PROJECT REPORT

ON

Reservoir simulation study of a producing field by creating a new simulation model using CMG simulator for monitoring of an oil field.

BY

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M-Tech(Petroleum Exploration)

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A thesis submitted in partial fulfillment of the requirements for the award of Degree in

Master of Technology
(Petroleum Exploration)

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CERTIFICATE

The undersigned certify that they have gone through and verified the report on the major project entitled "**<u>Reservoir simulation study of a producing field by creating a new simulation model using CMG simulator for monitoring of an oil field</u>**" submitted by **<u>V.SURENDRA SUNKAVALLI</u>**. and recommend to the College of Engineering, UPES for the acceptance of partial fulfillment of the requirements for the award of degree of **<u>M. TECH in PETROLEUM EXPLORATION</u>**.

Sokari 05 MAY 2011

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ABSTRACT

This project deals with the reservoir modeling and simulation of a producing oil field with the help of a CMG simulator. The first part of this project deals with the reservoir modeling. The geological maps which are generated from the well logging data are the inputs for the simulator .The static model or a geological model is prepared and it is converted into a dynamic model by giving PVT data and the relative permeability data. Once the model building is done , we will run the model with the help of a simulator for a single time step in order to calculate the reserves. Then we will compare this reserves with the reserves calculated from the volumetric analysis .If both are matching then the geological model is correct and we can proceed for further simulation runs. Otherwise we have to modify the reservoir model until a good match is obtained.

The field production data and the pressure data is imported into the simulator. Now, a constraint is given to the simulator (example: oil production rate) .So the simulator will forcibly produce oil at that rate .Now the major part is to do history matching. When the results of field data and the model data are compared ,only oil rate will match because it is given as a constraint. The major task is to match the bottom hole pressure ,reservoir pressure, water cut %,gas to oil ratio by changing the geological and other parameters.

Once ,we obtain an approximate history match, the prediction can be done.

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I wish to express deep sense of gratitude to Mr. A.K.Ray, Chief Manager (Reservoir) for being a source of inspiration during the project work which made the project work a learning experience. Words are inadequate in offering my thanks all members of Mehsana Asset Development Group Mr. N.N Badola, CM (Reservoir), Mr. Somnath Majhi, CM (Reservoir), Mr. Amit Roy chowdhury, (Chief Geologist), Mr. D. K .Mathur, CM (Reservoir) and Mr. Pankaj Bhuyan (Geologist) , K.Bhaskar CM(Reservoir) for their help and support to reach the successful completion of my project.

I would also like to extend my heartfelt thanks to Mr. J.P. Srivastava, CM(Reservoir), coordinator training for permitting me to work on this project at IRS, Ahmedabad.

Special thanks to Dean Dr. Shri Hari, H.O.D Dr.Pradeep Joshi and my internal guide Dr.SOKARI.P.BRAIDE.

I appreciate the warmth and friendship that existed between me and the staff and the teachers at UPES, whom I interacted during my study at the University of Petroleum and Energy Studies.

Last but not the least, I wish to express my deep sense of respect and gratitude towards my parents and other family members for their affection, care, support given at every phase of my life.

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EXECUTIVE SUMMARY

As a part of our M- tech curriculum we were scheduled to do a project work in the final semester. So I have chosen Institute of Reservoir Studies , to complete my dissertation work. This four month summer training was held in Institute of Reservoir Studies, ONGC from 4th January to 25th April, 2011.

Oil and Natural Gas Corporation Limited (ONGC), a Navaratna public sector enterprise is a leading oil company of India engaged mainly in exploration, development and production of crude oil, natural gas and other value added products. ONGC (incorporated on June 23, 1993) is an Indian public sector petroleum company. It is a Fortune Global 500 company ranked 335th and contributes 77% of India's crude oil production and 81% of India's natural gas production. Today

it has emerged as a fully fledged integrated upstream petroleum company with its service capabilities and infrastructures. It has been possible due to the strength of nine member R & D Institutes, viz. KDMIPE, GEOPIC, IMD of Dehradun; IRS, Ahmedabad; IOPGPT, IEOT, Mumbai; IPSEM, Goa; INBIG of Jorhat, Assam.

These institutes provide consultancy services on Exploration, Drilling, Reservoir Management, Production, processes, Engineering, Offshore Technology, Environment and Safety to private and multi-national oil companies around the World.

