PARALAX®

Non-Acid Matrix Stimulation Technology

Reservoir Rehabilitation Solution

OILCONTROL

Introduction

Matrix Stimulation is a technique that has been used extensively since 1930s to improve production from oil and gas wells and to improve injection into injection wells. Matrix stimulation is accomplished by injecting a fluid (e.g., acid or solvent) to dissolve and/or disperse materials that impair well production in sandstones or to create new, unimpaired flow channels between the wellbore and a carbonate formation. In matrix stimulation, fluids are injected below the fracturing pressure of the formation (McLeod, 1984). Payout time for matrix treatments is normally days rather than months as it is for conventional fracturing treatments. Many operators around the world have indicated that an average of 40% to 50% of their wells have significant damage, but routinely only 1% to 2% of their wells are treated every year (Nolte, Economides, 2000).

The most common formation damage problem reported in the mature oil-producing regions of the world is organic deposits forming both in and around the wellbore. These organic deposits fall into two broad categories, paraffins and asphaltenes.

Problem. The most common type of Formation Damage in the brown fields is organic heavy hydrocarbons (wax, asphaltenes, tars, resins). Brown fields are the majority of oil fields in the world.

Conventional Solution. Most common solution to such Formation Damage is pumping aromatic solvents, hot oil and hot water flushes. They remove Formation Damage, but last few days (Formation Damage will re-appear back in a few days).

Innovative Solution. Non-Acid Non-Hazardous alternative to matrix acidizing and solvent squeezes. PARALAX® acts as fixation agent that prevents further paraffin and asphaltene deposition for next few months.

PARALAX® is the missing part of the Conventional Solution. It will make treatments last a few months, rather than a few days. It is based on proprietary surfactants acting on new chemical principles.

