ID-1997554

Inter Well Tracer Test: A Unique Tool to Monitor Water Flood: Geleki Field of ONGC in Assam - A Case Study

Rakesh Kapur
Oil and Natural Gas Corporation Limited, E&D Directorate, Dehradun, India

Presenting author, E-mail: *kapur_rakesh@ongc.co.in*

Abstract

Geleki field was put on production in the year 1974. The field is a multi-layered heterogeneous reservoir producing under depletion drive. Average production rate is ~ 1300 m^3/d with a water cut of 20% & GOR of 300 v/v. Major sands are operative under depletion drive. Water is being injected to maintain reservoir pressure and sweep efficiency for improving recovery.

For effective use of water injection, monitoring the break-through of water flood movement is very important. There are different tools to monitor the significant impact of water injection. Radioactive 'Inter Well Tracer Test' is one of the most important tool used to track the injected water in the reservoir. In this technique radioactive material is injected in the water injection wells having good injectivity and injection rates. After regular intervals, fluid samples are collected and tested for tracer counts.

Present paper discusses the use of radioactive tracers in water injectors in Geleki field successfully. Results indicated water breakthrough in few nearby oil producers. Corrective measures by profile modifications in water injectors and water shut off jobs in oil producers were taken accordingly. The effective use of radioactive inter well tracer test has resulted in increasing the sweep efficiency and hence the percentage of recovery.

Introduction

Geleki field of ONGC discovered in 1968 is the second largest oil field of ONGC in Assam, was put on commercial production in 1974. The field is located on the southern fringe of Upper Assam valley and covers an area of about 25 sq km. Commercial oil production has been established in Tipams formation of Miocene age, Barails formation of Oligocene age and Kopilis formation of Eocene age.

The reservoir is multi-layered sandstone with interbedded siltstone. The Miocene Tipam sands divided into TS-1 to TS-6 from top to bottom occur at depths ranging from 2300 to 3500 m. TS-2, TS-3A, TS-4B & TS-5A are the main oil bearing sands along with Barail Coal Shale (BCS) at depths ranging from 3500 to 3700 m, Barail Main Sand (BMS) at depths ranging from 3700 to 4000 m and sands within Kopili formations.

During the journey of 40 years of production, the field has passed through various phases of challenges. Field has substantial oil inplace volumes but could not produce much due to various exploitation problems. Major sands are operating under depletion drive. Exploitation strategy envisaged water injection for pressure maintenance which was started in 1991 for obtaining optimum recovery. Even after water injection since 1991, reservoir pressures remain low and for oil production, gas lift is being used since long time. Water injection for pressure maintenance remained a challenging task for the field. In general, water injection is on a skewed pattern and in few of the sands it is peripheral pattern.

Inter well tracer tests provide a solution to trace the injected water in such heterogeneous reservoir and subsequently water shut off jobs in oil producers and profile modifications in injectors.

This paper deals with the use the successful application of isotope ratio analysis to the heterogeneous matured multilayered complex sandstone reservoir of Tipams formation of Geleki field to characterize injector-producer communication and intra-reservoir connectivity in a matured field.

The use of radioactive tracers Tritiated Water and Carbon -14 Labeled Ammonium Thiocyanate in different wells and examining the results of inter well tracer. Field work was carried out for pilot designated for an in-depth permeability modification treatment. The objectives were to delineate fluid migration in the reservoirs and to compare tracer performance. Residual oil saturations in the water flood areas were also measured using inter well tracers. In addition, production response to water injection may provide more definitive answers to questions about reservoir connectivity.

Water flooding is used to maximize production rates and recovery factor. Even the analysis of the failure data can be used to indicate the short-circuit caused by high stresses in the weak reservoir formation. Tracer study was also undertaken to provide information on the short circuit dimensions and to design a remedial treatment.

The case study presented in the paper will be helpful to those designing and implementing water shut offs, identifying water flood problems and testing low cost re-mediation alternatives by using inter well tracer studies.

Need for Inter Well Tracer Test

For the design and application of an EOR process for an oil field, it is extremely important to identify the reservoir heterogeneities that may significantly affect the flow performance of injected fluids. Some information about the reservoir heterogeneities in the vicinity of wells can be obtained from well logs and core analyses. Pressure-transient and pressure-pulse tests will give some knowledge of reservoir permeability, communication, or fractures over a wider region of the reservoir, but provide only averaged estimates of these properties. An inter well tracer test, on the other hand, can provide 3D characterization of a reservoir. The tracer-test data show the actual flow performance of injected fluid; hence the reservoir characteristics that affect the fluid flow can be estimated directly from these data, provided that an adequate method is devised to analyze them quantitatively.
Inter well tracer (IWT) tests were planned and executed with the objectives of:

- tracking of injection water movement behaviour in the target sand
- finding the directional/preferential flow trends, if any
- ascertaining the continuity of layer and characterizing the faults/barriers, if any

In depletion drive mechanism, to optimize the oil recovery from the reservoir, water is injected to jack up the depleted reservoir pressure. Water is injected through different injection patterns. High permeability streaks are embedded in the sandstone reservoir and these high permeability streaks are the main culprits in water injection mechanism.

