ỨNG DỤNG VẾT ĐỒNG VỊ PHÓNG XẠ ĐỂ GIÁM SÁT SỰ XÂM NHẬP NƯỚC Ở MỎ RẠNG ĐÔNG

APPLICATION OF RADIOACTIVE TRACER FOR MONITORING WATER BREAKTHROUGH IN RANG DONG FIELD

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TÓM TẮT

JVPC là một trong những công ty dầu khí lớn ở Việt Nam đang khai thác ở lô 15-2 mỏ Rạng Đông. Lưu lượng khai thác tích lũy đã đạt đến 100 triệu thùng vào tháng 6/2005 tính từ tháng 8/1998. Tương tự như các mỏ khác trong khu vực (Bạch Hổ, Sư tử đen, …), dầu chủ yếu được khai thác từ tầng móng. Năm 2004, người ta bắt đầu bơm ép nước vào tầng móng vào năm 2004 và lưu lượng khai thác được là rất khác nhau. Để hiểu được quá trình xâm nhập nước vào giếng khai thác, thì ngoài các phương pháp truyền thống như thử giao thoa, giám sát áp suất và việc phân tích nước, các vết đồng vị phóng xạ đã được bơm vào cùng với nước. Bài báo này mô tả cách lựa chọn các vết đồng vị phóng xạ, hệ thống giám sát và trình bày một số kết quả ban đầu của việc phân tích vết cũng như đề cập các yếu tố không xác định và những khó khăn gặp phải khi áp dụng kết quả phân tích vào mỏ Rạng Đông.

ABSTRACT

JVPC is one of the biggest oil companies in Viet Nam, and operates the Rang Dong field- block 15-2. Cumulative oil production of 100 MMstb was achieved in June 2005 since first oil in Aug 1998. Like other field in this region (White Tiger, Su Tu Den…), the majority of oil production comes from the basement reservoir. In 2004, water injection commenced in the basement reservoir with varying results. In order to understand the water breakthrough to producers and in addition to conventional methods like interference testing, pressure monitoring and conventional water analysis, radioactive tracers were injected with the injected water. This paper describes selection of tracer, monitoring system and the initial results of the tracer analysis. The uncertainties and difficulties we face when applying the results to Rang Dong field are discussed.

1. RESERVOIR OVERVIEW

Rang Dong field is located in the Block 15-2 in the Cuu Long basin of offshore southern Vietnam ca. 150 km from Vung Tau. The field started production in Aug-1998 in both Lower Miocene and Basement reservoir. At the end of June-2005, cumulative oil production of 100 MMstb with around 60MMSTB produced from Basement reservoir. This reservoir was initially under saturated and firstly produced in the Northern region. Later wellhead platforms were added in the east, south and central in 2002 and 2005. Currently, there are 18 production wells and 6 injector wells in Rang Dong basement reservoir.

In order to arrest pressure decline seen between 1998 and 2004 water injection was started in the basement reservoir in 2004 to help

to increase oil recovery. To help understand what really happens in reservoir under injection, tracer injection was applied. Understanding the behavior will lead a more effective water injection strategy and maximize oil recovery.

2. TRACER SELECTION IN RANG DONG FIELD

2.1. Purpose of using tracer

Tracer techniques can play an important role in investigation of water flooding process. Tracers are applied in Rang Dong field with the following aims:

- To determine direction of water movement from injectors to producers
- To determine residence time of injected water from injection based on breakthrough times of tracer
- To identify pattern of water movement by combining tracer breakthrough curves and pressure transient data
- To extract more information about reservoir structure

2.2. Tracer selection in Rang Dong field

2.2.1. Well selection for tracer injection

Rang Dong basement fractures are connected through a complicated fracture system that can vary in character not only by area but also within area. Based on dynamic data observed during DST, well test, production history, 2 injector wells in Northern region were initially selected to inject tracer. Since then all injector wells have had tracer injected in order to understand communication between wells and regions (Figure 1).