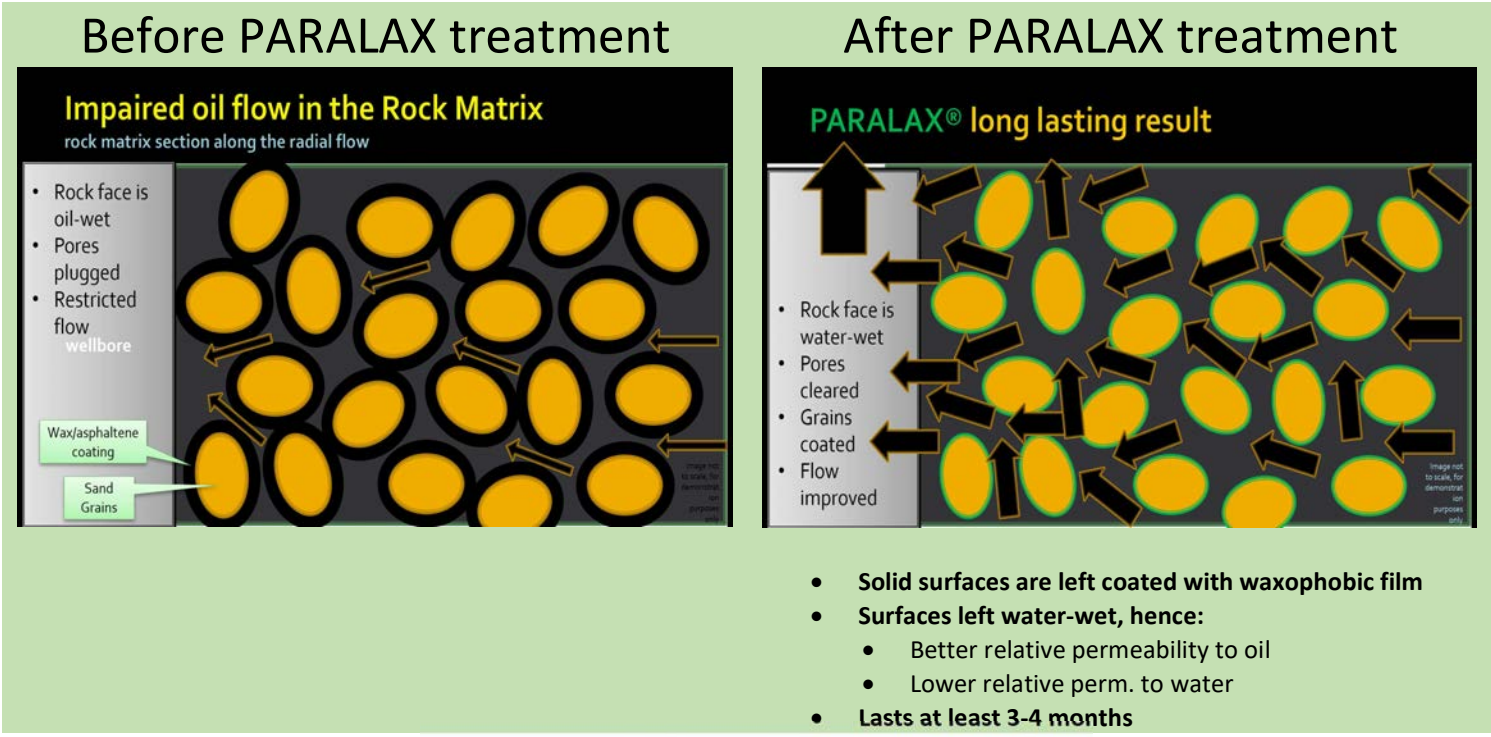


Fig.1. PARALAX® effect on oil flow in the formation

Well Performance & NODAL Analysis

Organic contamination in the form of asphaltene, paraffin and resins occurs along the production flow chain "Formation-Perforations-Tubing-Flowline-Facility". Quantification of PARALAX® performance and how it influences a well performance can be explained by Petroleum Engineering method, called NODAL Analysis. Interaction between driving force of the formation pressure (IPR curve) with tubing intake capacity (TI curve) brings to certain equilibrium production rate at a given flowing pressure, as depicted on the fig.2.

Several correlations for well performance are in use in the petroleum industry (Beggs and Brill, 1973; Hagedorn and Brown, 1965). Brown (1977), in a widely used work, outlined the procedure for pressure drop calculations.

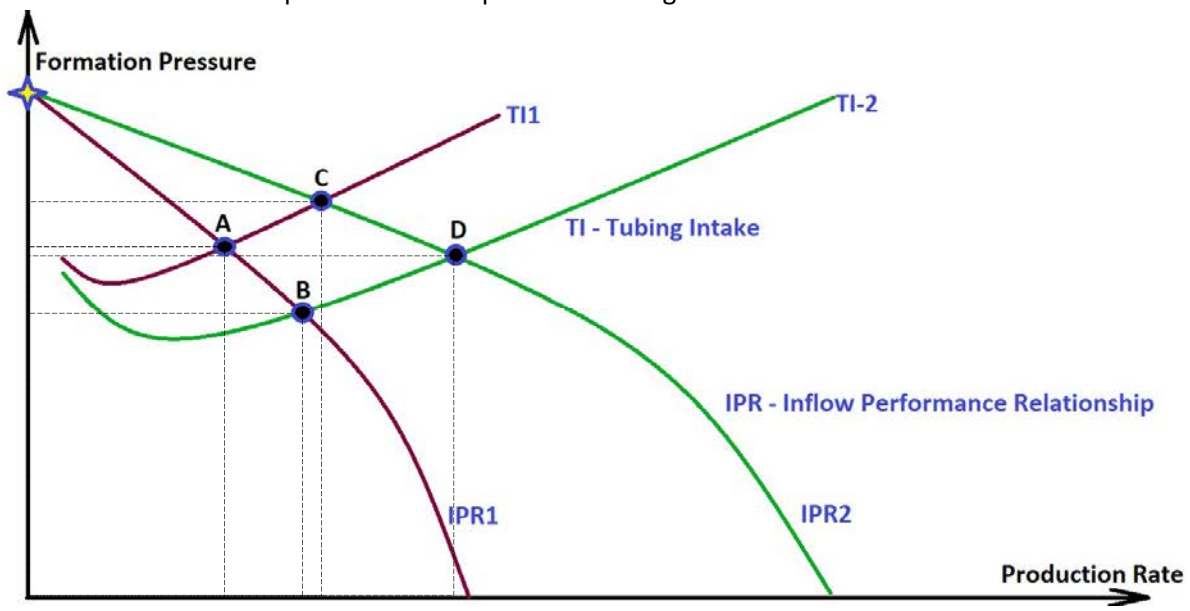


Fig.2. Well Performance analysis, 4 different stimulation scenarios

Dynamics of a PARALAX® job

Prior to PARALAX® treatment flow regime was in the point A when the well performance has deteriorated. When tubing is cleaned or pump accelerates the balance shifts to point B, where production can be deliberately increased, but further accelerations will be fatal, as it would lead to pump starvation and, potentially, collapsing. Pump starvation takes place when annulus fluid level drops to the depth of the pump intake, gas fills up the pump chamber and it gets gas-locked.