Theoretically, water front pushes the oil zone ahead uniformly but in actual water front moves in zig zag fashion moving fast in the high permeability streaks and thus causing a breakthrough of water front without pushing the left out oil zone. To find out, from which injector, the injection water is moving to which producer and to further to carry out profile modification of the injector well or water shut off of the producer well to enhance the oil production.

Method of Inter Well Tracer Test

Inter well tracer test is a very simple test but involves lots of accuracy, coordination and carefulness. Radioactive tracers are injected in the selected water injectors. Water injection is started and monitoring of injected radio-active tracers needs to be carried out with sampling and analysis of the produced fluid from the monitoring wells at regular intervals for the tracer response in brine phase. For the initial six months the well head samples from the monitoring wells are to be collected twice in a month and later on the sample collection is to be carried out on monthly basis.

If there is no break though of the water flood front, the salinity of the produced water will match with the formation water. In this case tracer counts in DPM/ml are measured and in one particular well surrounding the injector there is a breakthrough of the injected water flood front.

Well Selection Criteria

For the use of 'Inter Well Tracer Test' diagnostic tool, proper wells were selected where the permeability of the reservoir is relatively better & the water cut has risen in a very short period to a good extent. Injector wells were selected on the basis of following criteria.

1. Injection rate should not be less than 50 m3/d which in turn has to be ascertained by PLT studies carried out by logging services.
2. Should have good injectivity so that tracer solution can be injected easily in the formation.
3. Well should be cleared up to minimum 15 m below perforation intervals to carry out PLT logging.

Field Trial of Inter Well Tracer Method

In Geleki field, three injector wells A, B & C were selected based on the criteria mentioned above. All the three injector wells were selected based on invert square pattern.
Details of Injectors, oil producers for monitoring and the name of the Tracer and their quantity used is given below:

Sl No.	Tracer Injector Wells	Tracer Injector Sand	Name of the Tracer and Its Quantity	OIL Producer Monitoring Wells
01	A	TS 5A	Tritiated Water (50 Curie)	D, E, F & G
02	B	TS 2	Tritiated Water (30 Curie)	M & N
03	C	TS 2	Carbon-14 Labeled Amm. Thiocyanate (275 milicurie)	P, Q & R

Tracer injector wells were prepared for carrying out PLT studies to calculate the amount of water injected through the perforations. Dummy runs were carried out by logging team. CCL-GR-Temp-Flow-meter logs were recorded in flowing condition. Closed the well for 18 hours and recorded the flow at different cable speeds. Radio-active tracers were procured from BRIT, Mumbai.

Fifty curie Tritiated Water was injected in the well A (for sand 5A), thirty curie Tritiated water was injected in well B (for sand TS-2) and two hundred seventy five millicurie of Labeled Ammonium Thiocyanate in well C in the presence of BRIT and IRS representatives by taking complete protection against radioactive materials. Materials which came into contact of radioactive substance was burned and thereafter buried into official dumping site designated for such purpose. Water injection started in all the three wells A, B & C.

These tracers are low activity beta emitting radio-isotopes and do not pose any health hazards during sampling of the produced fluid from the identified producing monitoring wells. Oil samples were collected initially fortnightly and thereafter on monthly basis from the monitoring wells. The sample collection was continued for one year. Water was separated from sampled oil and was sent to IRS Ahmedabad for analysis for measuring the tracer counts in DPM/ml.

