Cyclic Injection of Production Gas in Provincia Field*

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Abstract

This presentation discusses the cyclic injection of production gas, which took advantage of the installed infrastructure of the gas lift system and the availability of production gas in the Provincia Field. It was performed initially in five wells, which produced good results and allowed for it to be applied in fifteen wells, though it is important to clarify that the fifteen wells had no barrels of production because they were inactive wells.

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CYCLIC INJECTION OF PRODUCTION GAS IN PROVINCIA FIELD

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CYCLIC INJECTION OF FLUIDS

The cyclic injection of fluids (Solvents, Production gas, Nitrogen or Flue Gas) is an oil recovery process, or stimulation, that consists of injecting certain volume of fluid in a producing well, then closing the well for a period of time (Soak Phase) to allow the phases reach equilibrium in the formation, and after that time the well is open again to initiate the production period.

CYCLIC INJECTION OF FLUIDS

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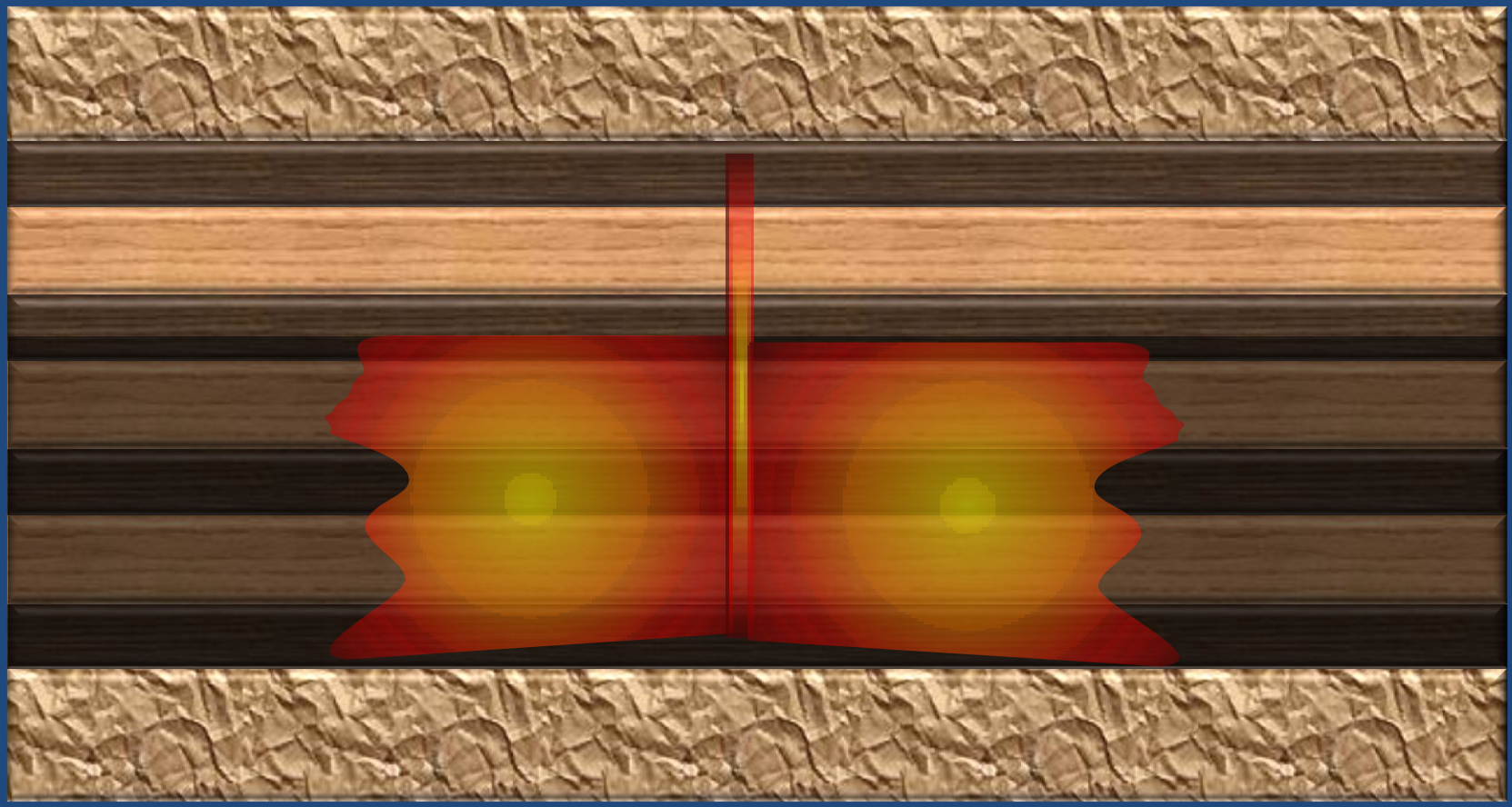