PARALAX® treatment, being a Matrix Stimulation solution, improves IPR /Inflow Performance/ by improving formation permeability. Slope of IPR curve is the Productivity index showing how many barrels per day produced per one PSI of bottomhole flowing pressure. Matrix Stimulation flattens the IPR curve slope allowing to produce more oil at the same pressure drop, and it shifts the balance to the point C.

The operator can now analyze other well parameters and, if the flow regime suboptimal, there is possibility to modify tubing intake and shift the balance to the point D, where the new optimal rate can be achieved.

PARALAX® Job Design

Treatment designs and procedures had been developed for various well types and drive mechanisms. Pumped and Flowing wells are two main categories. Pumped wells are normally driven by SRP – sucker rod pumps, PCP – progressing cavity pumps, ESP – electric submersible pumps, and less frequently by jet pumps. Flowing wells are naturally flowing and gas lift assisted.

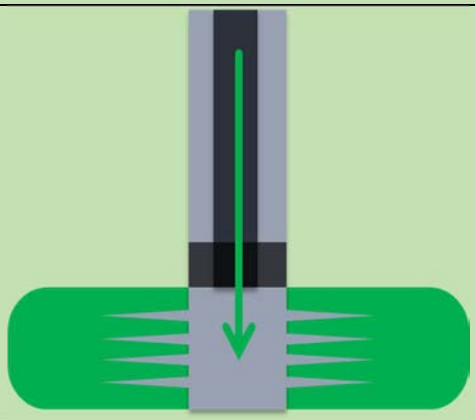
Basic pumping equipment will do the job: a pump truck (conventional, cementing, acidizing) or optional is the hot oil unit in case added heat is required do to temperature.

Pumped well job design is based on common fact that there is a pump and no packer in the well. Flowing well job design is based on the opposite: there is a packer and no pump.

Brief Job Procedure

1. Safety meeting. Discuss procedure, risks involved and everyone's responsibilities
2. Prepare PTO (PARALAX-treated oil) by mixing carrier fluid crude oil (diesel, condensate) with 2% to 5% PARALAX® by volume of carrier fluid
3. Pump PTO into the well and squeeze into the formation
4. To make sure all PTO squeezed into the formation - pump predetermined volume of displacement fluid (water, brine, oil, etc.)
5. Leave the well shut in, or circulating for few hours for reaction/soak
6. Return the well into the operation.

Pumped wells: Circulation
PARALAX® treatment method developed for the pumped wells equipped with ESP, SRP, PCP types of pumps
Method of circulating PARALAX®-treated oil (PTO) in the closed loop "Tubing-Annulus" up to 2-3 cycles
Reason: There is a pump and no packer
Expected results: Formation and tubing are treated for an extended and incremented wax-free production time



Flowing wells: Squeeze
PARALAX® treatment method developed for flowing or gas lift assisted wells.
PTO is injected down the tubing (bullheading) and squeezed into the formation
Reason: There is a packer and no pump (opposite of the above)
Expected results: Tubing is treated by PTO on the way down and up. Formation near wellbore is treated for higher production

Fig.3. Summary of various production drive mechanisms

Treatment Examples

To illustrate potential gains delivered by an average PARALAX® job, below are few examples taken randomly from previous treatments: PCP well in South Kazakhstan, SRP well from Brazil, SRP well from West Kazakhstan, Flowing well from Turkmenistan.