2.2.2. Tracer selection

Two kinds of tracer are commonly applied in the industry; chemical and radioactive tracer. Radioactive tracer is the chemical compound tagged with radioactive isotope that provides the compound with highly selective and sensitive analytical methods. The volumetric sensitivity of radiotracer detection allows greater sensitivity at low levels compared with chemical detection. Therefore from a practical viewpoint, the radiotracer was seen as especially suitable for use in the fractured basement because of the huge dilution volume and high temperature.

In Rang Dong field, radioactive tracers were selected after consideration of safety, stability, the ability to discriminate between tracers and cost. The following tracers were selected.

- Injector A: Ethanol (EtOH)
- Injector B: Benzoic acid
- Injector C: HTO
- Injector D: Ethanol (EtOH)
- Injector E: Methanol (MtOH)
- Injector F: HTO

3. MONITOR SYSTEM AND ANALYSIS IN RANG DONG FIELD

3.1. Tracers injection

Tracers are injected as a pulse during normal operation of the injection well. The procedure of tracer injection is as follows (Figure 2):

- Installation of tracer injector to injection line near to well head
- Filling tracer and monitor solution into injector;
- Pressure test of installed system at working pressure;
- Pumping tracer into well head by an air driven hydraulic metering pump; the injection time is up to 6 hours.
- Decontamination of working area and disassemble the tracer injection system.

3.2. Tracer sampling

Typical sampling points are at the wellhead of producing wells (Figure 3). Sampling is

started before tracer injection to measure natural background with one sample for one observation well (production well). Samples are collected once or twice a day for the first months then twice a week for the duration of the program. The keys points for success of tracer program are:

- Consistent sample size (usually 1 liter)
- Sample is taken on time.

3.3. Tracer analysis

The tracer breakthrough is confirmed based on the following conditions:

- Measured tracer activity exceeds Minimum Detection Limit (MDL) at the confidence level of 99% (3σ) in order to be distinguished from the background.
- The tracer activity distribution vs. time forms of peak that reflects the flow in fracture porous media.
- A good sampling program and measurement with adequate detectors (high efficiency, low background, and low statistical error) are essential to obtain good response curves which are the base for the further interpretation.

Tracer concentration during movement in the porous media is described by the equation [3]:

$$C(x,t) = C_{REF} \frac{1}{\sqrt{4\pi \frac{D_1}{vx} t_N^3}} e^{\frac{(1-t_N)^2}{4\frac{D_1}{vx}t_N}}$$

C_{REF} : Coefficient of tracer concentration,

t_N : Observation time since injection, day,

D_1: Dispersion coefficient, m^2/d,

v, x: Velocity (m/d), distance from injector, m.

Swept volume can be expressed by following equation:

$$V_s = \frac{m}{M}\frac{Q_i}{Q_p} V_p$$

m: Amount of tracer produced

M: Amount of tracer originally injected

Qi: Injection flow rate

Qp: Water produced flow rate

where, Vp, the mean produced volume, is calculated from the first moment of the produced tracer concentration, C, as a function of the produced volume:

$$V_p = \frac{\int_0^\infty CVdV}{\int_0^\infty CdV}$$

3.4. Tracer analysis results in Rang Dong field

Tracer analysis in Rang Dong field has just commenced but the results of tracer analysis are starting to gives a picture of fracture network in basement reservoir. In combination with pressure interference and water sample analysis the communication between regions or wells in the same region have been captured. Furthermore, the communication between wells (Injector C and Producer D') was observed by tracer breakthrough despite no indications from pressure interference or water sample analysis.

Tracer break through (BT) seen to date are:

Injector C → Producer C': Confirmed BT.

Injector C → Producer D': Confirmed BT.

Injector D → Producer D': Confirmed BT

Injector E → Producer E': Confirmed BT

Injector F → Producer F': Confirmed BT

Other wells: no BT is observed

Tracer concentration HTO (injected from Injector C) in producer C' and producer D' are 16,000 Bq/l and 323 Bq/l, respectively which

are higher than minimum detection limit (MDL) of 23.15 Bq/l. This indicated HTO had breakthrough to producer C' and producer D'. Up to now, tracer recovery in producer C' and producer D' are 8.45% and 0.1%, respectively (Figure 4&5).