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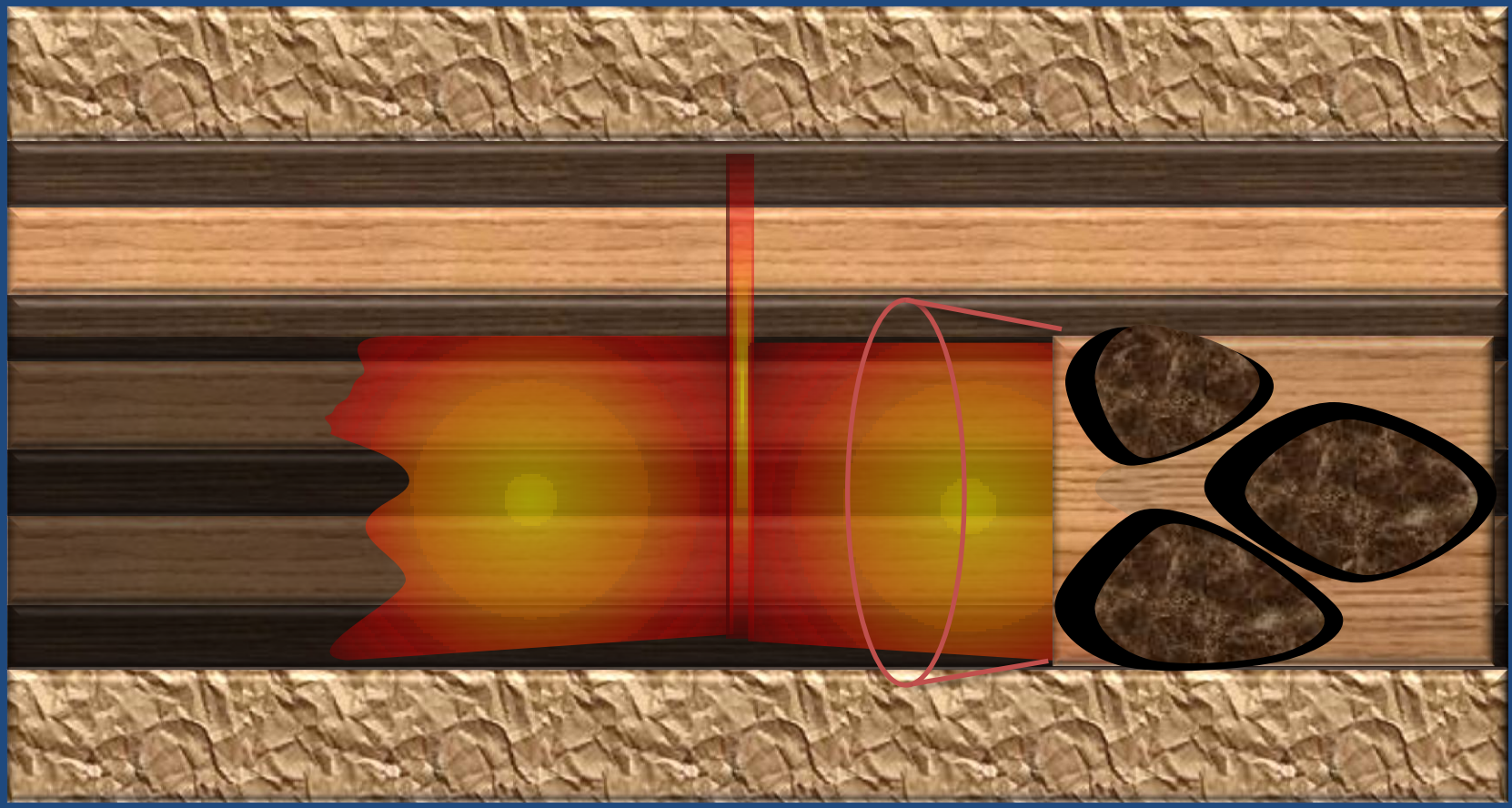

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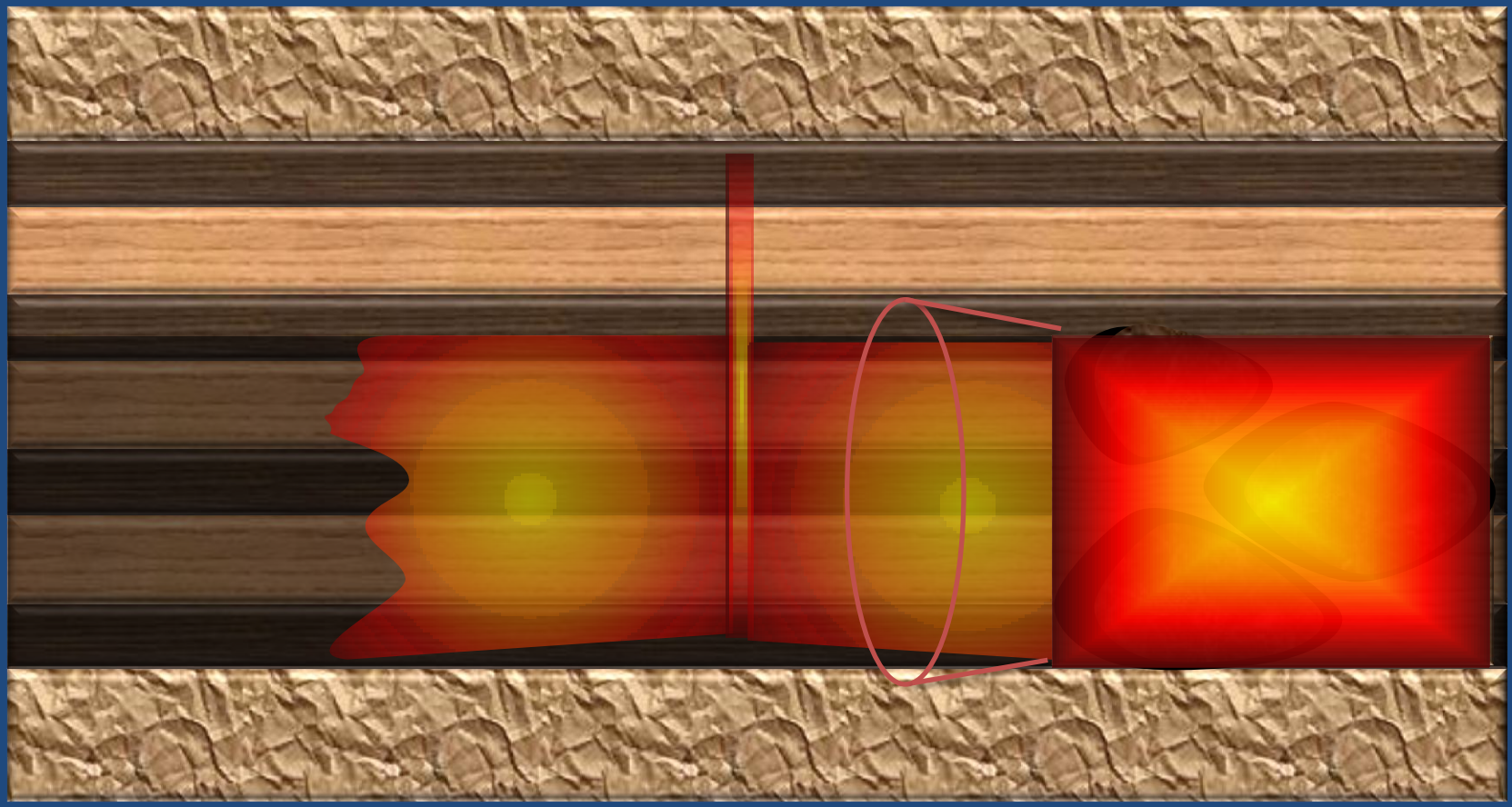