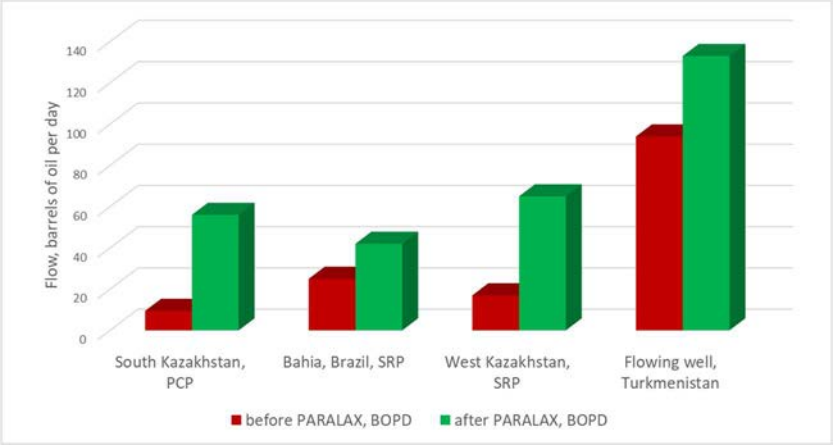


Fig.4. Incremental oil production, representing various cases.

Pumped wells are most likely underperformers, when more impressive production increase is possible, due to depleted formation pressure. Depleted formation pressure → production below "bubble point" → high possibility of asphaltene deposition.

Flowing wells may not have organic formation damage as severe as in the pumped ones.

More details of the above figures described in the below case studies:

South Kazakhstan, PCP

Organic deposition accelerated right after the well was converted from flowing into pumped production mechanism. Even though formation temperature relatively hot, 75°C, organic deposition takes place in the formation, perforations and tubing. Wax inhibitors solve some deposition issues in tubing, flowlines and production facilities, but below the pump – in the perforations and sandstone near wellbore matrix, it is treated conventionally by batch treatments of aromatic solvents. Solvents work good in removing asphaltenes and resins from the rock face, but deposition starts after 2-3 days of restarting production. Due to plugging of the formation pores well was underperforming, that was observed by falling annulus fluid levels.

PARALAX® treatment done on this well was targeted more at squeezing into the formation to clear asphaltenes and resins in the critical matrix, opening flow channels for much higher production, which corresponds to the shift from point A to point B of the Fig.2. As a result, **production increased from 1.5 to 9 m^3/day (9.5 to 56 BOPD)**, by enormous 493% because the well was performing so poorly.

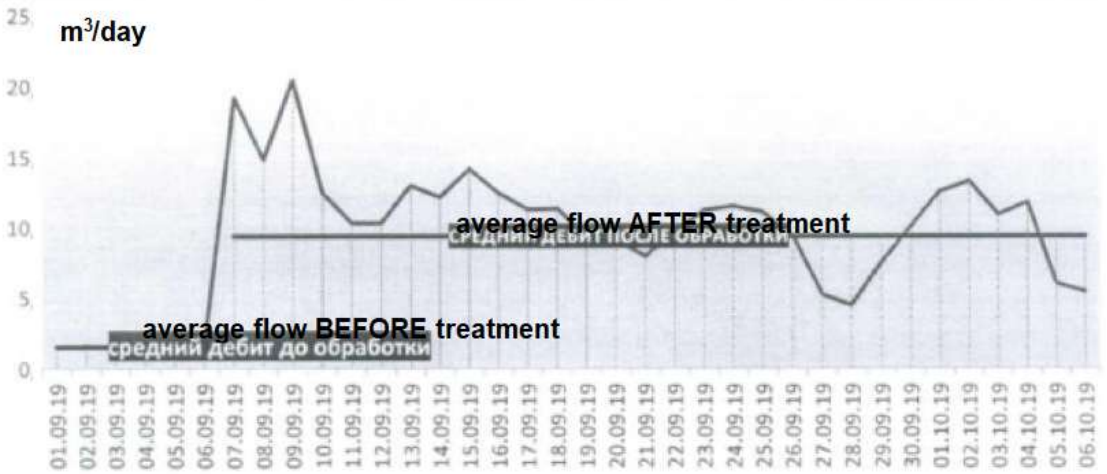


Fig.5. Amount of PARALAX® used is 100 liters

Brazil, SRP

Brown field in Bahia state of Brazil, it is typical and represents majority of the old wells in the whole world: high water cut, depleted formation pressure, prone to sand production, etc. PARALAX® treatment involved pumping 10m^3 of PARALAX®-treated oil (PTO) down the annulus with further 12 hours shut-in.

Due to very low formation pressure, PTO got squeezed into the formation by gravity, as the well cannot hold column of fluid in the annulus. Well performance shifted from point A to point C (Fig.2), after a month of stable flow, production engineers decided to safely accelerate production, meaning shift from C further to D (Fig.2). **Production increased from 25 to 42 BOPD**, by 68%.