To complete my dissertation work I worked with Mehsana Light Oil Development Group, IRS. My project was on Reservoir simulation study of a producing field and by creating a new simulation model using CMG simulator for online monitoring of an oil field.

CHAPTER 1

About IRS:

The Institute of Reservoir Studies (IRS) was founded in 1978 as a single-source and multi-service reservoir engineering agency with the objectives to:

- Maximize hydrocarbon recovery at minimum cost
- Maximize the value of proven reserves with conventional and improved recovery techniques.
- Enhance the skills and knowledge for better reservoir management

Since its inception, IRS has contributed effectively in the development of new concepts and innovative technique besides adopting State of art technological advancements as part of its concern.

A 400 seat Technical Seminar Hall, equipped with the latest audio-visual facilities and interpreter desks provides an ideal setup for technical presentations and conferences. The IRS library contains a wide range of books ranging from exploration to revenue management. It also subscribes to various petroleum industry related journals and magazines. A full set of SPE papers on microfiche and compact disks are available in the library. Seamless access to the internet is also available throughout the Institute through a lease line.

The Institute has been modeled around the concept of collaboration and interaction to accelerate the process of completing the studies, improve confidence by using the strengths of latest software and hardware and increase the accuracy of forecasting. IRS has a membership and technology transfer agreement with M/s Computer Modeling Group (CMG) Calgary, Canada. The Institute also has a technical collaboration for investigation in High-Pressure Air Injection (HPAI) as Improved Oil Recovery (IOR) process in medium and light oil reservoirs with the University of Calgary, Canada.

The activities of the Institute can be broadly classified into two categories to provide comprehensive solutions:

- Oil & Gas Field Development
- Laboratories

Oil & Gas Field Development:

IRS is the nodal agency for formulating the development schemes of oil and gas fields of ONGC. The emphasis is on Integrated Reservoir Studies combining seismic, geological, reservoir and production data areas as diverse as:

- Onshore and offshore environment
- Clastics, carbonate and basement
- Reservoirs containing gas, gas condensate, volatile, light and heavy oil.

The services offered in this field are:

- Data evaluation of well logs, core, seismic and production
- Formation evaluation
- Single well and field scale reservoir simulation
- Reserve estimation and production forecasting

The facilities available are:

- Multi-CPU Seismic Workstation
- Reservoir Characterization Workstation
- Multi-CPU Reservoir Modeling
- Simulation Workstation
- Multi-CPU Database Server
- HP 9000 series Workstations
- SGI Octane series Workstations
- P-II & P-III Servers

Laboratories:

Laboratories at IRS provide a complete range of studies on Reservoir Characterization, EOR Process and Well Productivity Enhancement. The integrated setup of laboratories itself becomes a guarantee to provide maximum profitability from reservoirs all through.

The services offered are:

- Conventional and special core analysis
- Phase behavior studies of all types of reservoir fluids
- Single and inter well tracer tests
- Physico-chemical characterization of injection water
- Screening and evaluation of water treatment additives
- Screening and characterization of polymers and surfactants, Laboratory evaluation, pilot design and monitoring.
- Identification and evaluation of biocide treatment
- Evaluation of cultures for improved oil recovery
- Water shutoff/ profile modifications

The facilities available are:

- Basic Data Generation Labs:
    - Scanning Electron Microscope with EDS
    - Facilities for conventional and special core analysis on consolidated and unconsolidated sands
    - X-ray diffraction machine
    - Phase behaviour studies of Oil-Gas and Gas-Condensate systems
    - Extended molar composition studies to feed up to C20
    - Perkin Elmer's Gas Chromatograph
    - Liquid scintillation counter
    - Spectrophotometer

- Enhanced Oil Recovery Labs:
    - Oil oxidation and spontaneous ignition tests
    - In-situ combustion and steam displacement assemblies
    - Displacement studies on 1-D core pack, 2-D sandstone block and sand packs

- Full suite of reservoir simulators including Thermal simulator- STARS 4, Component Black Oil and Simulator- IMEX, Compositional Simulator- GEM, and ECLIPSE Simulator

CHAPTER 2

RESERVOIR SIMULATION

What Goes Into Reservoir Simulation?