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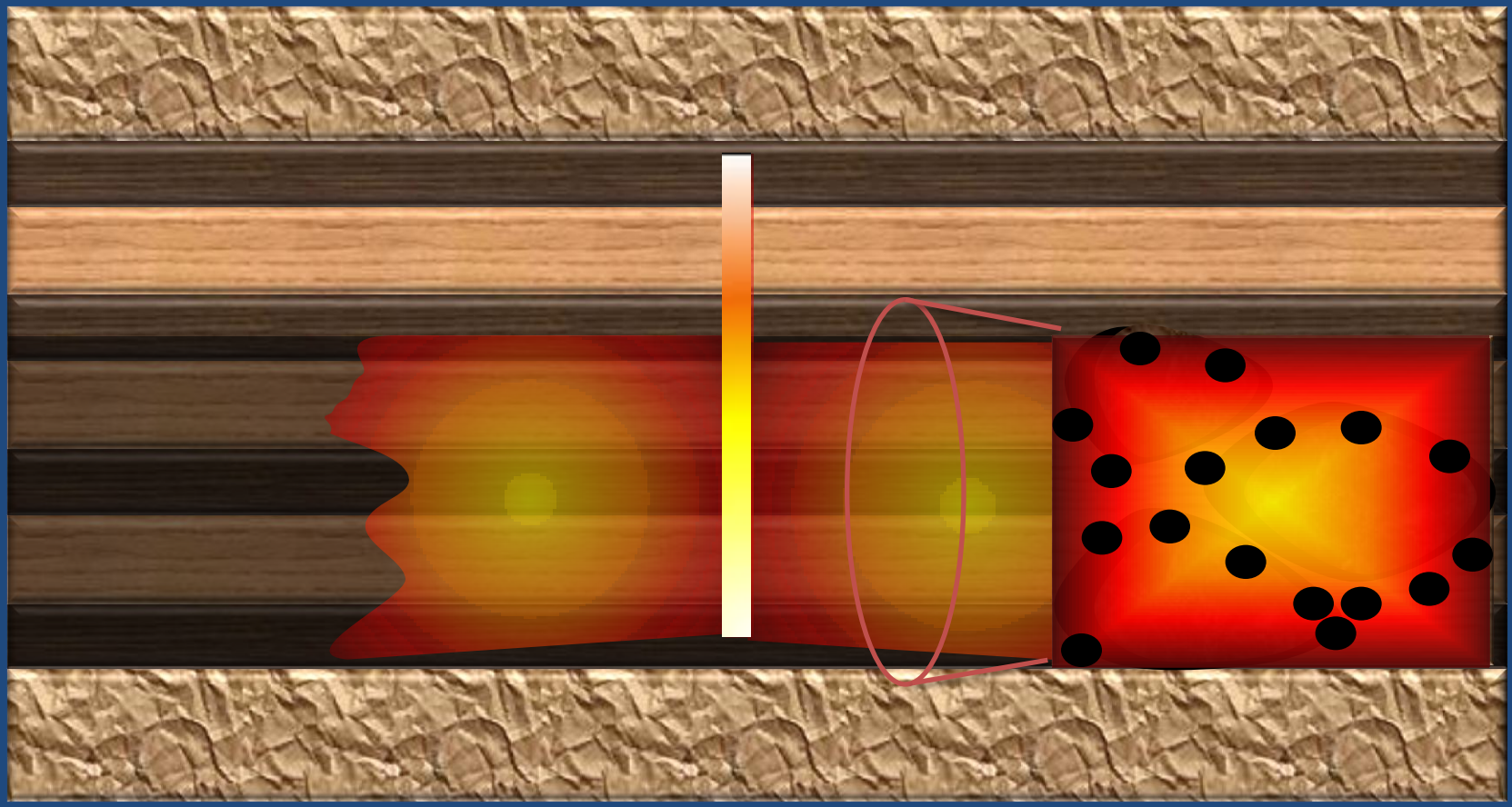
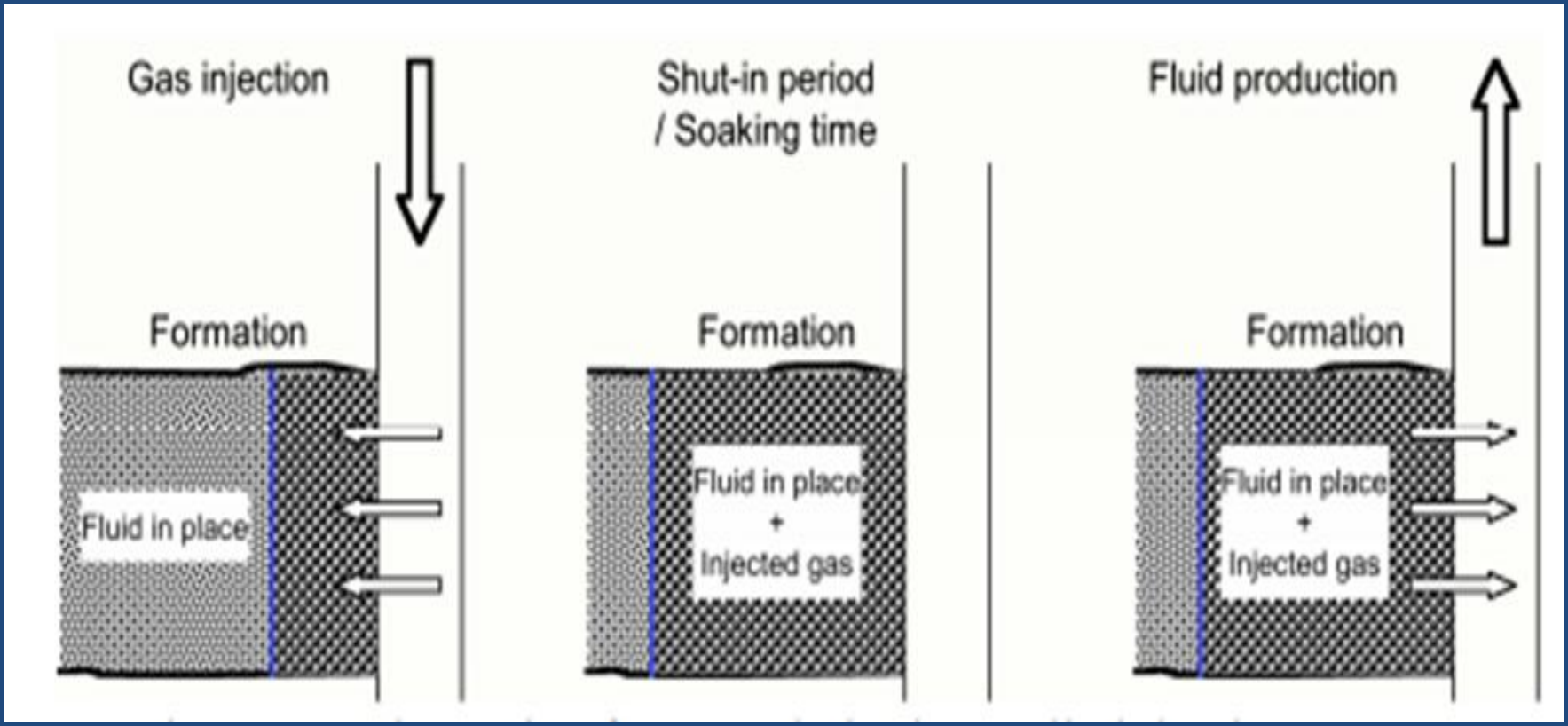