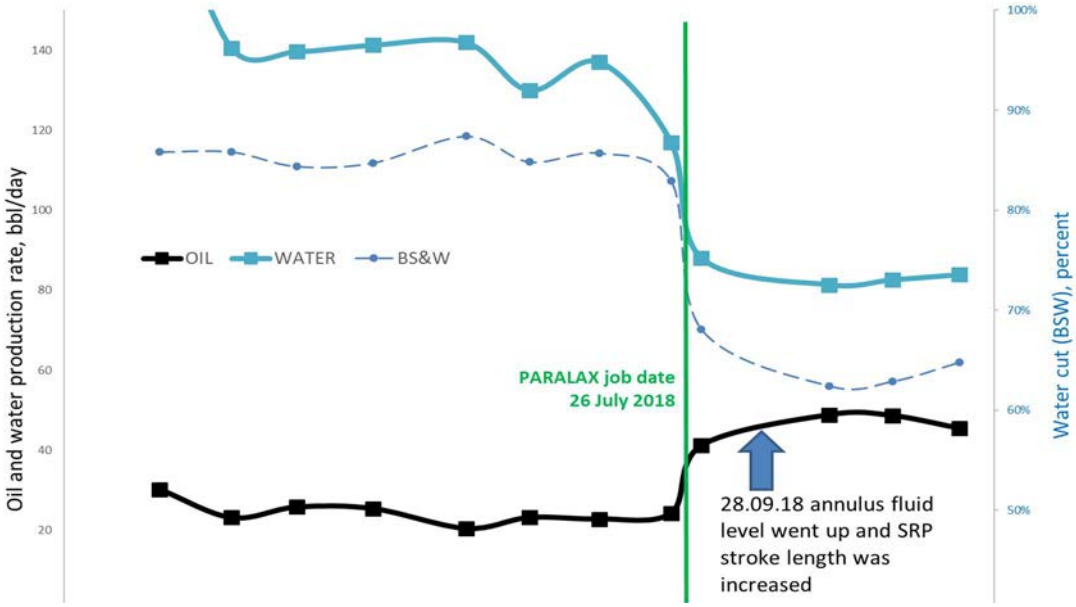


Fig.6. Amount of PARALAX® used is 200 liters

Fig.6.1. Hot Oil Unit connected to the wellhead annulus via high pressure hose

West Kazakhstan, SRP

This well was not scheduled for PARALAX® treatment and added to the service plan on short notice of 2 days. Reason for such a hurry was that the high profile well (good oil producer with low water content) showed abrupt production decline, indicated first by fast falling annulus fluid level and further confirmed by declining oil rates.

Treatment design was hot PTO Squeeze into the formation with closed loop "tubing-annulus" circulation, in order to clean tubing, clear sandstone formation pores and improve permeability to oil in the critical matrix, which corresponds to the point D of the NODAL analysis. As a result of the treatment, **production increased from 18 to 65 BOPD**, by 260%.

