Oil from Granitoid Rocks - Reservoir Characterization of Fractured Basement in Neuquén Basin, Octógono Field, Argentina*

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Search and Discovery Article #20280 (2014)**
Posted November 24, 2014

*Adapted from oral presentation given at AAPG International Conference & Exhibition, Istanbul, Turkey, September 14-17, 2014

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Abstract

Located in Argentina, the Paleozoic basement in the Octógono Field, Huechulafquen Formation, consists of granitoid rocks underlying Los Molles shale which is the seal and one of the source rocks together with the Vaca Muerta Formation. The field was discovered in 1918 and produced from shallow reservoirs. Development activity in the basement is a recent upside. The main tectonic pillar was formed in the Early Jurassic. After rifting, sedimentary units of the Cuyo Group were deposited on the basement in hemi-grabens, later elevated during tectonic inversion during the Upper Jurassic. The structure was already formed when hydrocarbon migration started. All permeability and storage had been originated from fracturing and alteration. Fracturing is the result of tectonic processes that raised the basement more than 1000 m above the surrounding rocks. These occurred before the initial stages of the basin and several reactivations took place.

Six alteration zones corresponding to the differential weathering can be correlated based on 3D seismic and well logs. Resistivity is affected by iron content; also, due to the low matrix porosity, small variations in the mineralogy strongly affect indirect storage estimations. Resistivity, NMR and acoustic logs allow deriving an estimation of total fluid as well as storage and permeability indicators. A fracture intensity index can be obtained from picking of open discontinuities. NMR allows the characterization of total pore space, in addition to the interpretation of fluids by the analysis of diffusion maps and comparison

of T2 spectra. A permeability indicator is based in the reduction of velocity and amplitude of the Stoneley wave in presence of mobile fluids, a function of mobility that can be seen as a coupling into a formation wave known as a slow wave. The reservoir is described by partition coefficient and classifies as type BA (35% of storage in macrofractures). The recovery factor is estimated at 25% considering expansion of a 300 m thick gas cap. The oil leg is 450 m thick, down to the depth of chaotic seismic reflectors typical of unaltered basement. Faults at seismic resolution and each of the alteration zones are mapped in detail. The integration of the processed information into a 3D model allows identifying regions where storage capacity is higher. Mapping of fracture intensity helps to orientate the development to sectors where flow capacity is higher, thus optimizing EUR.

References Cited

Aguilera, R., 1999, Recovery Factors and Reserves in Naturally Fractured Reservoirs: Journal of Canadian Petroleum Technology, Distinguished Authors Series, v. 38/7. doi.org/10.2118/99-07-DA.

Coalson, E.B., D. J. Hartmann, and J.B. Thomas, 1985, Productive characteristics of common reservoir porosity types: Bulletin of the South Texas Geological Society, (February 1985) v. 25/6.

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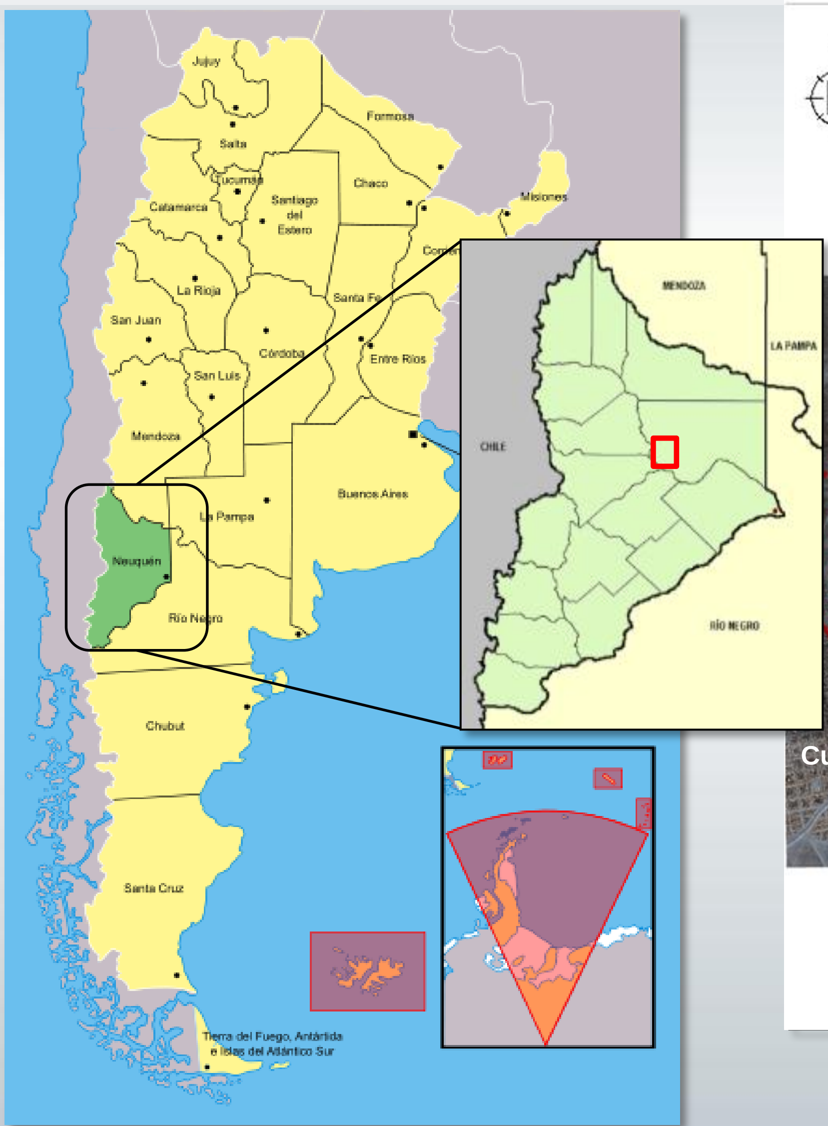
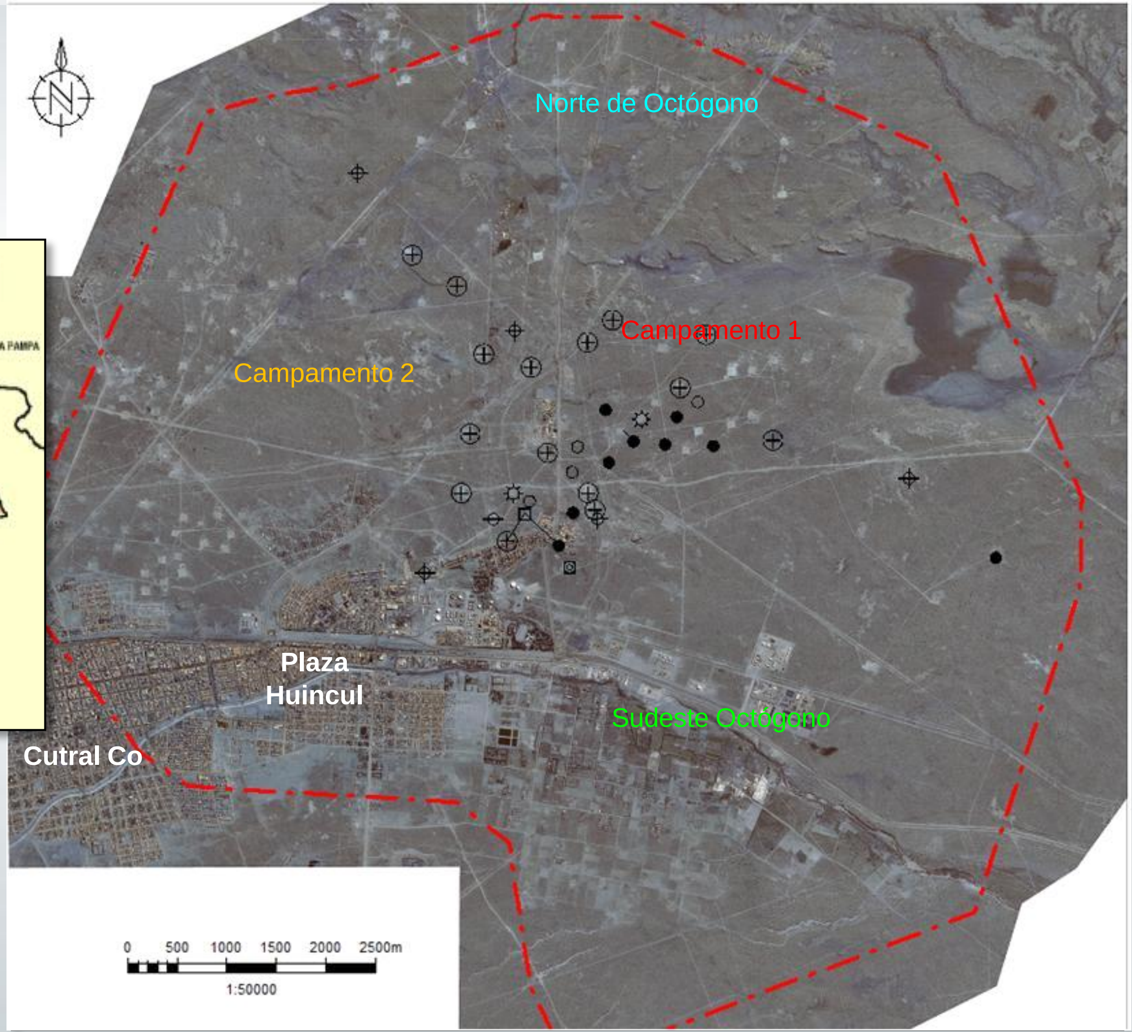
September 2014. AAPG ICE, Istanbul