Schematic of One Cycle in the Cycle Injection Process



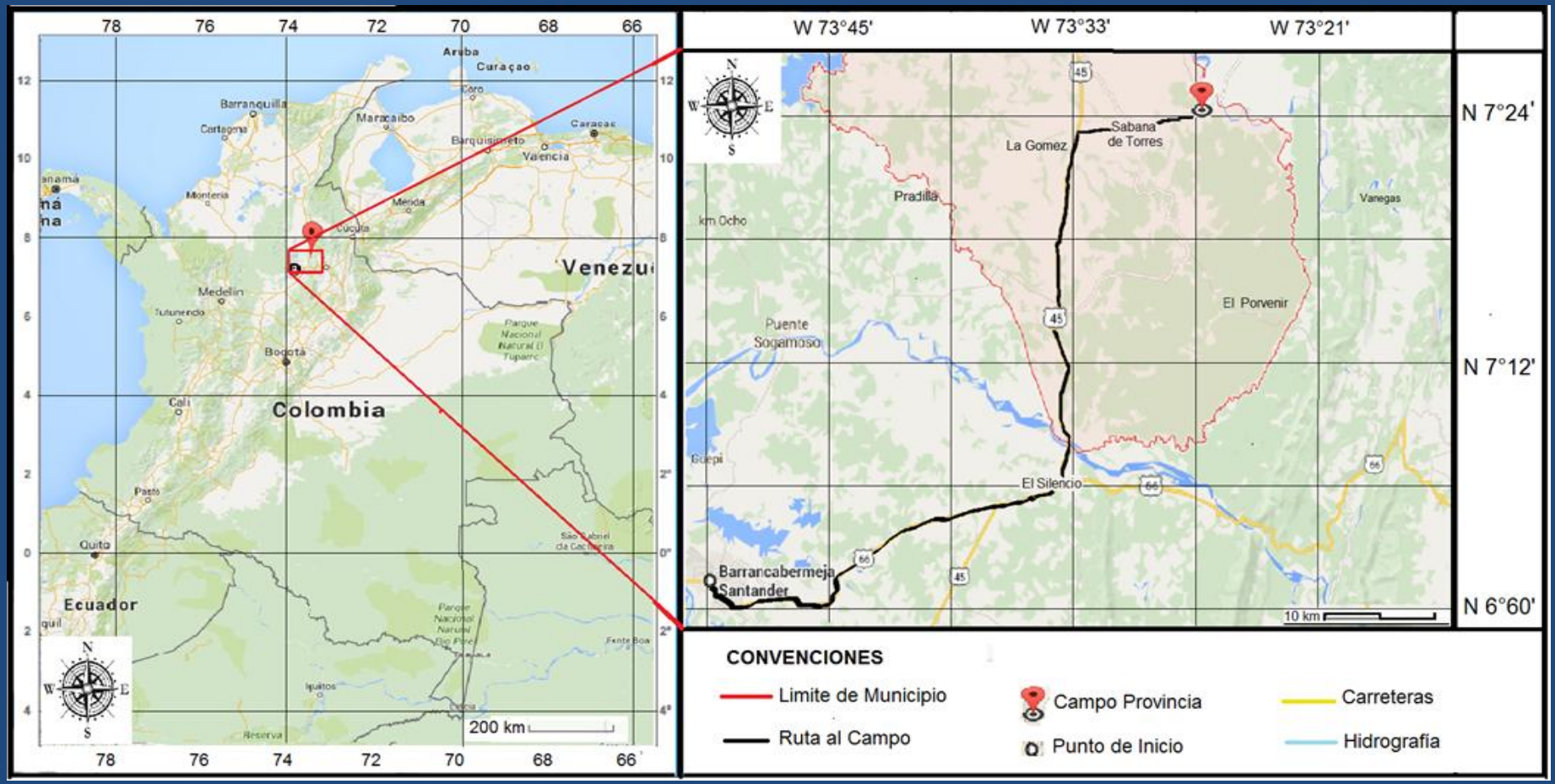
CYCLIC INJECTION OF FLUIDS

In general, the production mechanisms attributed to the Cyclic Gas Injection are:

- **Reduction of oil viscosity.**
- **Oil swelling.**
- **Push by gas in solution.**
- **Reduced interfacial tension.**

& Changes in wettability of the porous medium.

Geographical Location of the Provincia Field



Provincia Field s Average Reservoir Properties

Provincia field	La Paz	Mugrosa	Esmeralda
Average Depth (ft)	9.000	7.500	5.500
Mechanism of Production	Solution Gas Drive	Gas Cap	Solution Gas Drive
°API	31 – 34	24 – 28	18 – 23
Reservoir Temperature (°F)	175	170	150
Average Porosity (%)	16	16	18
Permeability (mD)	<275	<31	<130
Sw (%)	30	40	36
Oil Viscosity (cP)	1	2,1	2,1 – 5
Gas Viscosity (cP)	0,7	0,725	0,84
Gas Volumetric Factor (PCY/SCF)	0,0013	0,0032	0,0029
Initial Pressure (psi)	4.250 @ 9.000´	4.000 @ 7.500´	2.000 @ 5.500´

Gas Injection Cycle Operational Procedure

The operational procedure for each injection cycle per well is as follows:

- Test of gas injectivity to the selected well. Inject approximately 600 KCFD @ 1000 psi.

- Run Static Gradient or/and Dynamic Gradient of Pressure & Temperature to each well before starting the gas injection cycle. To check the bottom of the well and the operation of the Gas Lift system.

- Ensure that each well has surface facilities in good condition before starting the gas injection cycle (Differential pressure or flow recorders, injection and production lines).

- Install the Orifice Platen to register a flow rate of 1 MMCFD of gas.

Gas Injection Cycle Operational Procedure (Cont.)