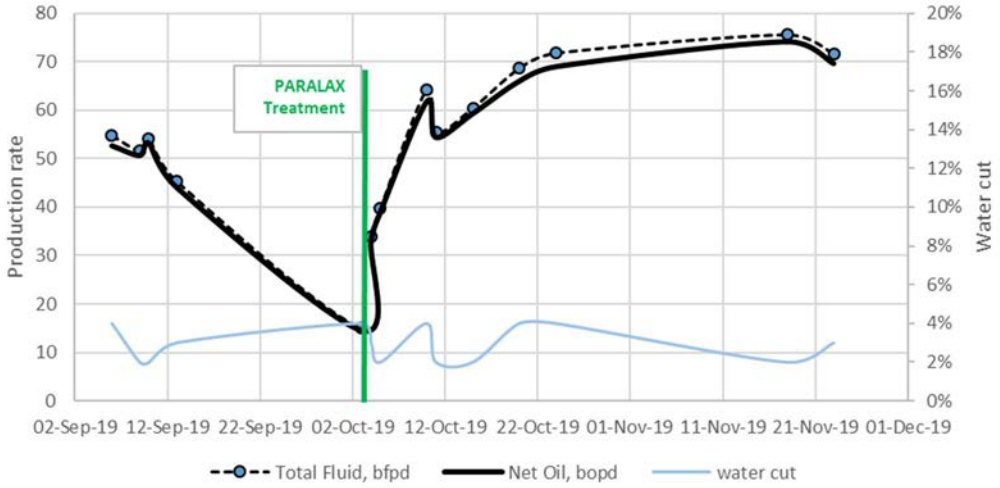


Fig.7. Amount of PARALAX® used is 200 liters

Fig.7.1. Hot Oil Unit pumps PTO from the vacuum truck into the wellhead annulus

Flowing well, Turkmenistan

This well produced waxy crude oil with insignificant amount of asphaltenes and resins. Formation is quite hot 95°C and high GOR. Produced gas expansion cools down high molecular paraffins that drop out inside the tubing as a hard deposit. Conventional wax cutting by slickline does not work as the tool gets stuck in hard paraffin. Therefore, tubing cleanout operations call for hard pipe of CT with round knifes while jetting light crude.

PARALAX® mixed at 2% with gas condensate was jetted on the way down the tubing to clean and inhibit further wax deposition. Sandstone formation is hot enough to keep formation damage away. After the treatment, well performance shifted from point A to point B, as the formation was not affected. **Production increased from 94 to 133 BOPD**, by over 41%.

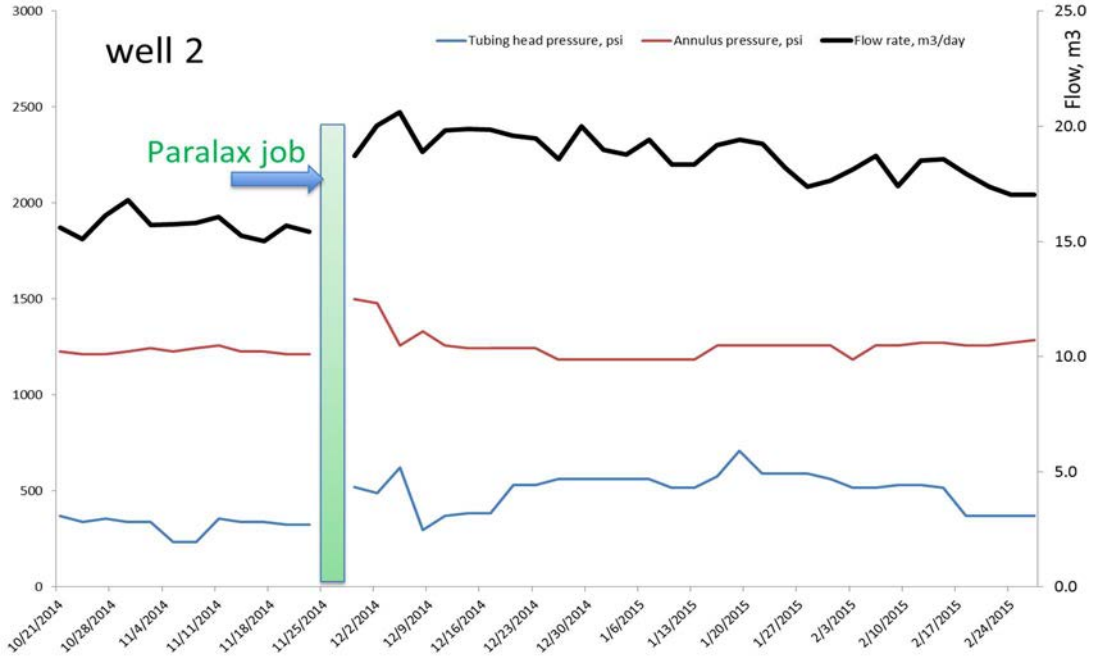


Fig.8. Amount of PARALAX® used is 300 liters

Improvement of the pump efficiency

Graph on fig.9 shows that the operator had to reduce pump rate after PARALAX® treatment from 300 to 250 RPM, but still produce 50% more oil.

Reason is high GOR and stimulation effect feeding more oil into the pump, pump rate had to be reduced in order not to draw more water, as the perforations were right above the WOC.