The basic tool for conducting a reservoir simulation study is a *simulator*. The development of this tool requires a good understanding of the physical processes occurring in reservoirs and a high level of sophistication and maturity in advanced mathematics and computer programming. Although simulation engineers generally do not get involved in actual software development, the effective use of reservoir simulators requires that they at least appreciate what goes into this development.

Like any tool, a reservoir simulator has its strength and limitations, and it is well to keep in mind the various assumptions that factor into its development. This is not to suggest that all simulation engineers must be expert programmers; rather, they must be *intelligent users*. Therefore, knowledge and understanding of the simulation process are necessary precursors to a reservoir simulation study.

At first, a simulation study might look like a once-and-for-all exercise. In truth, however, it is an evolutionary process, throughout which we continually refine our conceptual understanding of the system. While we cannot overemphasize the importance of accurate reservoir description in a good reservoir simulation study, we must at the same time acknowledge that the data needed for an accurate description is seldom available; invariably, studies start out with less than complete data. However, by carefully analyzing and interpreting the voluminous information generated during the study, we should be able to refine and extend the input data base. Such refinement should lead to a better understanding of the system and, ultimately, to a better reservoir description. Of course, this requires some agility and creativity; there is no such thing as a casual simulation engineer.

It is, therefore, apparent that there are three basic interwoven components that go into a simulation study. These are:

- The tool: reservoir simulator
- The intelligent user: simulation engineer
- The pertinent information: reservoir description

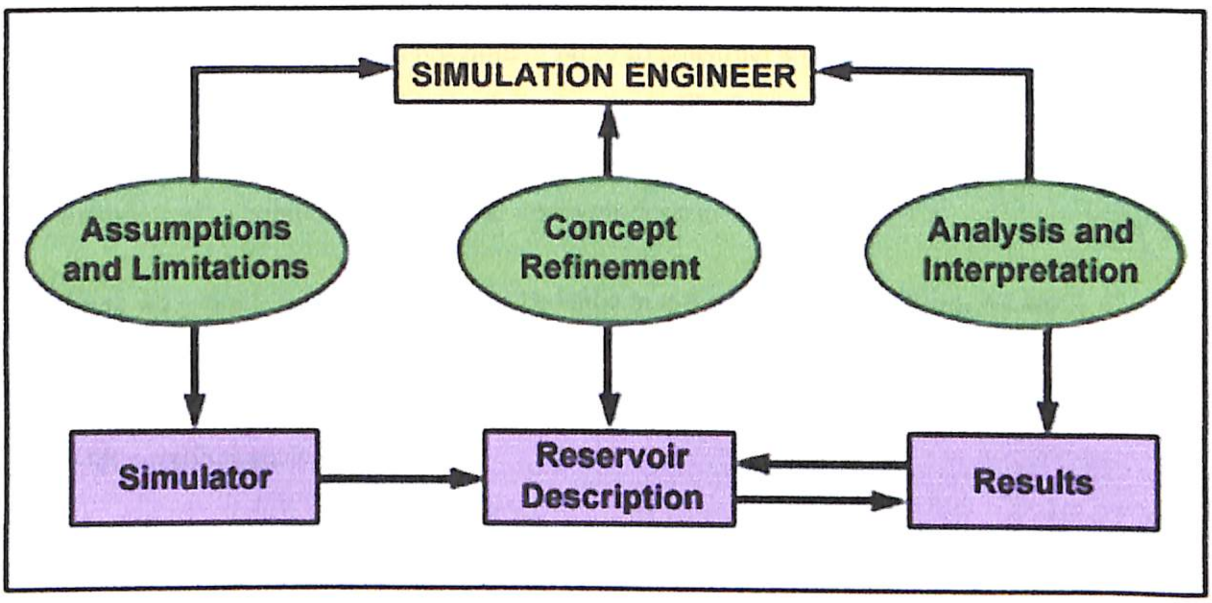

Figure 1:Reservoir simulation methodology

The engineer is clearly the prime mover in conducting the simulation study, and must be in control of other study components. This control involves: being cognizant of the simulator's limitations and the assumptions that go into its development

- being able to adequately describe the reservoir
- being fully conversant with the analytical techniques involved in interpreting the results.

Based on the initial results, it is not uncommon for the simulation engineer to revisit the appropriateness of the reservoir description through concept refinement.

Why Do We Need Reservoir Simulation?