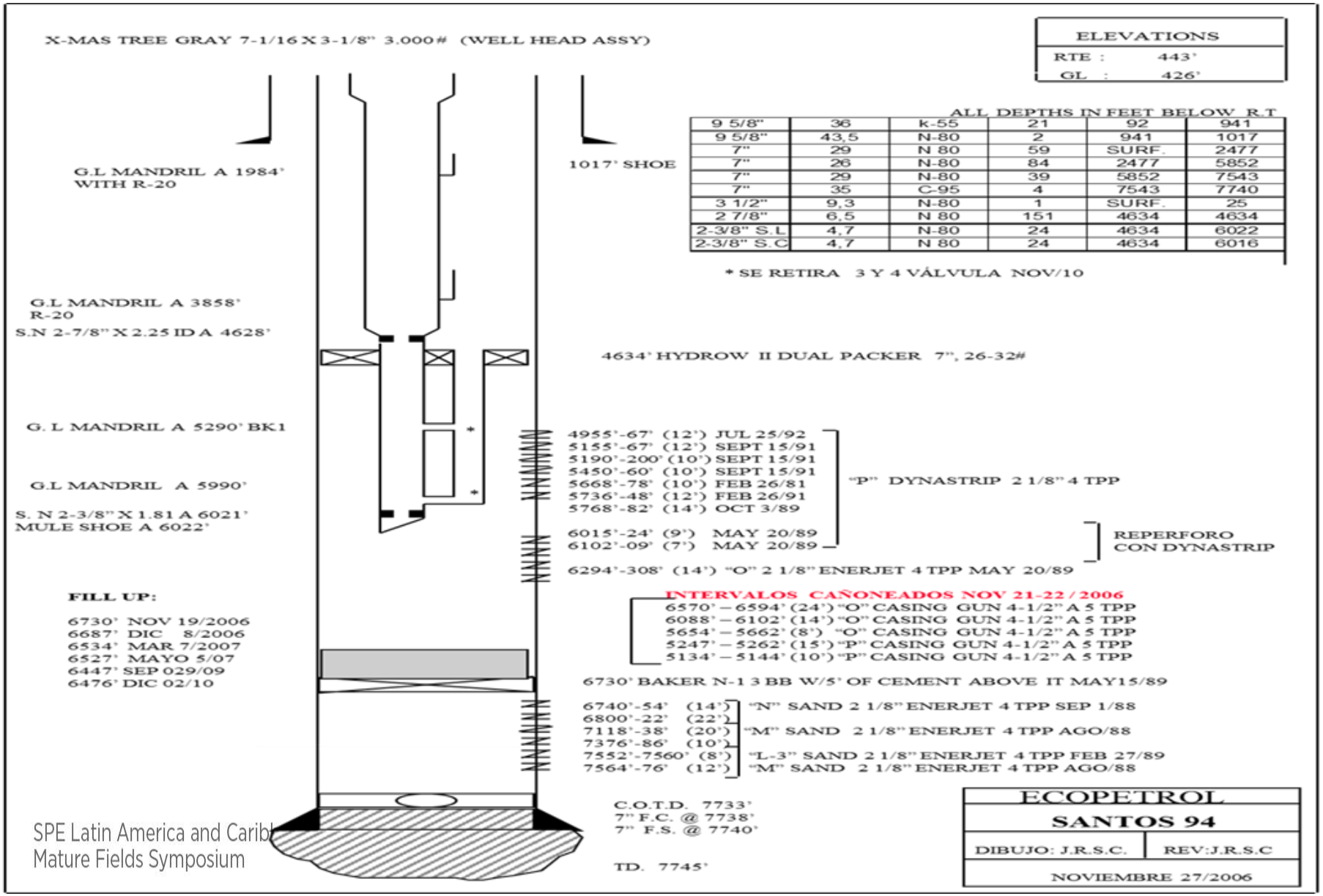
- Close the Lateral or Well Production Valve.

- Open the injection shock or valve at the desired injection rate (1 MMCFD of gas @ 1000 psi).

- Monitor the injection conditions daily to ensure that 1 MMCFD of gas is injected and verify that the well is receiving the injection (Do not block the injection).

- Inject 20 or 30 MMCF of gas per well.