4. CONCLUSION ON INITIAL RESULTS AND UNCERTAINTIES/DIFFICULTIES

4.1 Initial results

- Tracer method in combination with pressure interference, water sample analysis helps us to understand more about communication in fracture network in Rang Dong field.
- Communication between wells to wells can be seen by tracer analysis despite no indication in pressure interference (Tracer of injector C was observed in producer C' and D').
- We can use cheapest type of radioactive inject to some wells to reduce the cost if we know fracture is isolate by regions. (Injector A&D: Ethanol, Injector C&F: HTO).

4.2. Uncertainties and difficulties

- Operation affects tracer analysis result:
  - Water injection operation is not working continuous.
  - Bad weather condition prevents to collect sample on time.
- Reservoir characteristic affects tracer analysis result:
  - Water injection slumping will cause a lot of tracer dispersion so could get very long breakthrough times.
  - Tracers can show very small swept volumes-difficult to apply in simulation scale.
- Some wells interference can be seen by pressure interference but has not seen yet by tracer. Difficult to imagine fracture network in reality.
- Tracer response curves are still building up. Need to close monitor and combination to other methods (pressure interference, water analysis) to understand more about the fracture network.

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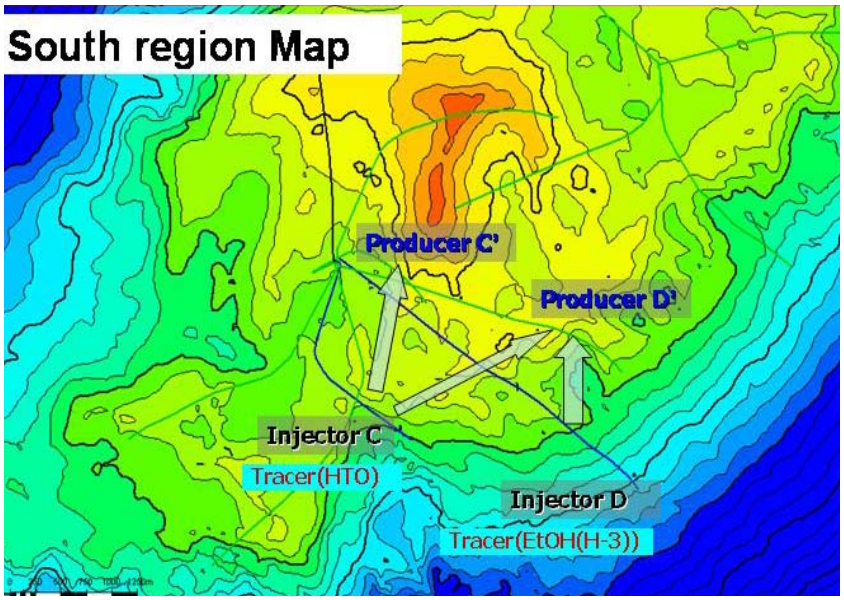