Objectives

- Reservoir characterization of Huechulafquen Formación (Basement).
- To analyze opportunities in not yet exploited resources in a mature field with just a marginal production.
- Incorporation of the naturally fractured Paleozoic Basement as main objective for development, project conceptualization and execution.
- To explain production behavior from the geological model.

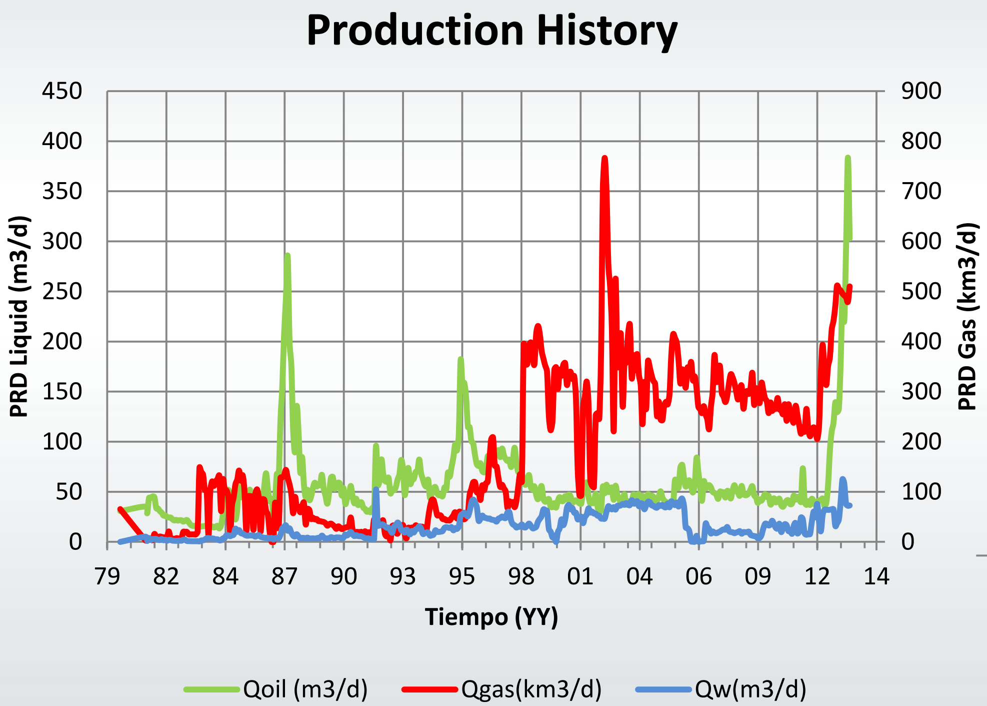
Peri-urban location

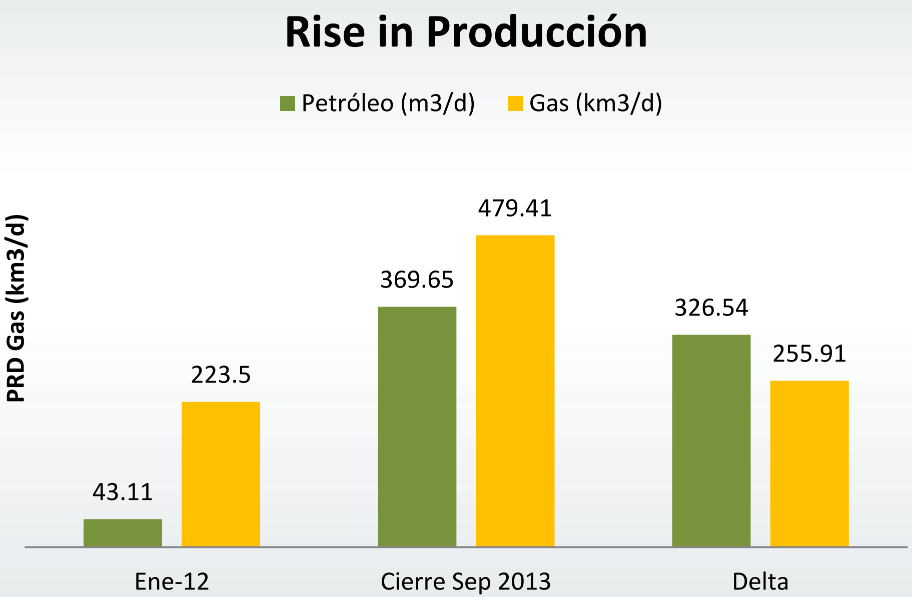




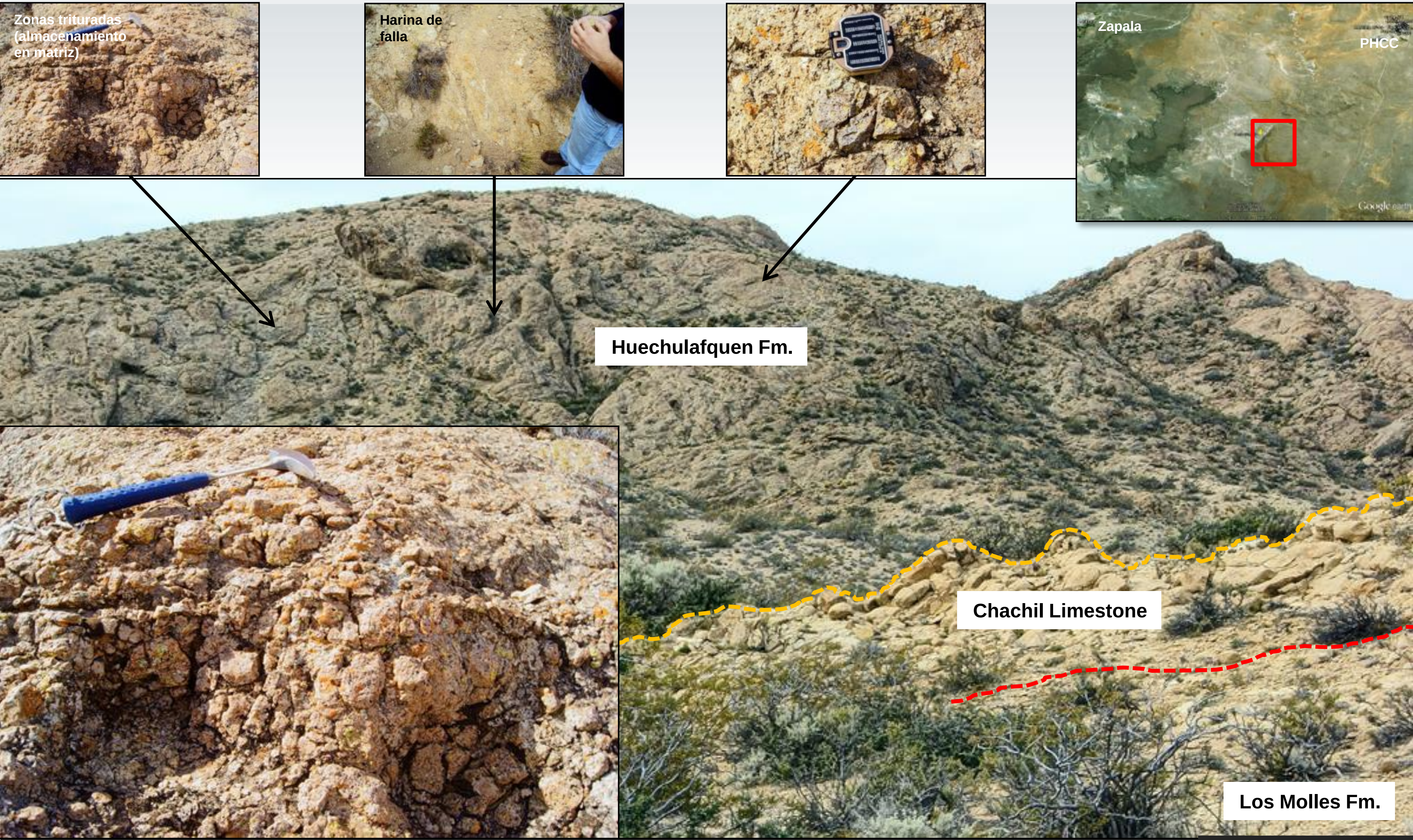
- Campamento 1, was discovered in 1918, main development was in the 1950s decade.

