LASI VI

Neuquén Basin

The Physical Geology of Subvolcanic Systems – Laccoliths, Sills and Dykes

Malargüe, Argentina – November 25-29, 2019

ABSTRACTS

Cover photographs

Top: andesitic sills (brown cliffs) emplaced in organic-rich shale, El Manzano, Mendoza, Argentina (O. Galland)

Bottom: oil pump of the Río Grande Valley oil field, Mendoza, Argentina (O. Galland)

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Edited by
Olivier Galland, José Mescua, Octavio Palma

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An Exploratory History of Igneous Reservoirs in the Rio Grande Valley, Malargüe, Argentina

Rébori L.[1], Rapela C.[2], Fantín J.[3] and Medialdea A.[4]

[1] *Searcher Seismic, Argentina* – l.rebori@searcherseismic.com
[2] *CIG-UNLP, Diagonal 113 No. 275, La Plata, Buenos Aires -Argentina*
[3] *YPF , Av. España 955, Capital. Mendoza, Argentina*
[4] *YPF , Jorge Newbery s/n., Malargüe, Mendoza - Argentina*

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The association of igneous rocks with oil seeps has been identified in Argentina since early Spanish colonial times (Yrigoyen, 2007), in the Mendoza province sector of the Neuquén Basin: "Cerro Alquitrán (Mina Los Buitres)" and "Cerro La Brea (Arroyo Las Aucas area)" in San Rafael county and "Cerro Bayo de los Coyihuales (near the Zampal) and "Mina Theys" in Malargüe county.

Also, the teams of YPF - Field Geological Commissions described the potential of the igneous rocks of the El Molle Fm in the Rio Grande Valley as unconventional reservoirs as early as the 1970s, (Bettini – Vasquez, 1978/79).

Although by the late 1970's there was already a history of wells with productive levels of igneous rocks (El Manzano x-1; The Volcanoes is-1), the discovery of unconventional igneous reservoirs in the Rio Grande Valley did not occur until 1980 with the discovery of the Rio Grande field. The well proposal, led by Fernando Bettini, was made based on 2D seismic data and the location of the exploratory wells were based on a structural high, which turned out to be an andesite laccolith. The 2D seismic data quality of the time was insufficient to image and differentiate these igneous bodies.

At that time, a specific operational methodology was developed by the Well Site geologists of the Mendoza Geological Exploration Department of YPF to evaluate these unique reservoirs. Specific mud logging control procedures were developed to ensure consistency both within the company and when the service was outsourced.

While drilling, special attention was paid to the observation of cuttings, bit rate penetration, total gas detection, core samples, drill stem tests and log analysis.

a) **Observation of drilling cuttings** were made using a binocular magnifying glass (10 to 40 X), In addition to recognizing the lithology, the emphasis was oriented to the presence of oil and the appearance of singular details such as vugs, fissures and filling minerals like calcite. The methodology was published early in the work of (García et al, 1982) and form part of this work.

b) Bit rate of penetration was used to identify indications of fractured areas.

c)Total Gas continuous detection was monitored, and it was found that no significant changes were ever observed between the reservoir and the country rock (shales of the Agrio and Vaca Muerta formations). In fact, often the background value of the shales was higher than in the sills, Fig.1.

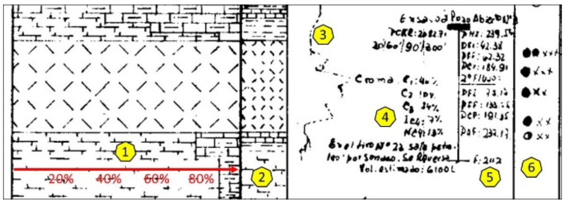

Fig. 1 – Strip-log of one of the discoverer well, showing percentage (1) and interpreted lithology (2), Total Gas (3) curve; chromatographic data (4), data from DST (5) and oil shows (6).

d) Core Samples played a very important role from both a qualitative and quantitative point of view. Cores were used for calibration of the petrophysical evaluation, and for detailed evaluation of the reservoir properties and nature of the porosity and permeability. The presence of pores and micropores (Fig. 2) was analyzed, with many of them found to be filled by biotite (García et al (op cit)).

e) Drill Stem Tests (DSTs) were essential in determining the fundamental characteristics of the reservoir, including the flow rates, formation pressures and fluids contained. DSTs were also a fundamental tool used for the selection of the stimulation method.