Typical mechanical status of a well in the Provincia field

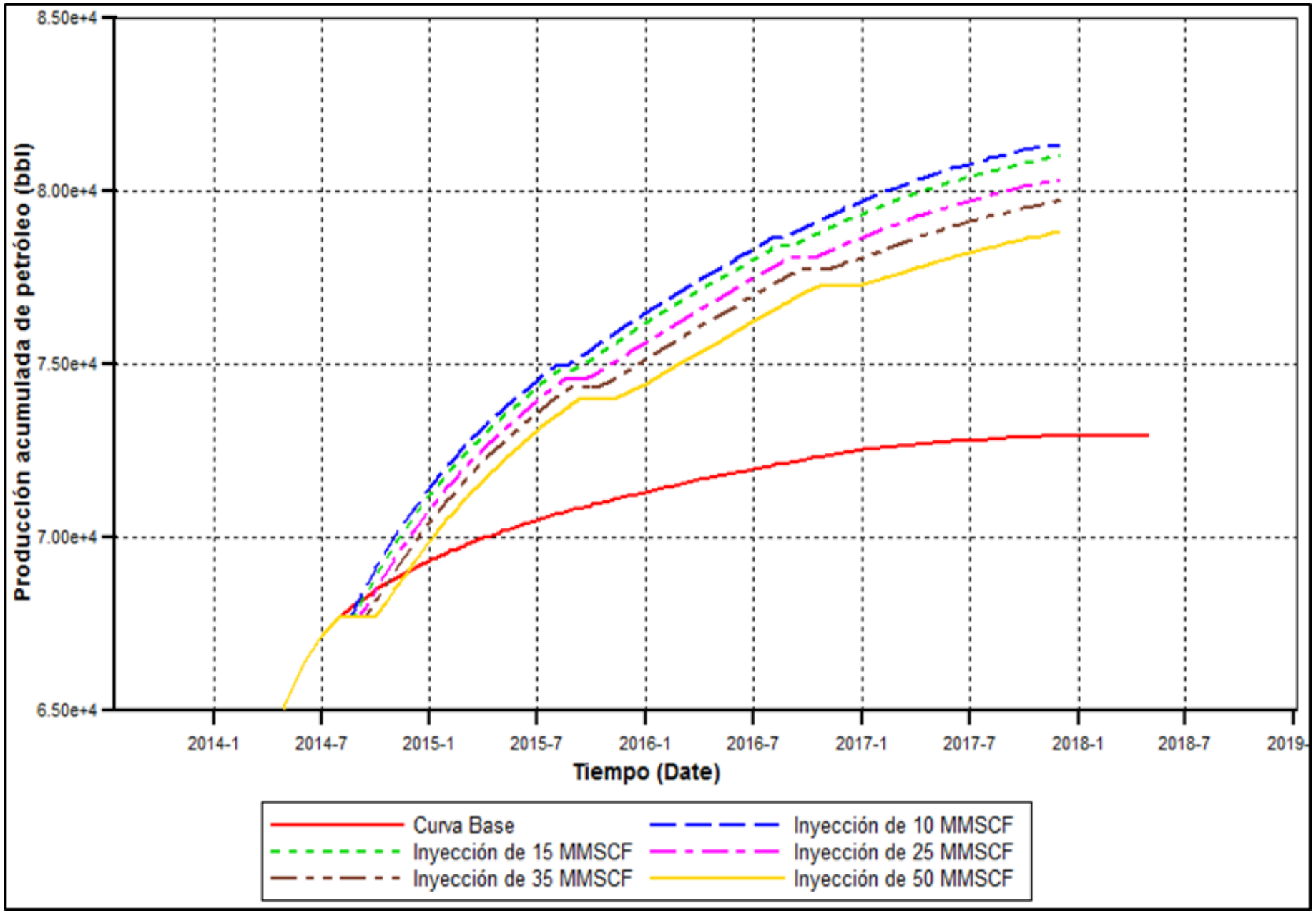


GAS COMPOSITION

The production gas composition of Provincia field used in the Cyclic Gas Injection (CGI) is:

Components	Molar %
CO2	0,43
H2S	0
N2	0
C1	68,6
C2	8,01
C3	5,02
i-C4	0,75
n-C4	1,8
i-C5	0,51
n-C5	0,87
C6	1,01
C7+	13
Total	**100**

NUMERICAL SIMULATION



CYCLIC GAS INJECTION (CGI) PILOT

The pilot test was carried out in June of 2014 in 6 inactive wells of the Provincia field (0 barrels of production). The Candidate