Production / Operative



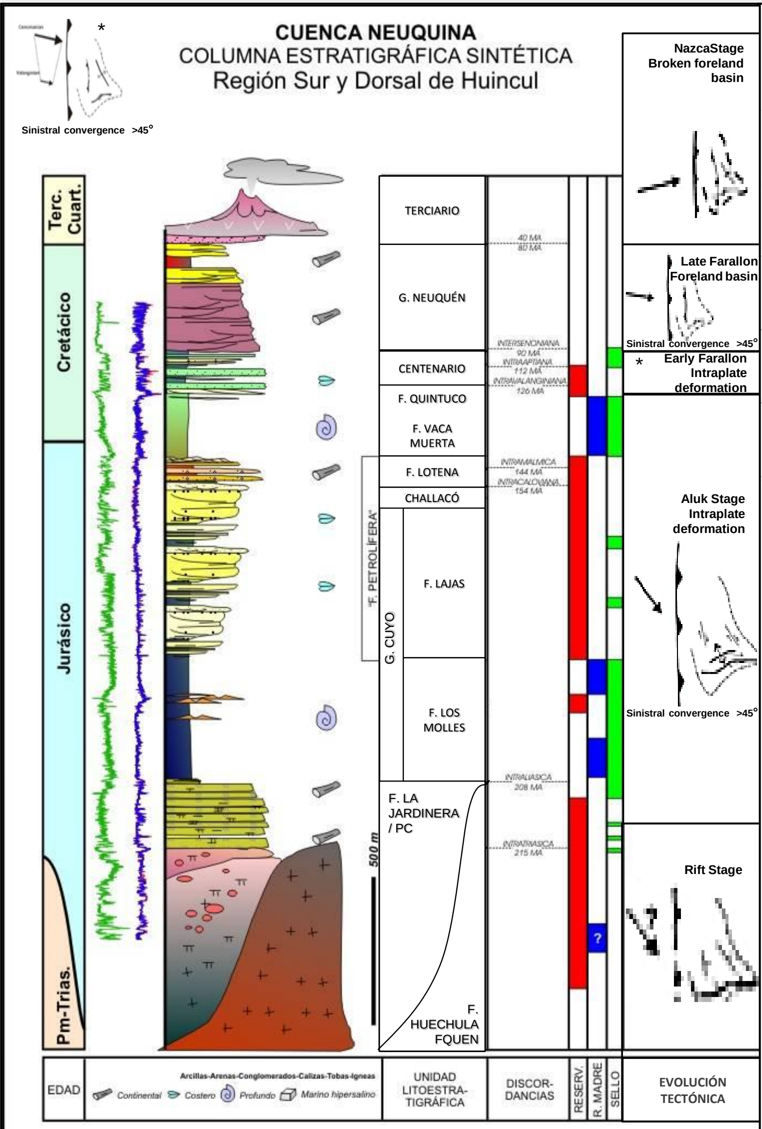


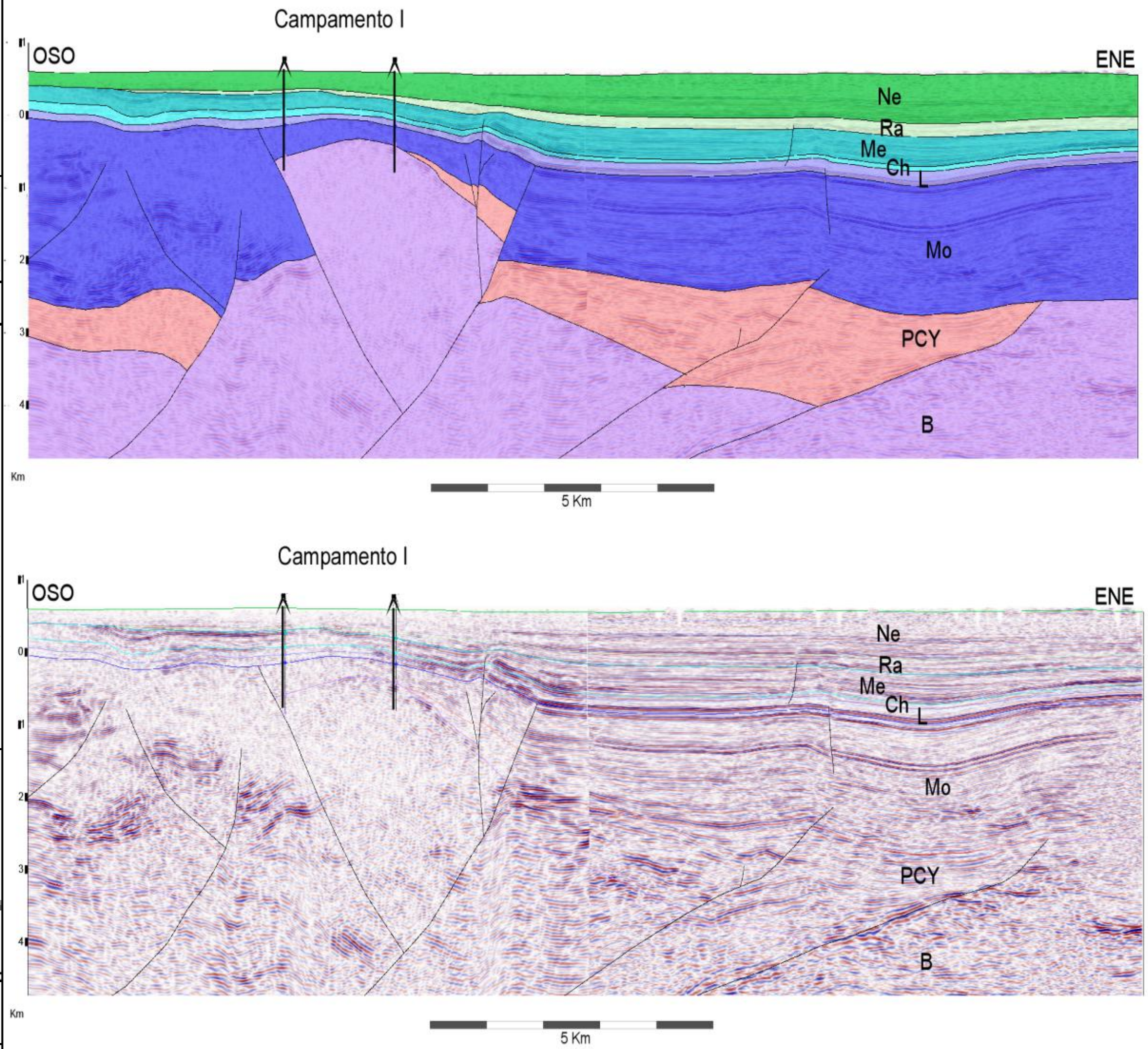
- 50 wells, 29 of them during the 2012/14 campaign.



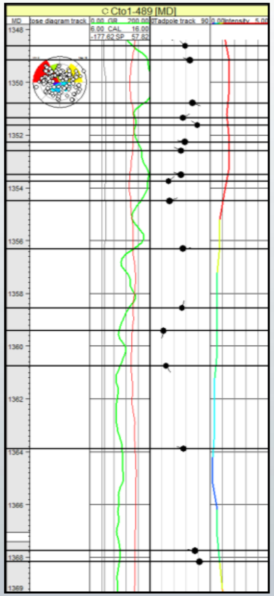
Outcrop analogue 30 Km away in the Cerro Granito.