Thus, empirically three (3) types of responses were determined:

1) Good flow rates and high closing pressures, corresponding to wells that were naturally flowing. This happened with bodies intruding the Agrio Fm.

2) Regular to poor flow rates with high pressures of rapid recovery. In these cases, it was determined the need to stimulate the well, acidifying first and then performing a hydraulic fracturing operation with sand proppant. This was the case of

the intrusives of the Vaca Muerta Fm in the Los Cavaos field.

3) Low flow rates and low pressures. These levels were determined to be unproductive (García et al (op cit)).

f) Quicklook Log Analysis was performed, and the unique response of the different logs was verified when crossing the intrusive bodies. Low GR values indicated basic composition, high resistivity was observed in the igneous bodies and the inverse, high conductivity was observed in the contacts, due to the presence of sulfide minerals. It was also proven that these intrusive bodies would not erode any part of the sedimentary column, but rather they exert an effect similar to that of a hydraulic device. This effect is discussed in more detail in García et al (op cit).

Shortly after the core were obtained, they were sampled as well as several outcrops to try to define the rocks petrographically and to understand the mechanisms of emplacement. A total of 69 rock samples were taken, 37 from 10 wells and the rest (32) from 17 outcrops (Fig. 2.) These samples were sent to the Exploration Laboratory of YPF in Florencio Varela (province of Buenos Aires). Then these samples were delivered to the Faculty of Natural Sciences and Museum of the National University of La Plata. There Dr. Carlos W. Rapela and his team studied them and created a report, which is still unpublished.

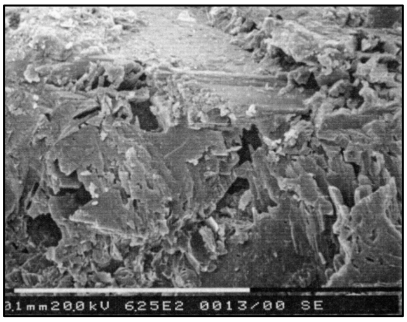

Fig. 2 - SEM Image showing micro and cryptpores with poor connections, "Los Volcanes" field.

There were six main rock types recognized petrographically (Rapela, 1982). They were as follows;

a) Augitic andesites.
b) Andesitic porphyries and hornblendic - augitic andesites.
c) Polymaphytic andesites and basalts.
d) Hypersthenic andesites
e) Leucoandelacites.
f) Olivinic basalts.

The most important conclusions were that the samples of wells corresponding to Río Grande, Loma Atravesada, Los Volcanes, Buta Relvún, Cerro Divisadero, and Sierra Azul Sur, are characterized as being andesites and occasional basalts with augite, hornblende, biotite and altered olivine, which allows characterization of these rocks as belonging to the same igneous event.

No obvious correlation is observed between well samples and outcrop samples, the only similarities observed were between the samples of Agua Botada wells and Bayo de la Batra outcrops, composed of andesite and augitytic-hornblendic porphyries, and surface samples of Cerro Tronquimalal of equal composition.

Fig. 3 – –Augitic Andesite from "Barda de Chachao".

A unique occurrence is observed in the lime mudstone of the Sierra Azul well, which corresponds to a sparite with prehnite rosettes (confirmed by X-ray diffraction) and as sulfide has been recognized as pyrrhotite possibly linked to hydrothermal activity produced by layer filons housed in limestones.

Geochemical studies of the oils that produced the fields of the Rio Grande Valley were also initiated during 1982, almost simultaneously with the geological characterization of the intrusive reservoirs as described above.

Acknowledgements

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