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El Boletín para Nuestra Comunicación

INTRODUCCIÓN

En nuestros Boletines de años anteriores les acercamos distintos Casos Históricos publicados que consideraban realizaciones tanto en el Modelado Estático como la Simulación Numérica Dinámica, las que usaban además metodologías complementarias para el logro de los Modelos Integrales de Yacimiento.

Particularmente, les presentamos la Calibración del Modelo Geológico del Campo Puesto Hernández, Fm. Rayoso de la Cuenca Neuquina.

En este caso les acercamos una importante realización, por su tamaño y complejidad: el Modelado Integral en Líneas de Flujo del Bloque 4 del mencionado campo, realizado para lograr la Optimización, Control y Seguimiento del Barrido con Agua en aplicación, publicado en el LACPEC 2007, realizado en Buenos Aires.

Por cuestiones de brevedad, les acercaremos la publicación de esta manera: en este Boletín la Generación del Modelo de Entrada al Simulador; en el Boletín N°13, el proceso de Ajuste Histórico en distintos niveles y en el N°14, el Análisis de Escenarios de Explotación.

Los invitamos a enviarnos sus comentarios y/o propuestas. Podrán encontrar los Boletines anteriores en nuestra Página Web. Al pie del Boletín hallarán la dirección de nuestra Página y otras formas de comunicación con nosotros.

Finalizamos este Boletín, como siempre, con la Sección Novedades.

STREAMLINE-BASED INTEGRAL MODELING FOR WATERFLOODING DESIGN OPTIMIZATION, SURVEILLANCE AND MONITORING (1° PARTE)

Abstract

The Dynamic Numerical Simulation in Flowlines (DNSFL) is an alternative tool adapted to handle Dynamic Models in Fine Scale. This feature has been particularly relevant for studying the current case, a huge multilayered waterflooding process developed in a giant field of great extension reservoirs with considerable facial and stratigraphical variations.

The DNSLF develops these tasks suitably because uncouples reservoir geometry and heterogeneity from transport equations, solving the problems dominated by convective flows in a faster and computationally more efficient way. This allows to build models of greater space discretization and, therefore, to represent better the heterogeneity of the reservoirs.

The analyzed field is constituted by fluvio-lacustrine deposits, nine sand-clay cycles of normal grading (only eight of them were modeled), partially connected reservoirs; with 250 actives wells in commingled production and water injection; and with a long and detailed history of simultaneous primary and secondary events.

In a previous paper (SPE 94815) a Streamline-based Global History Matching of this field was presented. This process enabled to achieve the Geological Modeling Calibration, a clear conceptualization of the current primary and secondary production mechanisms, its productive behavior, and to evaluate the geostatistical and Upscaling procedures to apply for the definition of the Simulation Model.

This paper illustrates how the Integral Model achieved, with a detailed Streamline-based History Matching, is used for Waterflooding Design Optimization, Surveillance and Monitoring, showing that these principles are key factors to understanding reservoir performance and identifying opportunities that will improve the ultimate recovery.

During the detailed History Matching process CPU runtimes around 200 minutes were achieved using a 1225000 grid cells Model, with 190 timesteps, quarterly at the starting, and monthly after, based in a Pentium 4 PC, 3.2GHz CPU and 2GB RAM. It showed that it is possible to work with a big Streamline-based Model in relatively short processing time.

Introduction

The classical techniques of waterflooding surveillance, including methods like: mapping (gas-oil ratio, water cut, pressure, etc.) total liquid production vs. time, injected poral volumes vs. recovery factor, Hall plots, etc., jointly with the monitoring process have backed-up successful Exploitation Optimization processes[1]. Most of these techniques, as those mentioned above, are 0D; some recent practices made 1D or 2D spatial distribution of the relevant characteristics to the process, essentially productions and injections, but without integrating the pressure fields.