Stratigraphic column / Structure

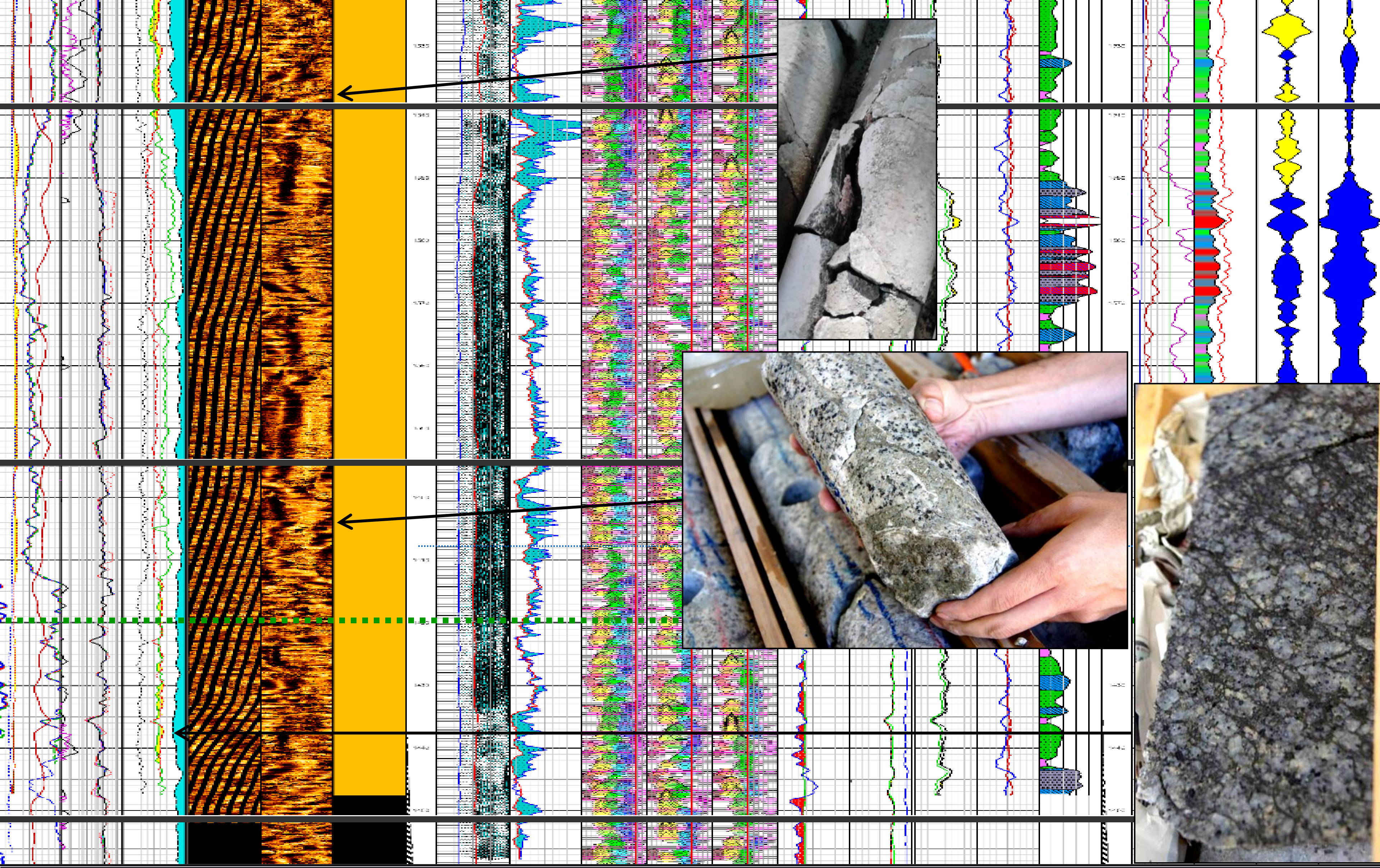




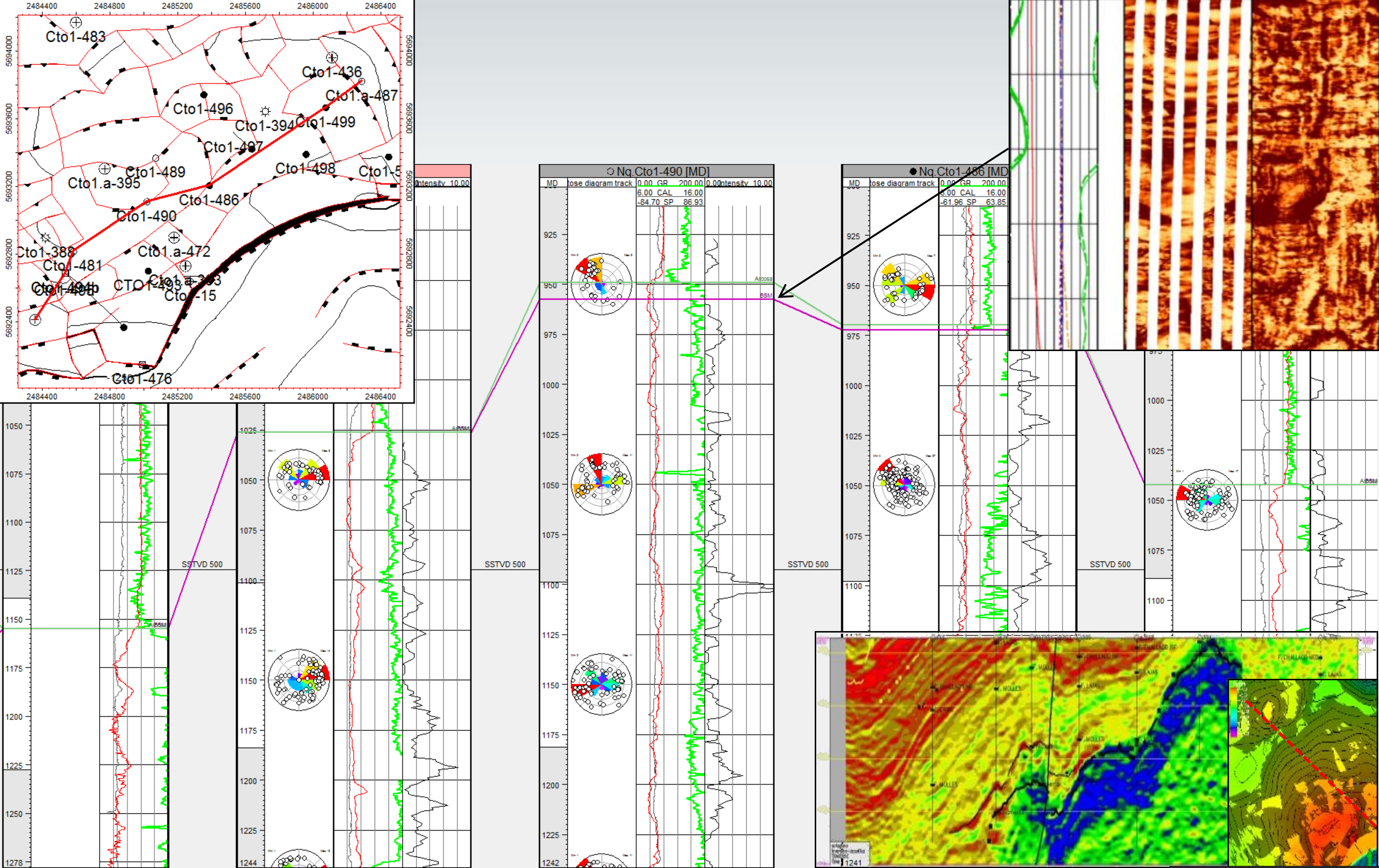
- Sedimentary Mesozoic sediments (Los Molles shale) directly above and hemigrabens – Tectonic inversion by oblique convergence, reactivation of extension faults during Toarcian.



The basement in rock cores. Left: fractured reservoir, right: unaltered granodiorite

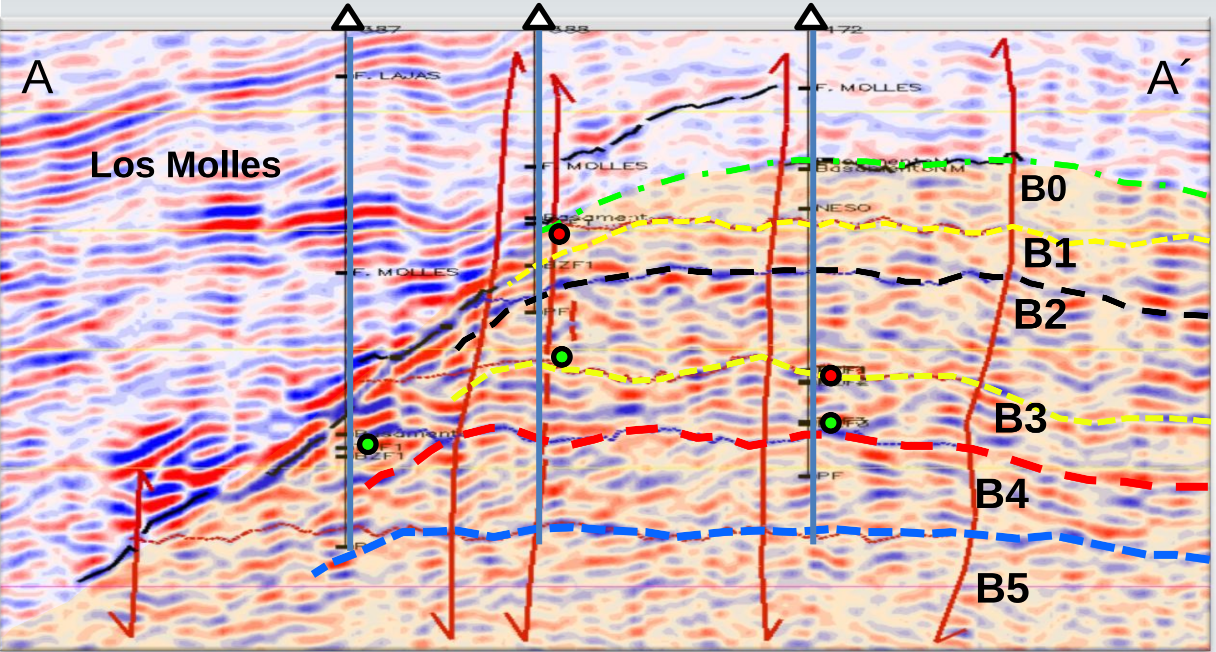


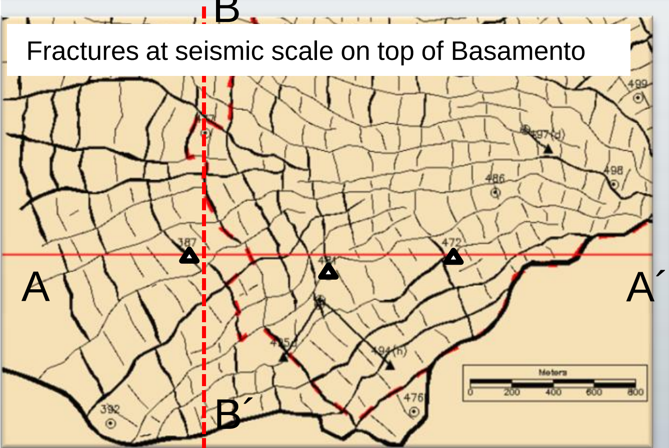
- (pseudo) matrix porosity and fracture porosity