Fig. 1 Water Injection wells in south region

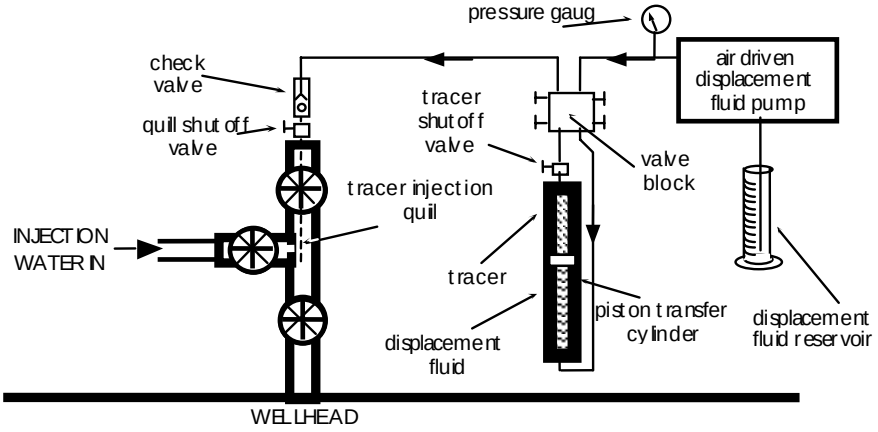

Fig. 2 Direct tracer injection

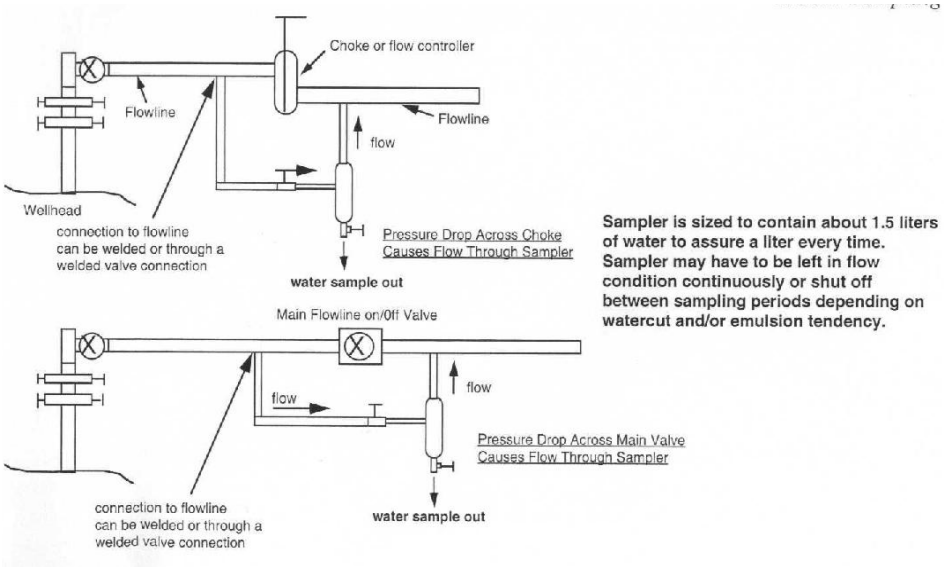

Fig. 3 Well head sampler installation