Field Response

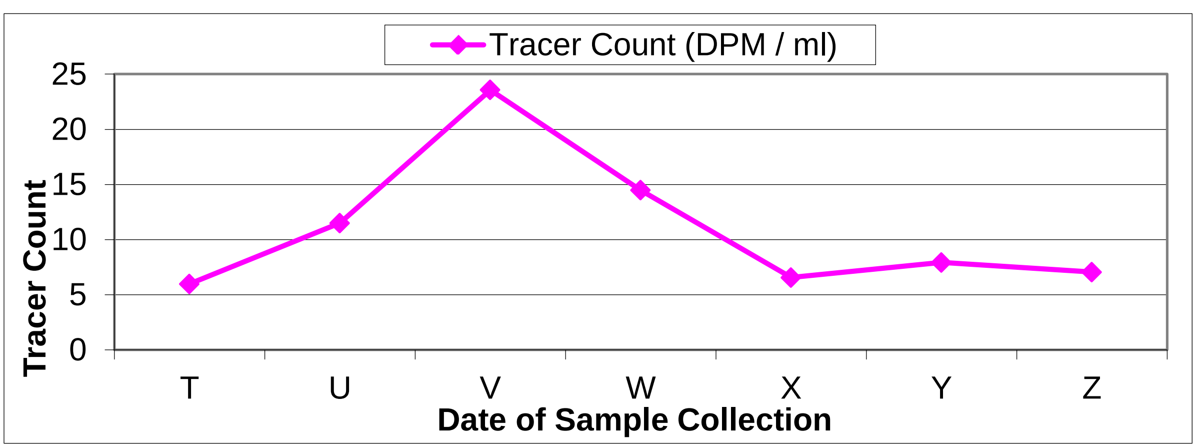
Water containing a chemical tracer was injected at a constant rate into an injector surrounded by designated production wells. Effluent analyses showed very early breakthrough of injected water in two of the producing wells. The test results suggest strong area heterogeneity of the tested formation. The model treats tracer solution as a fourth component and can also account for adsorption of tracer. Simulation efforts were concentrated on matching the breakthrough times and tracer profiles after breakthrough. Through both the analytic and the simulation work, the reservoir is characterized by a highly heterogeneous distribution of horizontal permeability, a thin layer of high permeability, and a natural water drive that cause a preferential flow trend in a direction toward one producer.

Results are tabulated & plot of tracer count in producing well with time indicate that the maximum value of tracer count was observed in producer well in about 3 ½ months after injection.

Pic. Injection of tracers in the Geleki Wells

Sample Analysis for Tracer Response: Monitoring Well D (Tracer Injector A)

Sl No.	Date of Collection	Tracer Count in Well D (DPM / ml)
01	T	5.98
02	U	11.5
03	V	23.56
04	W	14.47
05	X	6.56
06	Y	7.92
07	Z	7.06



It is evident from the plot that the tracer count in the monitoring well 'D' had increased with time after injection and reached to a maximum level of 23.56 DPL/ml, thereafter it started reducing and reached near to its initial level i.e. 7.06 DPM/ml. This clearly indicates the breakthrough of injection water from injecting well to monitoring producer well.

Oil gain in Producer well by Inter Well Tracer Test

Fig-1 : Log motif of hydrocarbon bearing layer of TS-2 sand of Well 'D' before CSQ job.

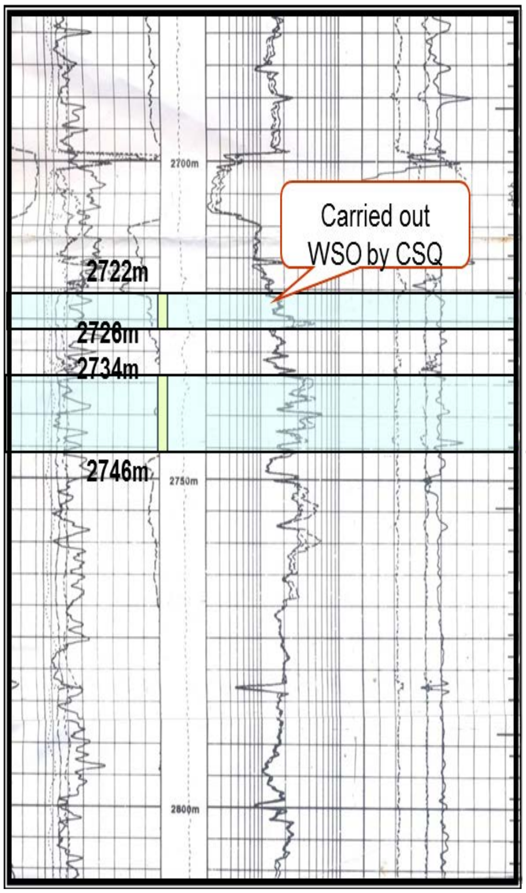
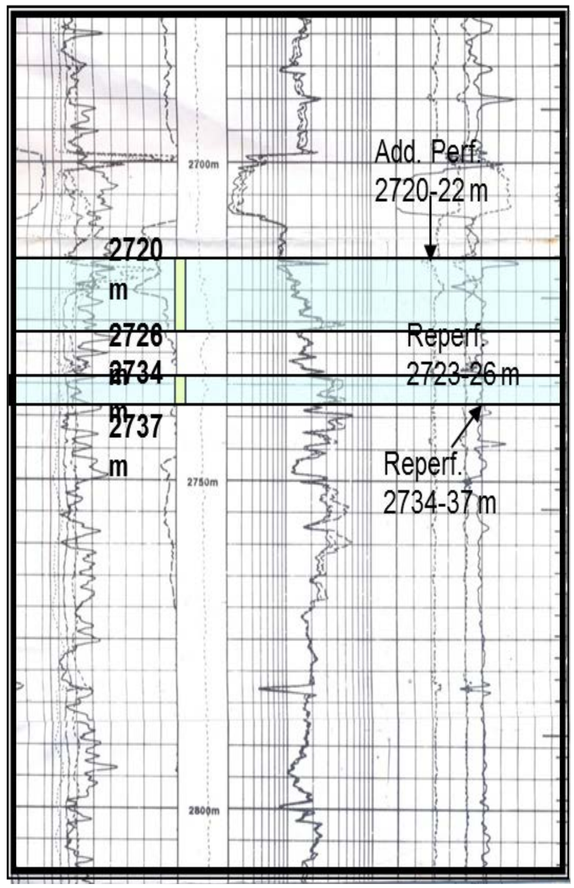