wells for the CGI are Sabana 2, Conde 7, Suerte 16, Santos 73, 94 and 98. The gas injection was performed in the M and N Sands (Esmeraldas Formation) and in the Arenas O and P (Mugrosa Formation).

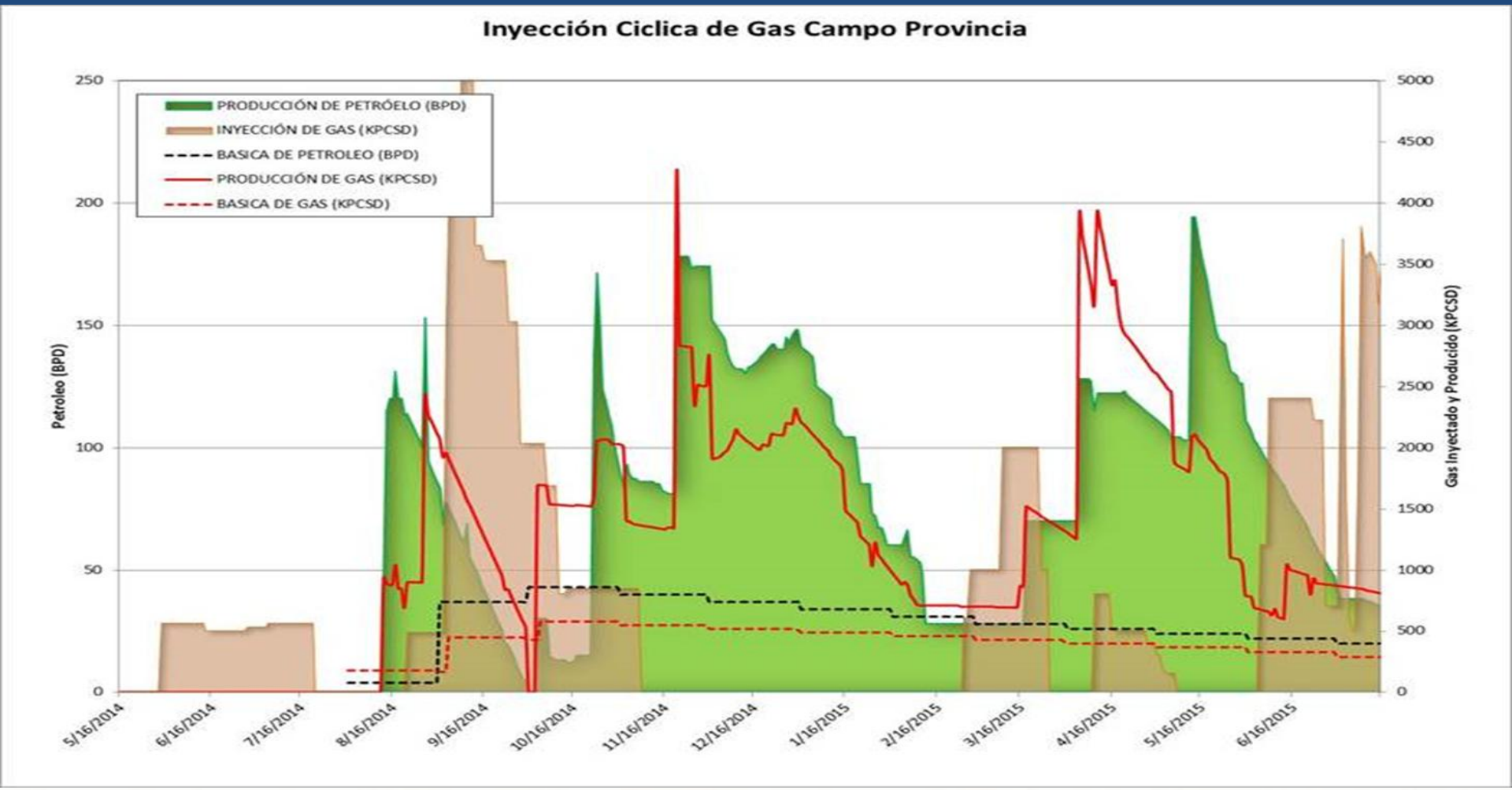
After the gas injection cycle, the well must be closed for a given time of 30 to 50% of the time used in the injection cycle ("Soak" cycle), in order for the gas to dissolve in the oil decreasing the viscosity thereof, further allowing the well to gain energy and increase the production of the well.