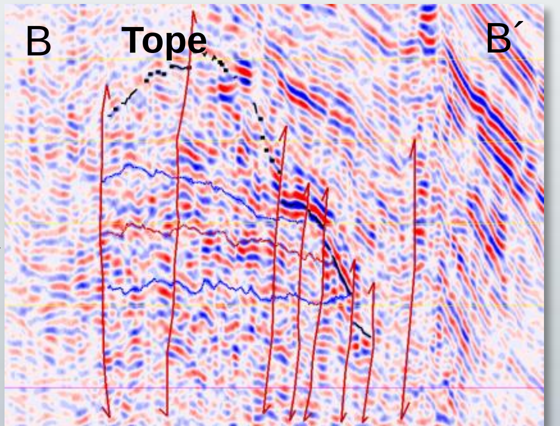


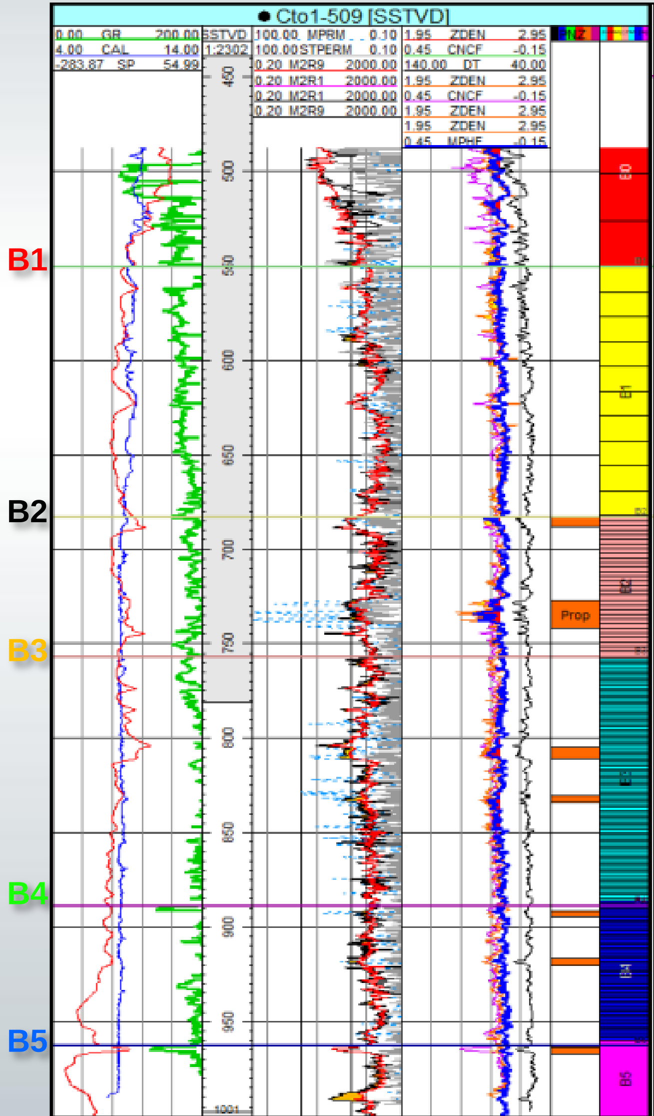
■ Arcose levels dated Toarcian, source from the Basement, deposited in structural lows