Streamline simulation goes further and incorporates pressure fields, which determine streamline as the most probable way of fluid movement. In this sense, and always in the pressure field, there are two well differentiated work levels in the waterflooding projects[2] (Fig. 1):

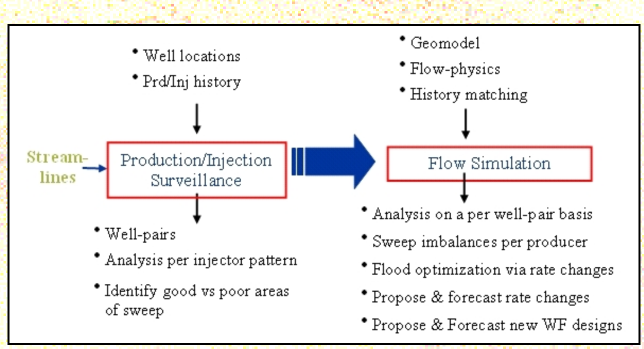

Fig.1 Two-Step Solution with Streamlines

Taken from: Using Streamline-Based Simulation to Proactively Manage Well-Pairs to Promote Improved Sweep and Reduce Fluid Cycling. Presented @ 2006 SPE ATW.

1. The first level, called "Production-injection surveillance" based on the historic analysis of the waterflooding, allows for the examination of injectors and producers, identifying well and poorly swept areas.
2. The second level, "Streamline-based simulation" based on a detailed geological model, fluid physics and history matching, which allows, in addition to the previous one, for an integral redesign and forecast of the waterflooding towards its optimization.

Both levels are sustained and fed by monitoring the field process; as it is clear, the development of the second level, as in the example of Puesto Hernández Rayoso Field– Block 4, implies achieving the first level.

As it is known, the classical surveillance techniques have been widely discussed in several well-known publications and experts have recommended some high-value principles to develop them. The following principles make up the minimum platform required by simulation techniques, especially by the streamlines, here considered:

- A key ingredient of any surveillance and simulation program is the planning, gathering and validation of "all" available information.
- To implement surveillance and simulation efforts it is essential to "understand" the reservoir expressed in their characteristics and fluid flow, while reducing the uncertainty of the interpretation. In the case of simulation, this understanding is reflected in reservoir models adjusted in the History Matching process.
- In general, one classical surveillance technique is not meaningful because different parameters (characteristics of reservoirs, production mechanisms, etc.) can produce similar answers. Instead, a well planned simulation model integrates the relevant analysis to the process under evaluation –waterflooding evaluation in this case- thereby avoiding this problem.
- Achieving a waterflooding surveillance controlled by fluid balance in the patterns requires important technical efforts (from engineering and geology) during the life of the project. Simulation also requires important technical efforts but specially concentrated on the initial phase –i.e. when models are developed.
- Surveillance techniques should always induce thorough deeper studies which include numeric simulation.

As mentioned above, streamline simulation in Puesto Hernández Rayoso – Block 4, and the related surveillance tasks, feed and depend from the monitoring process of the field to optimize the waterflooding presently in progress.

In all simulation process, including proposed optimizations, the methodological approach was based on blocks, sectors, well groups and wells resulting from the review of many cases of waterflooding. This type of work avoids implementing partial action plans or fast judgment, which is especially important in up to date situations where human and capital resources are critical.

Development

Puesto Hernández field is at the NW border of Neuquén Basin of Argentina (Fig. 2), extended along 147 km2. It is developed in the Neuquén embayment, where the stratigraphical column is complete although thickness is reduced due to the proximity to the basin boundary (Fig. 3.)

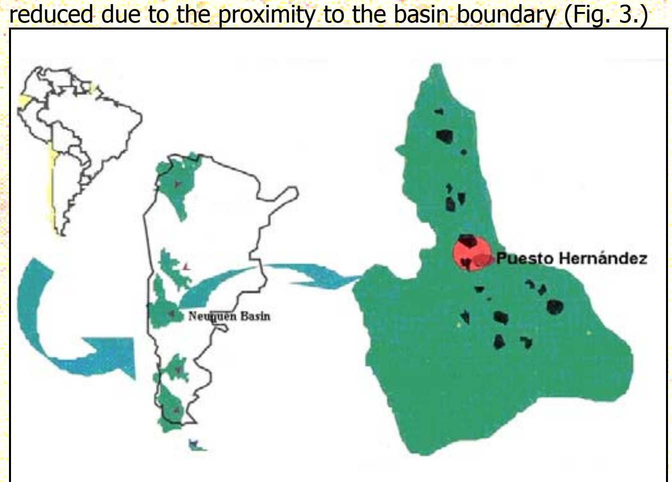

Fig. 2 Puesto Hernández Field Location, Argentina, Neuquén Basin
Taken from: Rocas Reservorio: Los Reservorios de la Formación Rayoso, IAPG Mar del Plata 2002

Description and Main Characteristics of Reservoirs

The productive reservoirs of the field, Rayoso, Huitrín and Agrio belong to the Cretacic age. This work is developed in the Rayoso Fm, the main field producer.

