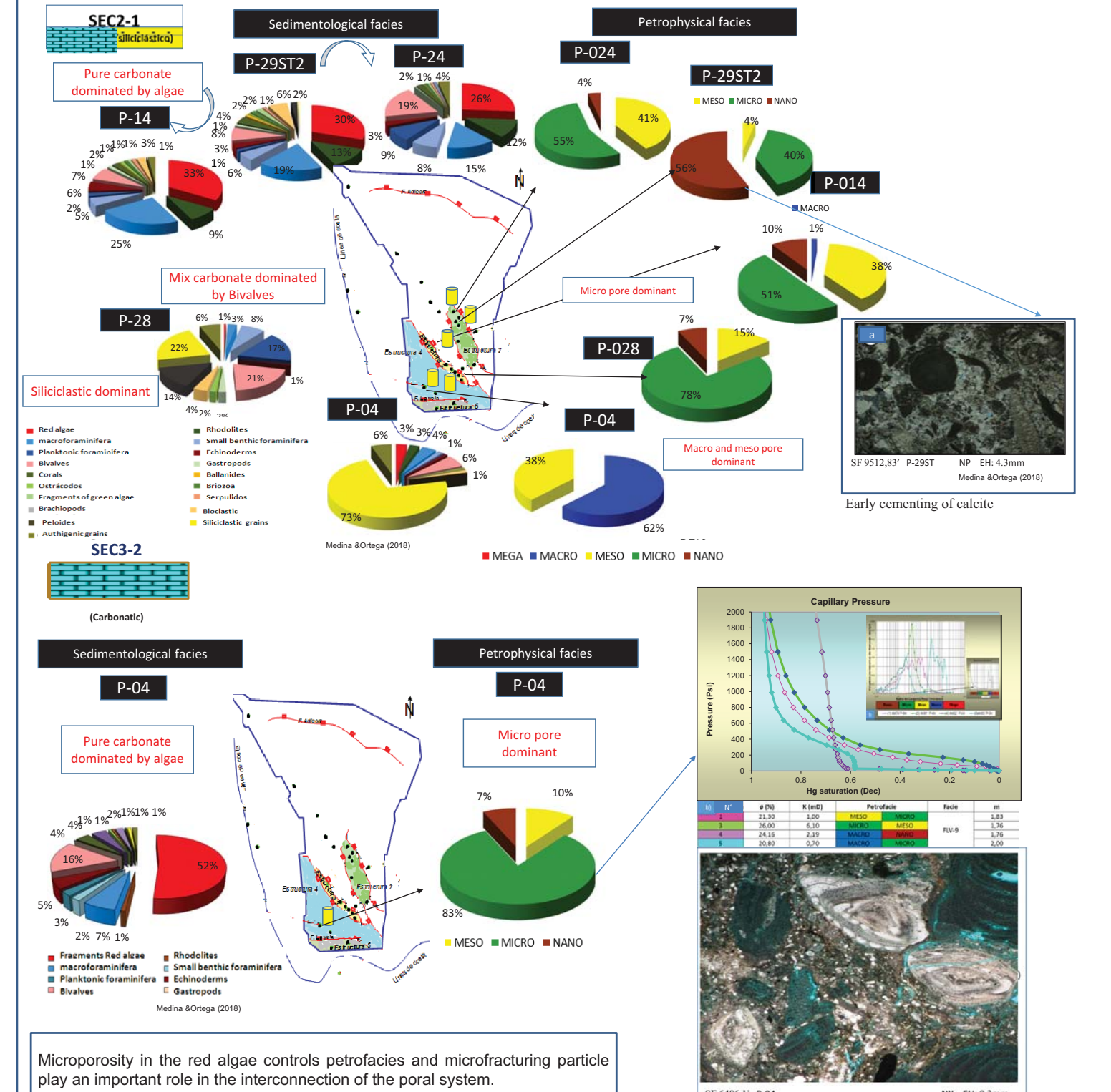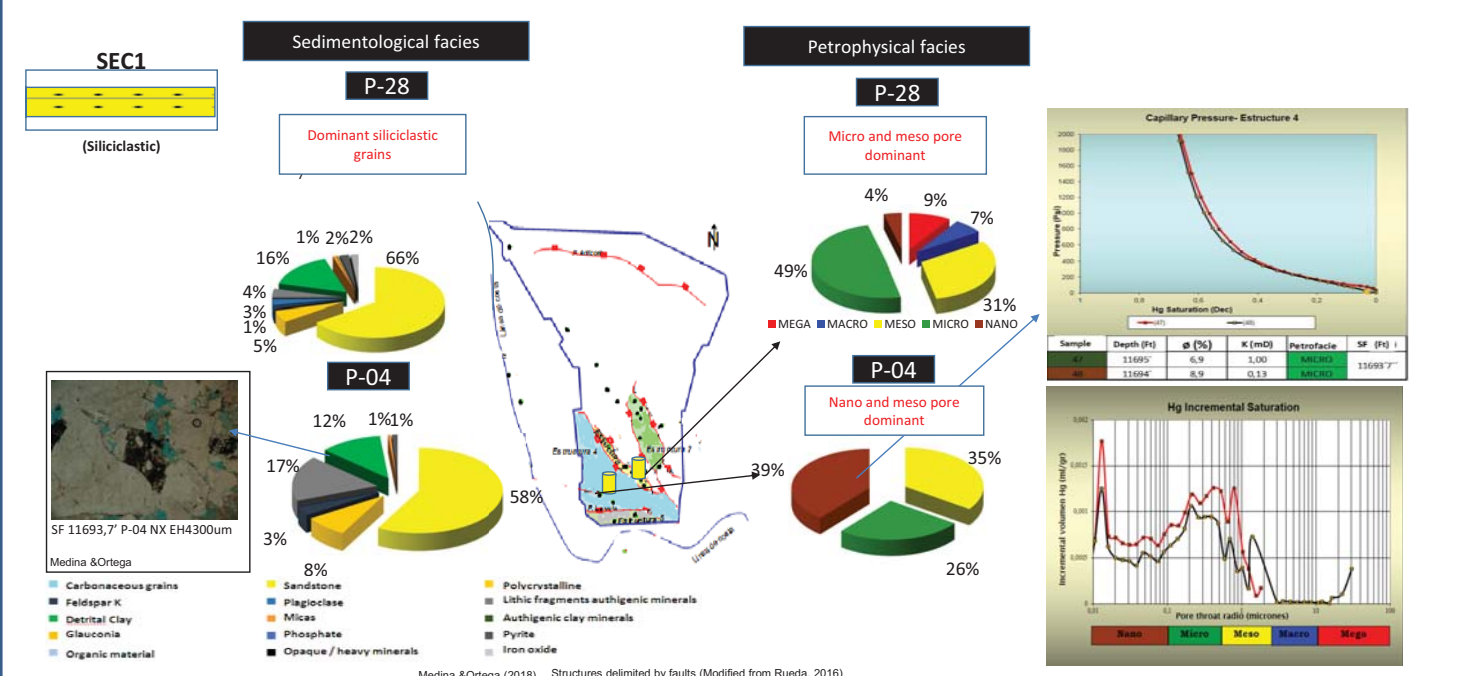
High heterogeneity required analysis by sequences