Seismic features in Basamento



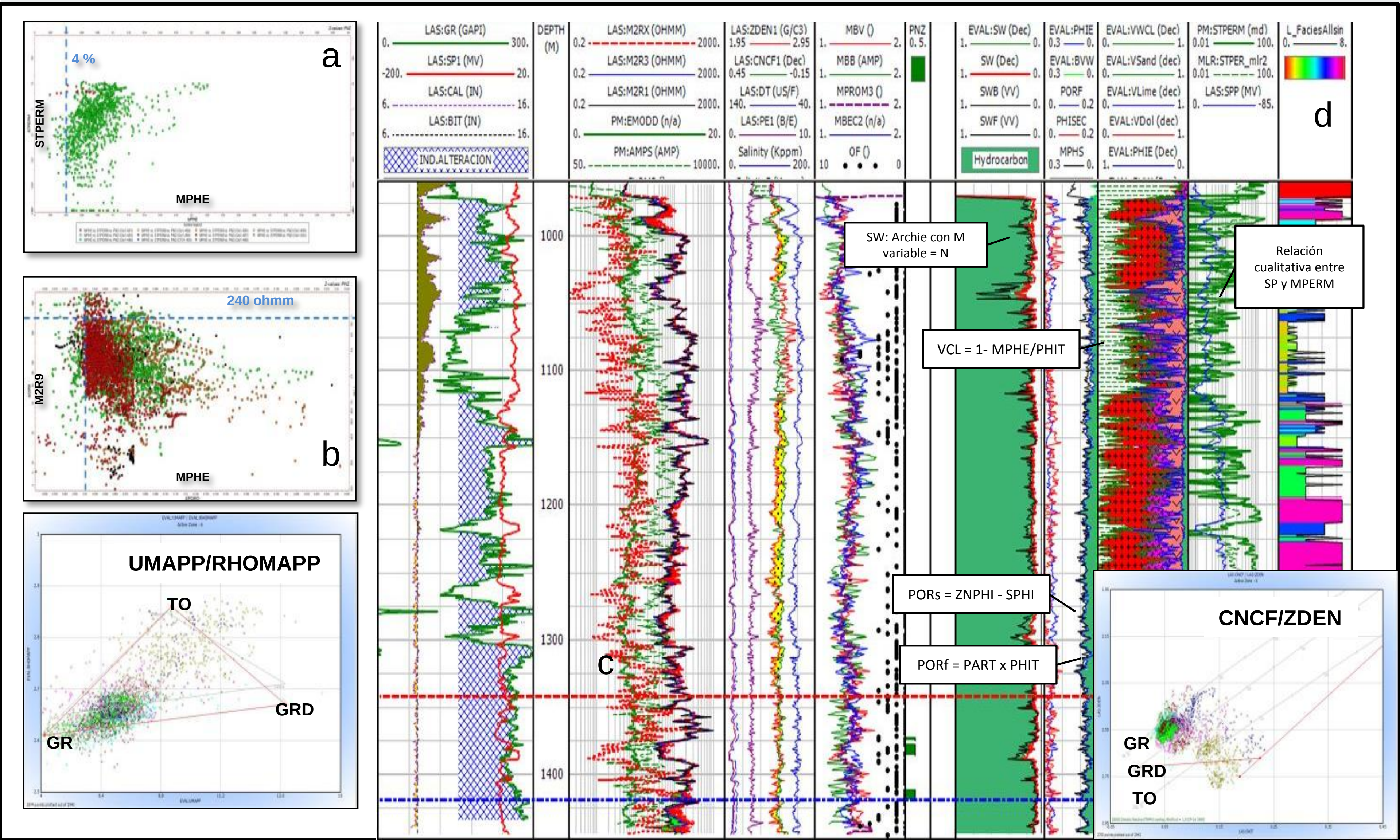






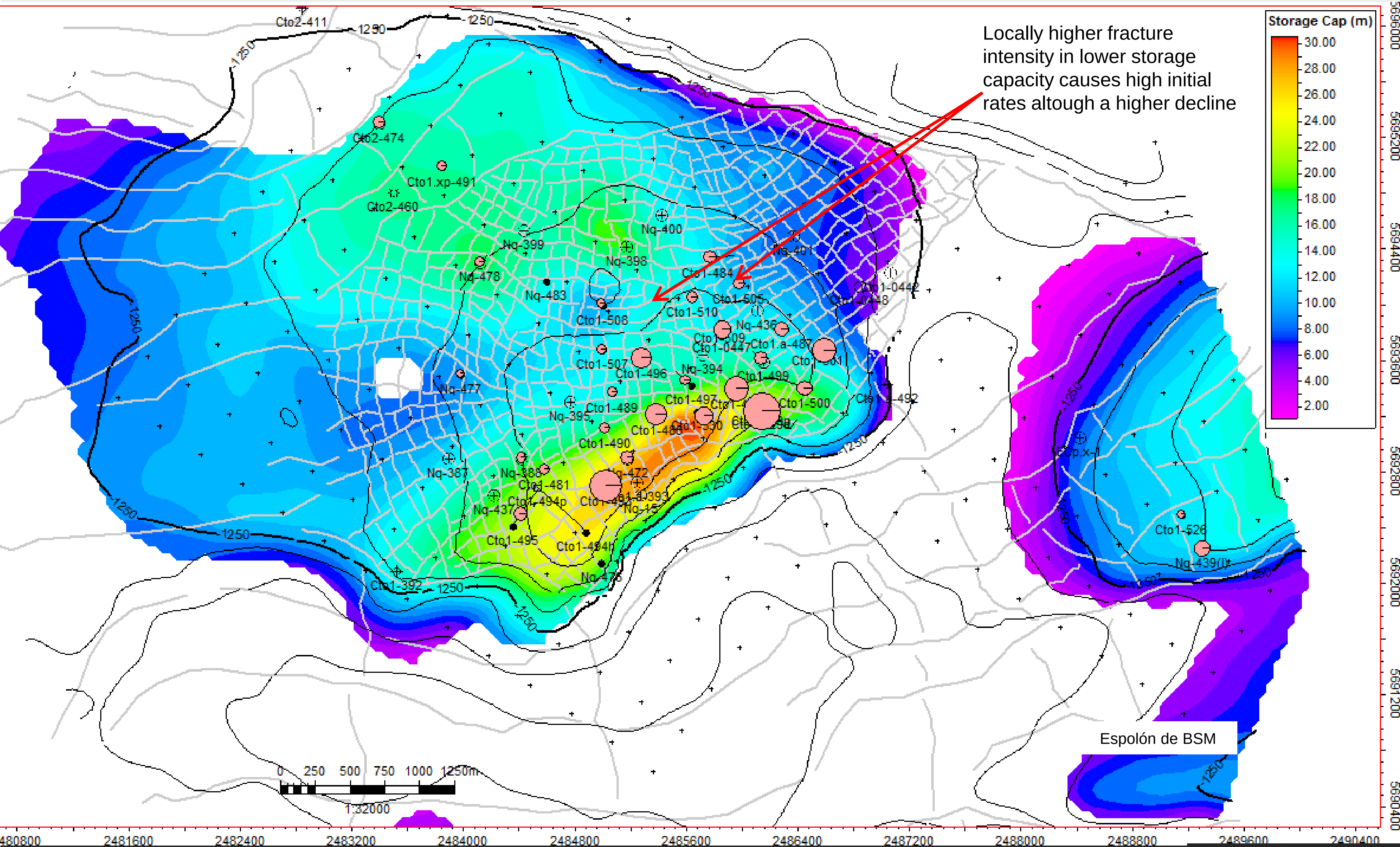
- Seismic features, correlation zones, expression in well logs. Gas cap up to 300 m thick placed in B0 and B1, there is some compartimentalization due to acid dykes as recognized in the Cerro Granito