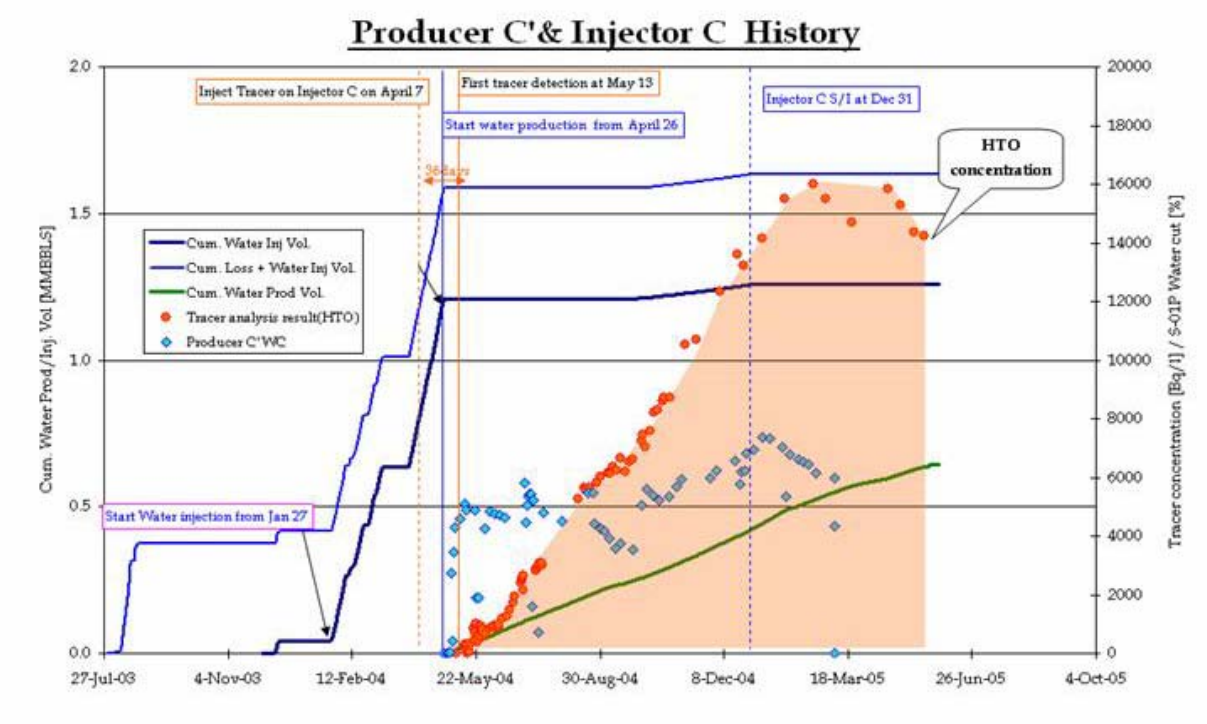

Fig. 4 Tracer analysis: Injector C to Producer C'

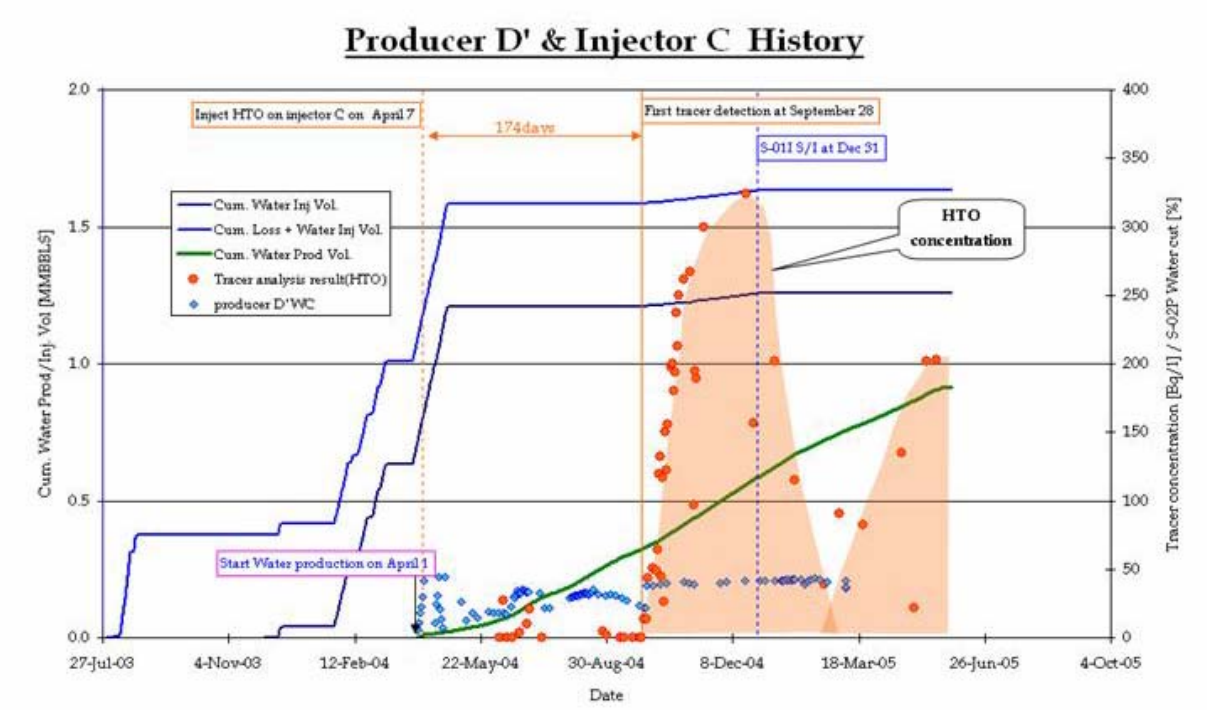

Fig. 5 Tracer analysis: Injector C to Producer D'