Fig-2 Log motif of hydrocarbon bearing layer of TS-2 sand of Well 'D' after CSQ job.



It was found from radioactive counts that there is water breakthrough in well 'D'. Logs of well 'D' and that of injector A were studied in detail and proposed for water shut-off by cement squeeze job in well 'D'. The perforation intervals in well 'D' before water shut-off job were from 2722-2726 m and 2734-2746 m. (Log shown in Fig-1). Well 'D' was a good producer since beginning but subsequently water cut increased and the well became sick. The complete open zone was squeezed with cement and again additional perforation was carried out from 2720-2722 m. Reperforation was carried out from 2723 - 2726 m and 2734 - 2737 m. (Log shown in Fig-2). The well was put on production in a very short span of time and the present oil rate is 33 m3/d contributed a significant oil gain.

Commercialization

Based on the encouraging results achieved during field testing, the technology can be extended to commercial level in the fields of ONGC as well as Oil India Limited.

Results and Discussion

Inter well tracer survey is widely used in the Mumbai High fields where we are adopting the peripheral injection and invert pattern also. As per the records available, this technique is used in Geleki field of ONGC's Assam Asset on trial basis and achieved significant oil gain after performing cement squeeze job in the monitoring well of the tracer injected water injector.

Inter well tracer can be used in different fields and also from different horizons of the same field as shown in the well list taken up for this job. This technique has increased the oil production rate.

Constraints

- The major constraint is the dependability on BRIT for the radio-active isotopes.
- Health hazards if there is any leakage of radioactive isotopes.
- Wells need PLT studies for injection rates after hole clearance.
- Liquid samples are contaminated in the monitoring wells.
- There is a need of proper demulsification of produced fluid in low water-cut wells, to separate water and facilitate tracer analysis.
- Low water cut trend in the monitoring wells.
- Lengthy process starts from injector identification, radioactive isotopes procurement, injection, monitoring and in the last profile modification or cement squeeze job in the monitoring wells.

The Uniqueness of the Technique

- No work over rig required for injecting tracers.
- No depth constraint for inter well tracer survey job to be executed.
- Does not require sophisticated equipments for field implementation.
- Definitely help in improving the bottom line of the company.

Conclusions

Water injection is the most common secondary recovery process. Injection optimization requires a correct assessment of interwell communication. This is valid in sandstone reservoirs which are heterogeneous in nature, the dynamic impact is usually difficult to assess with static data such as wellbore images or seismic. Production logging or interwell tracing are among the most applied and valuable monitoring techniques to evaluate this impact.

The Way Ahead

Considering the encouraging results obtained in the field implementation of inter well tracer injection jobs for water front movement, it is to be planned to extend the technology to other fields as well.

References

1. Review of Tracer Surveys by Wallace Johnson (Cardinal Chemical. Inc. Odessa. Texas) | Billy P. Morris (Cardinal Surveys Co. Odessa. Texas).
2. Some Case Histories of Remedial Work Resulting from Water Tracer Surveys by Walter O. Ford Jr. (Ford Well Logging Co.)
3. Application of Chemical Tracers in IOR: A Case History by Mahmoud Asadi (ProTechnics) | G. Michael Shook (Chevron ETC)