Evaluation by variable m = n and some crossplots



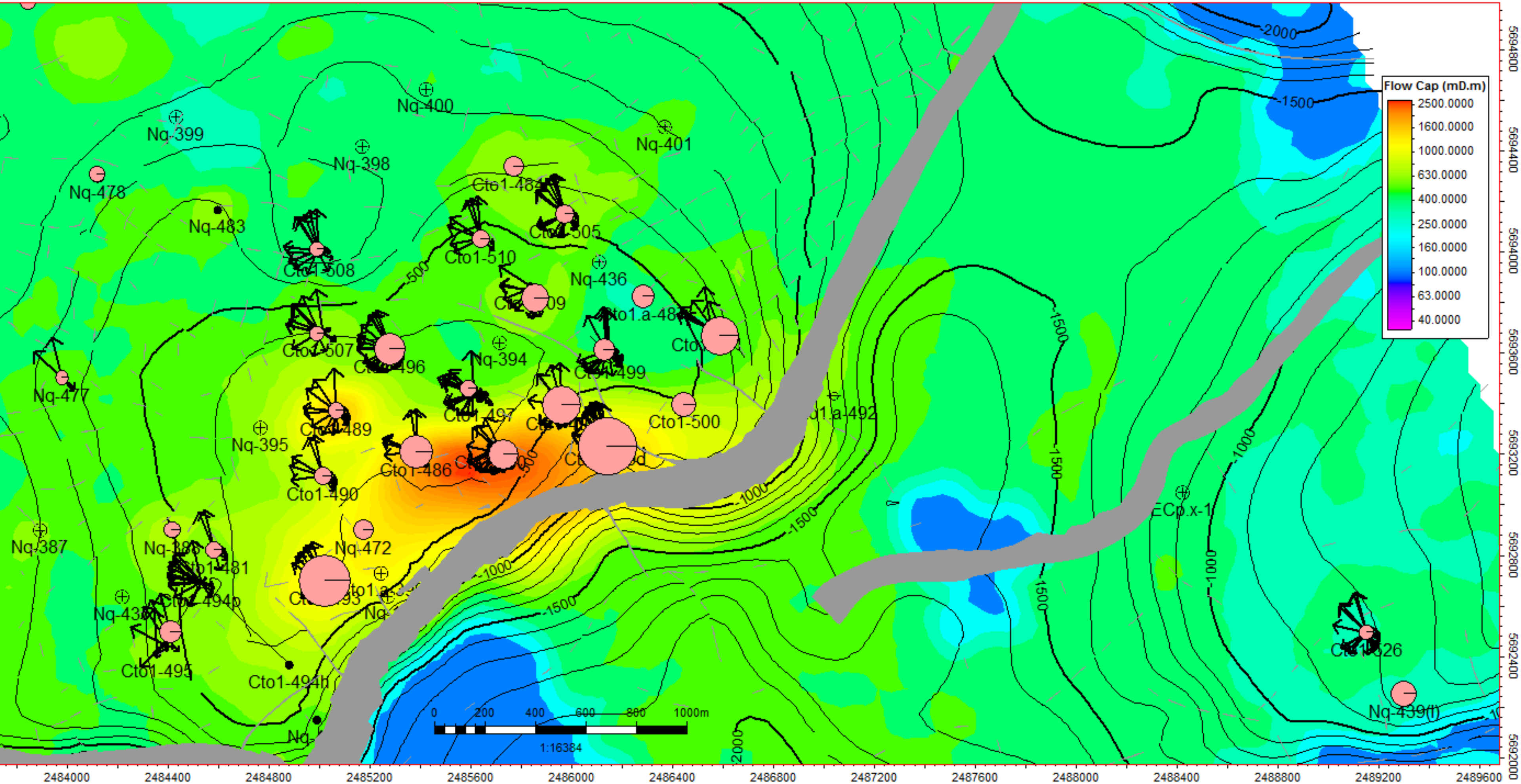
- Variable m: arithmetic average between rescaled EMOD and S amplitude, and the relation of –Log (RT) / log PHIT

Storage Capacity (MPHE x h)