Fm. Rayoso belongs to a clastic-evaporitic unit deposited in a predominantly continental environment of fluvio-lacustrine character[3]. The clastic section is interesting from the economic perspective; there are 11 sand-clay cycles, of normal grading out of which the most important 8 were modeled. The cycles are truncated towards the E-NE by the intercenomanian unconformity at the top of Fm Rayoso, with three different CAPOs (Original water-oil contacts); they consequently form three Hydraulic Units: inferior (IHU), medium (MHU) and superior (SHU). Fig. 4 shows the truncation of the various cycles of the Hydraulic Units, used to define the sectors of Block 4.

Structurally the reservoirs are a homoclinal of 5º average slope and dip to the SW. The 3D seismic registered in 1995, showed a main faulting that result in E-W vertical and sub-vertical faults, of few meters of throw. This paper analyzes the hydrodynamic connectivity of these faults, especially in Block 4 (Fig. 5).

Productive levels are relatively shallow, depth is below 600 mbgl (meters below ground level), show good petrophysical characteristics, low initial reservoir pressure and oil viscosities that vary laterally and with depth.

The main characteristics of these reservoirs, in the modeled area of Fm. Rayoso are:

- Average depth: 500 to 700 mbgl
- Average crude density: 25ºAPI
- Crude viscosity: 15 to 95 cp
- Initial static pressure ≈ 26 Kgf/cm2
- Bubble pressure ≈ 15 Kgf/cm2
- Gas in oil solubility ≈ 6 m3/m3
- Reservoir temperature: 33ºC

Development and Exploitation History

By mid 1976 the primary exploitation of Fm. Rayoso in Puesto Hernández Field started (Fig. 5). Production increased at the beginning of 1983 by perforating this formation in several wells that produced before the deepest levels. Water injection started at the beginning of 1994 in some peripheral wells; by mid of 2000 new wells drilling was intensified and changed to an irregular 9 spot injection pattern.

By the end of 2005, over 1500 wells were drilled in the Puesto Hernández area, 37 % from Fm. Rayoso.

The simulation area contains 265 wells (185 producers and 80 injectors) comprising Block 4, where the model is developed, and well strips from Block 3 and 5 (South and North from Block 4), as boundary conditions (Fig. 6).

Production or injection of most of these wells takes place in over one Formation. Only 240 wells perforated in Fm. Rayoso, produce this formation exclusively (38%), these are called turnkey wells and the remaining are non-turkey wells.

Most of injectors have valves to assure the selective injection among various formations but not among the various hydraulic units of Fm. Rayoso. To the Rayoso non-turnkey producers the oil production was allocated prioritizing the trends noted in Agrio and Huitrín formations.

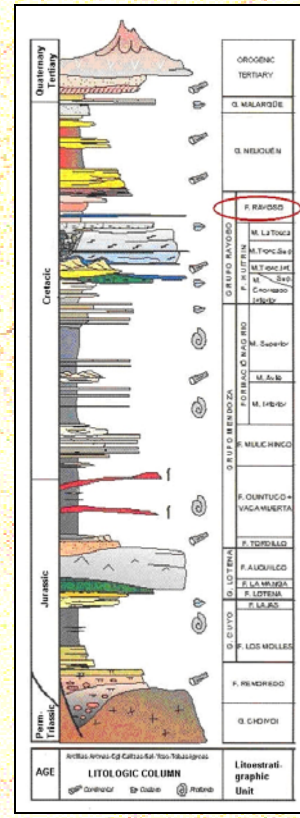

Fig. 3 Stratigraphic Column, Rincón de los Sauces Area, Neuquén Basin, Argentina.
Taken from: Rocas Reservorio: Los Reservorios de la Formación Rayoso, IAPG Mar del Plata 2002