According to the Well Performance graph Fig.2, balance shifted from point A to point C, and then to D, but backwards along the IPR curve

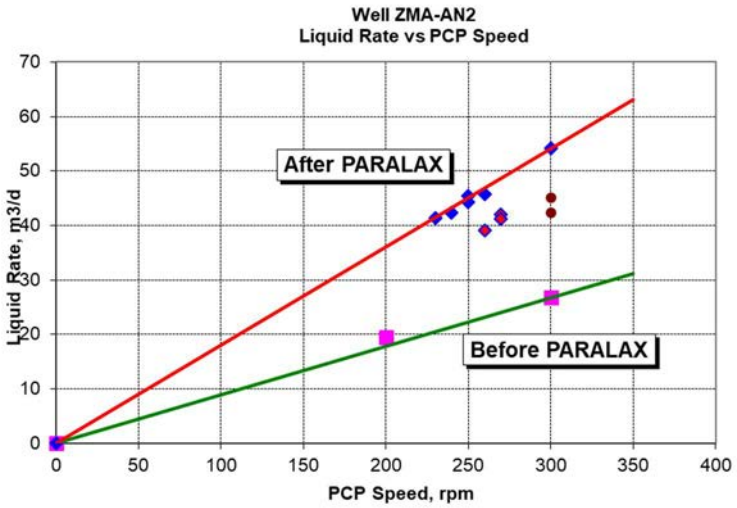


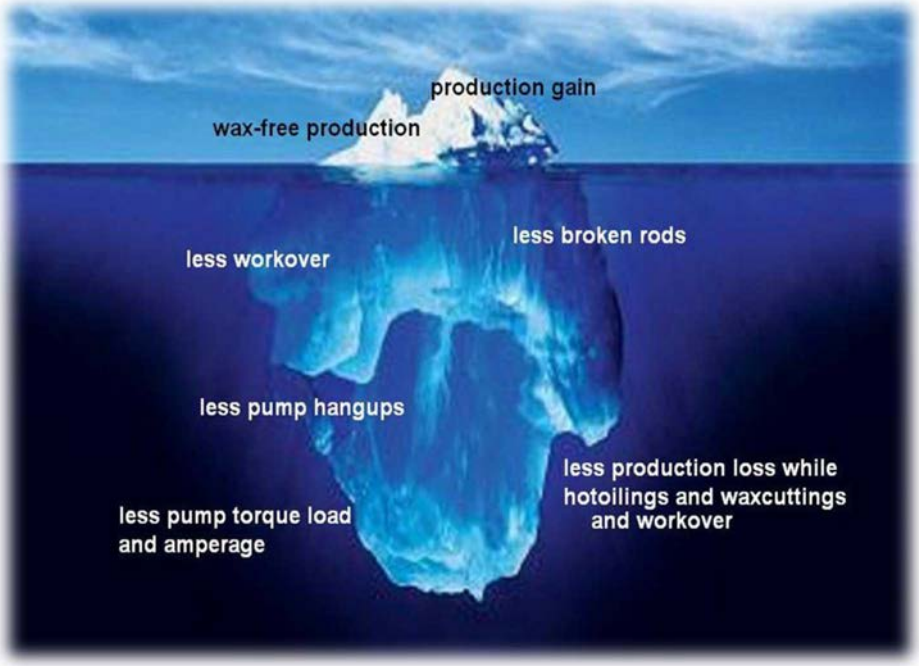
Fig.9. Cutting back the production, in order to avoid water breakthrough.

Conclusion and Economics

Return on Investment (ROI) when using this Non-Acid Matrix Stimulation technology is typically in the range of 400 to 600% on average. These figures achievable with proper candidate wells recognition and selection for treatments. However, in the worst cases of plugged solid wells PARALAX® delivers best results: ROI can be much higher due to unleashing high pressures built up for years behind asphaltic/waxy plug in the critical matrix.

In addition to above mentioned ROI figures, there are other significant benefit that are not so obvious and not measured by monetary values. It becomes clear that after 1 or more years of PARALAX® application and analysis, operators realize following differences:

1. Up to 80% reduction of workover interventions due to wax (pump hangups, broken/stuck rods)
2. Less HSE exposure and footprint due to fewer approaches to the wells with dewaxing operations. Lower overall risks of LTI.
3. Higher personnel efficiency



Non-Acid Matrix Stimulation technology when deployed fieldwide in the long term can be a brown field rehabilitation instrument and raise overall NPV of producing assets.