❖ What effect has the rock quality on the behavior of capillary pressure curves and the domain of petrofacies in each sequence?

SEC1 (Siliciclastic)

Sedimentological facies — P-28 · Dominant siliciclastic grains · P-04

Petrophysical facies — P-28 · Micro and meso pore dominant · P-04 · Nano and meso pore dominant

Capillary Pressure- Extructure 4

MEGA · MACRO · MESO · MICRO · NANO

SF 11693,7' P-04 NX EH440um · Medina &Ortega · Structures delimited by faults (Modified from Rueda, 2016)

SEC2-1 (Pure carbonate dominated by algae) · Mix carbonate dominated by Bivalves · Siliciclastic dominant

Sedimentological facies · Petrophysical facies · Micro pore dominant · Macro and meso pore dominant

Early cementing of calcite · SF 9512,83' P-29ST · NP EH: 4.3mm · Medina &Ortega (2018)

SEC3-2 (Carbonatic) — Pure carbonate dominated by algae · Micro pore dominant

Microporosity in the red algae controls petrofacies and microfracturing particle play an important role in the interconnection of the poral system.

SF 6486,1' P-04 · NX EH: 0.3mm · Medina &Ortega (2018)

❖ Distribution of isoproperties in the field

Cutting parameters

SEQUENCE	øC (%)	Swc (%)	VshC (%)
SC3-2	5	60	30
SC2-1	5	60	30
SC1	8	55	20

Isoproperties by sequences

SEQUENCE	Vsh_prom V/V	ø_prom
SEC3-2	0,14	0,14
SEC2-1	0,12	0,11
SEC1	0,12	0,19

Porosity model

MESO · MICRO · NANO

Conclusions

Poral system characterized by "m" allowed to calculate hydrocarbon saturation with a lower degree of uncertainty. This parameter with a value less than two is associated with porosity due to microfracture particle and the presence of authigenic minerals; these indications of secondary porosity were also evidenced from the detailed interpretation of well logs, including thin sections.

Microfracturing of particles plays an important role within the sequences, since it interconnects the poral system, which generally includes porosity intraparticle, interparticle, moldic and micro vugular, although these last two are extremely localized on specific spots. Genesis of the rock and diagenetic processes are considered to have affected the geometry and architecture of the pores, visible with the different analyzes and tests. All of them mark and impact the quality of the rock and its fluid content.

Ensenada de la Vela deposits present dominant micro pores. The capillary pressure tests by the mercury injection method constitute an alternative to obtain better results in time to characterize this type of deposits.

Sequence SEC1 in its siliciclastic deposits with an average porosity of 19% and shale volume of 12%. A large pore domain was observed between macro and mega porous, whose porosity / permeability relation was grouped within the petrophysical class 1 S1.

For the SEC2-1 sequence in its carbonate unit with an average porosity of 11% and clayness of 14%. A domain of micro pores was obtained in the petrophysical facies controlled by the carbonate producing component of planktonic / benthic foraminifera, bivalves and red algae which in turn demarcate the porosity / permeability relationship as class 1 S2.

For sequence SEC3-2, the dominant unit is carbonatic with an average porosity of 14% and 14% of arcillosity are counted, there is a microporosity domain. This implies associating in the porosity / permeability relation to the petrophysical class 3, whose the main carbonate components are red algae and macrophylaminifera.

With the methodology implemented in this study, it is possible to obtain more realistic petrophysical values of shale, porosity and water saturation, which make it possible to determine the thicknesses of sand and gross oil limestone to have a better exploitation of the field.

Suggestions for Further Reading
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