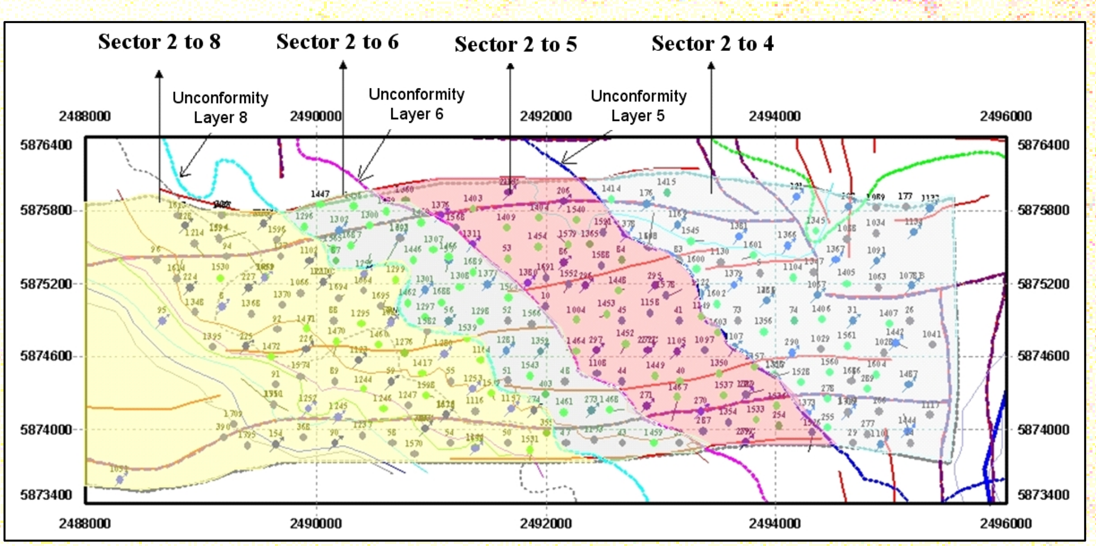

Fig. 4 Sectors of Block 4

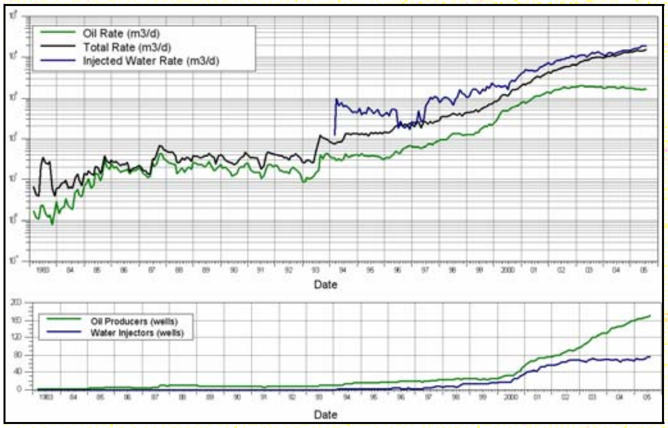

Fig. 5 Production and Injection History, Fm. Rayoso

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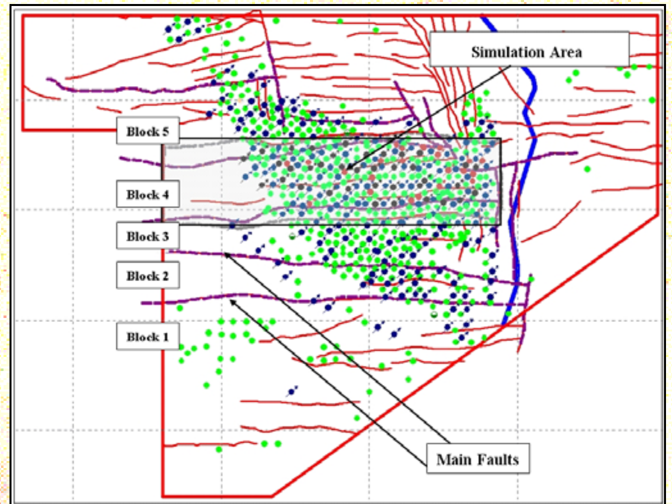

Fig. 6 Puesto Hernández Field and Simulation Area

Contáctenos

: mgoilandgas@mgoilandgas.com.ar

: www.mgoilandgas.com.ar

(5411) 4325-8985; Gratuito desde México: 01 800-123-4788

NOVEDADES

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