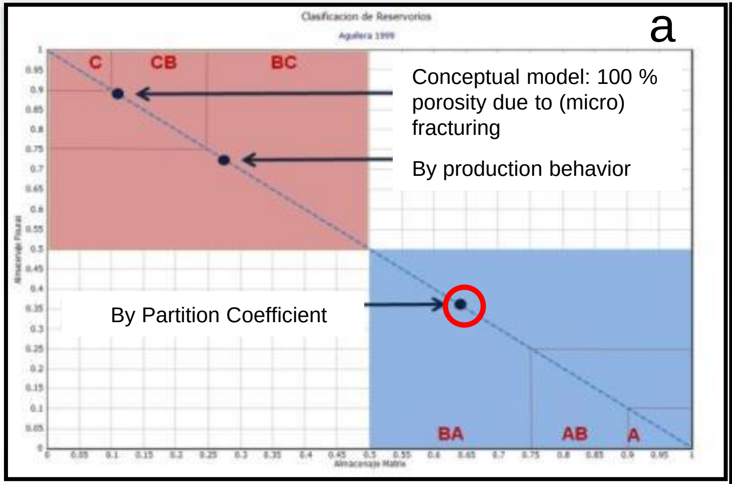
Storage Capacity (MPHE x h) given by matrix porosity due to micro-fracturing as the main property as a key to productivity

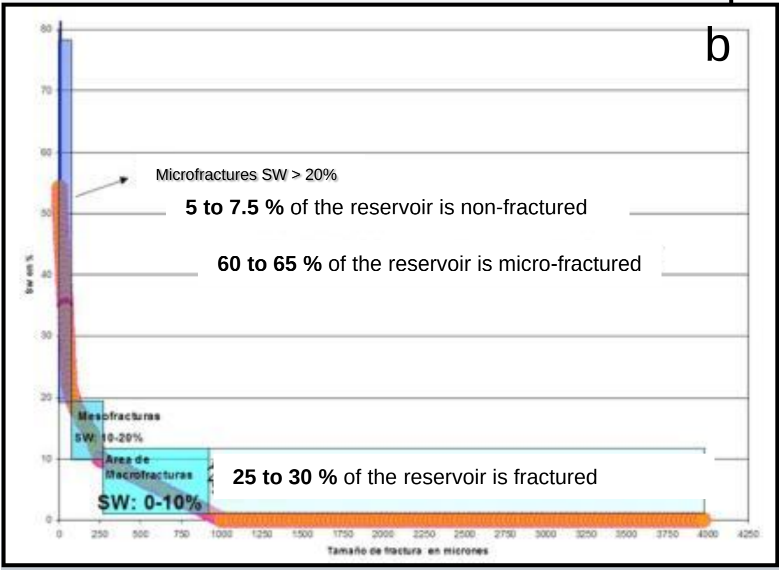
Flow Capacity (STPERM x h)

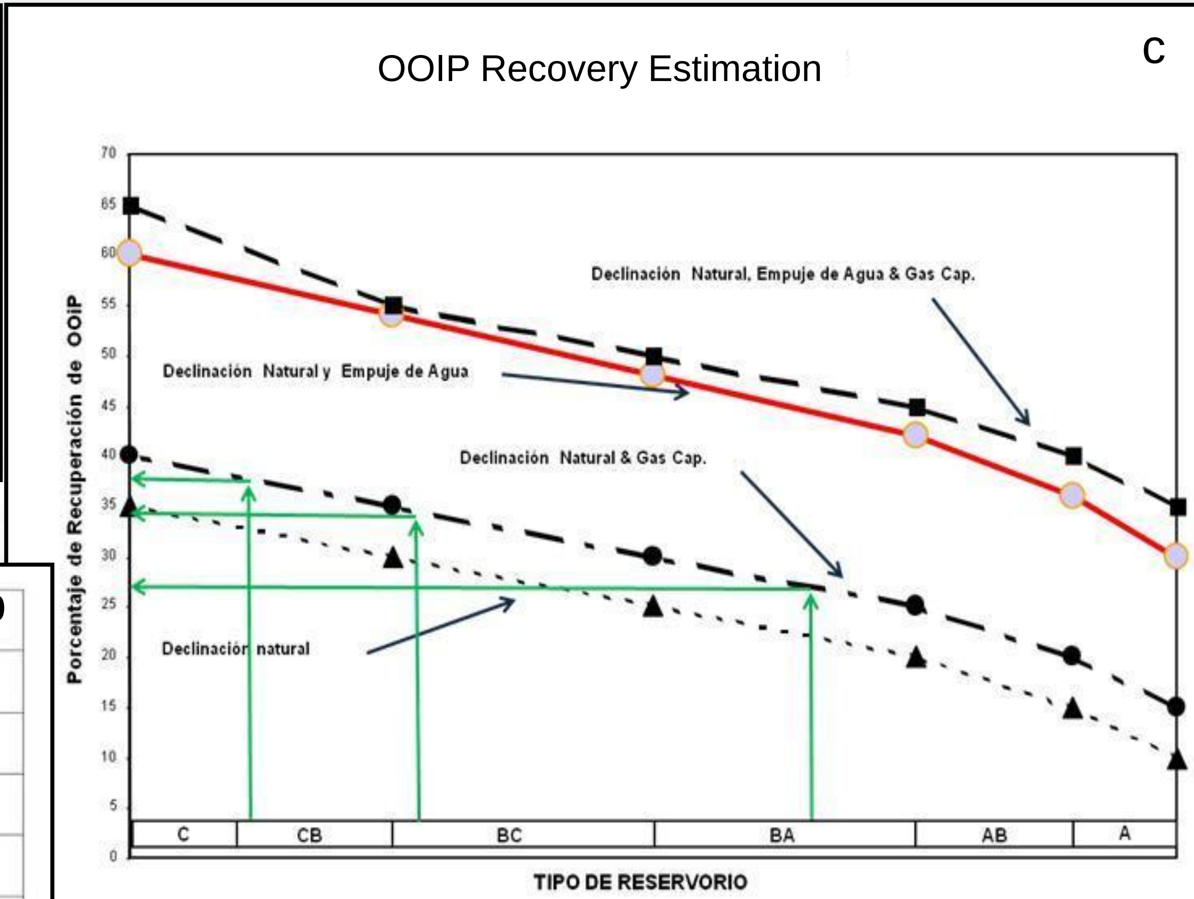


Flow Capacity (SPERM x h), also dip azimuth indicator, its relation with Qoi

Preliminary analysis and reservoir type







a and b) modified from ***Aguilera***, Roberto, **1999**: "Recovery Factors and Reserves in Naturally Fractured Reservoirs", Journal of Canadian Petroleum Technology, Distinguished Authors Series, July 1999, volume 38, no. 7

.b) adapted from ***Coalson***, E. B., D. J. ***Hartmann***, y J. B. ***Thomas***, **1985**, Productive characteristics of common reservoir porosity types: Bulletin of the South Texas Geological Society, v. 25, no. 6

- Reservoir type BA 65 % of storage in matrix. Recovery factor estimated in 25 % after natural declino and gas cap expansion. SW = 10 to 20 in microfractures.

Conclusions

- 5 correlation zones are recognized based on differences in seismic features.

- The presence of wide acid dykes would cause compartmentalization as recognized by differences in the GOC.

- The key property in order to explain reservoir behavior and potential (within original pressure) is Storage Capacity (MPHE x h)

- Macrofractures may increase Flow Capacity (STPERM x h) in regions where MPHE x h is low.

- Higher storage is due to matrix porosity caused by intense micro-fracturing