Posterior to this soaking cycle, the well is placed on production and production tests must be performed for at least two days in the first production week. Production must be monitored at least every two weeks.

Summary of the Results of Cyclic Gas Injection Pilot

WELL	CYCLE #	INJECTED GAS (KCF)	PRODUCED OIL (Bls)	PRODUCED GAS (KCF)	EFICIENCY (KCF/BL)
SABANA 2	1	27942	4097	72038	6.8
SABANA 2	2	20720	4659	78826	4.4
SABANA 2	3	20500	3524	75481	5.8
SABANA 2	TOTAL	69162	12280	226345	5.6
CONDE 07	1	17945	377	187205	47.6
SUERTE 16	1	25825	3246	92920	8.0
SANTOS 73	1	30800	7668	63562	4.0
SANTOS 94	1	32450	2134	32395	15.2
SANTOS 98	1	11730	4522	10832	2.6
SANTOS 98	2	9200	2246	9139	4.1
SANTOS 98	TOTAL	20930	6768	19971	3.1

NUMERICAL SIMULATION FOR THE EXPANSION



Expansion of the Cyclic Gas Injection in the Provincia Field

It was decided to apply the CGI in 9 more wells, due to the good results that were obtained in the pilot test. In the end there were 15 wells in the expansion of the application of the CGI: Sabana 2, 3, Conde 7, Suerte 16, 48, 54, Santos12, 40, 45, 46, 47, 73, 94, 98 and 104. Next Table presents the summary of the oil and gas productions obtained for each injection cycle per well during the expansion of the CGI in the Provincia field.

The cumulative production for the 15 wells of the CGI process to October 10, 2016 was 140094 barrels of oil and 2297 MMCF of production gas, for a total of 543015 equivalent hydrocarbons barrels in 28 months of applying CGI technology in the Provincia field.

Summary of the Oil and Gas Productions Obtained for Each Injection Cycle per Well

WELL	CYCLE #	PRODUCED OIL (Bls)	PRODUCED GAS (KCF)
SABANA 2	1	4097	72038
SABANA 2	2	4659	78826
SABANA 2	3	3524	75481
SABANA 2	4	3336	166326
SABANA 2	5	442	20930
SABANA 03	1	13763	42437
CONDE 07	1	6491	299567
SUERTE 16	1	3246	92920
SUERTE 16	2	5430	235228
SUERTE 48	1	6625	105238
SUERTE 54	1	5141	84174
SANTOS 12	1	9252	31962
SANTOS 45	1	10550	88256
SANTOS 46	1	10619	171966
SANTOS 47	1	7301	55220
SANTOS 73	1	7668	63562
SANTOS 73	2	5554	118487
SANTOS 94	1	2134	32395
SANTOS 94	2	401	44395
SANTOS 94	3	6070	190203
SANTOS 98	1	4522	10832
SANTOS 98	2	2246	9139
SANTOS 98	3	7143	18448
SANTOS 98	4	720	7956
SANTOS 104	1	7673	64422
SANTOS 40	1	1487	116240

CONCLUSIONS

In the results obtained in oil & gas production presented in Table 3 we can conclude that the pilot test of the CGI process carried out in the Provincia field was successful. The hydrocarbons production in each well before the CGI was 0 Bls. (Inactive Wells). A total of 32473 barrels of oil and 622.4 MMCF of gas were obtained for a total of equivalent hydrocarbons barrels of 141666 during the pilot test.

In the pilot test, the well Santos 73 was the one that produced more barrels of oil in a single cycle of gas injection (7668 Bls); obtaining an Efficiency of the process of 4 KCF / Bl. 4000 CF of gas is needed at reservoir conditions to produce 1 barrel of oil.

CONCLUSIONS

The cycle that presented the best Efficiency of the process was the first cycle in the well Santos 98= 2.6 KCF/Bl. In other word, 2600 CF of gas are needed at reservoir conditions to produce 1 barrel of oil.

The effectiveness and efficiency of CGI technology was evaluated. The cumulative production for the 15 wells of the CGI process on December, 2016 was 165874 oil barrels and 2553 MMCF of production gas, for a total of 613750 equivalent hydrocarbons barrels in 30 months of applying CGI technology in the Provincia field.

CONCLUSIONS

No HSE incident occurred during injection and production testing. The pilot test and CGI expansion were carried out under the best conditions of process safety, achieving at the end of the same zero impacts to people, the environment and equipment.

Using the production gas in cyclical injection generates greater value compared to other alternatives like the gas sale or the generation of energy.

ACKNOWLEDGEMENTS

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Thank you for your attention

¿Questions?