The information we obtain from a newly discovered field is scanty at best. It is also disjointed to a certain extent, because bits and pieces of information are emanating from different parts of the field. Our first task is to integrate these pieces of information as accurately as possible in order to construct a global picture of the system. A reservoir simulation study is the most effective means of achieving this end. As field development progresses, more information becomes available, enabling us to continually refine the reservoir description.

Once we establish a good level of confidence in our reservoir description, we can use the simulator to perform a variety of numerical exercises, with the goal of optimizing field development and operation strategies. We are often confronted with questions such as

- what is the most efficient well spacing?
- what are the optimum production strategies?
- where are the external boundaries located?
- what is the predominant recovery mechanism?
- when and how should we employ infill drilling?
- when and which improved recovery technique should we implement?

These are but a few of the critical questions we may need to answer. A reservoir simulation study is the only practical laboratory in which we can design and conduct tests to adequately address these questions. From this perspective, reservoir simulation is a powerful screening tool.

Steps in a Simulation Study

There are five basic steps in conducting a reservoir simulation study:

(1) setting concrete objectives for the study

(2) selecting the proper simulation approach

(3) preparing the input data

(4) planning the computer runs (including the order in which they occur)

(5) analyzing the results

(1) Setting the Objectives

Setting objectives is the most important step in conducting a simulation study. Clearly defined objectives help us obtain the best information at the lowest cost and in the least amount of time. Improperly set objectives can take the study on a long, roundabout journey which leads to nowhere.

There are a number of factors that help us define appropriate objectives. The most important of these are data availability, the required level of detail, availability of technical support and available resources. In setting objectives , we use all of these factors to determine how to proceed.

In the broadest sense, when we consider all these factors, we will arrive at one of two types of objectives. These are sufficiently distinct that they affect the entire planning process of the simulation study. One type of objective is fact-finding, while the other is to establish an optimization strategy.

- *Fact-finding* involves answering questions about a system or process that is already in place. For example, a simulation study that matches well test data for the purpose of determining the damaged zone around a wellbore is a fact-finding mission.
- *Optimization* involves developing a number of plausible scenarios for a process (e.g., water flooding) and studying the system response in an attempt to determine the optimum scenario. In this case, we must design a suite of numerical exercises, being careful to avoid waste on exercises that may not significantly contribute toward the goal.

(2) Choosing the Simulation Approach

In choosing the simulation approach, we need to consider three basic factors:

- reservoir complexity
- fluid type
- scope of the study

While reservoir complexity and the scope of the study determine the simulator's dimensions and coordinate geometry, the fluid type (together with the processes involved) dictate whether we should use a black-oil model or a more specialized model. For example, predicting well performance in a gas condensate reservoir will require a compositional rather than a black oil simulator. Furthermore, if the reservoir is thin and unlayered, it will be sufficient to use a one-dimensional radial flow geometry. In any case, we must exercise our judgement and ingenuity in selecting the most appropriate simulation approach.

(3)Preparing the Input Data

Preparing the input data can be a laborious task for reservoir simulation. However, the time spent in ensuring that data are properly prepared is worthwhile, in that it can prevent a great deal of headaches and waste later on in the study. Often, we discover data input errors only after a problem surfaces during the run, which wastes both time and computing resources.

We should resolve inconsistencies during the data input preparation. When data inconsistencies are present, they can lead to an ill-posed problem. Even worse, they could go undetected. With an ill-posed problem, we may be able to find the inconsistency by the failure of the simulator to run; but in the case of buried inconsistencies, the simulator may run and yield erroneous solutions.

While data preparation is the simulation engineer's job, input from other supporting personnel is extremely important. If inconsistencies appear in the data, or even if some data appear doubtful, it is imperative to resolve the problem with the help of the geologist, geophysicist and perhaps the production engineer. In summary, there is no overemphasizing the importance of adequate data preparation prior to making a simulation study. The payoff is exceptionally good.

(4)Planning the Computer Runs

Planning computer runs is deceptively simple. To understand the necessity and the complexity of this planning, we only need to imagine a simulation study as a complex road map where the traveler knows the point of origin and the destination (these are clear enough from the objectives of the study). However, just as a traveler requires careful mapping out of the route that will get him or her to the destination in the best time possible, we must carefully map out the type and number of computer runs that will achieve the set objectives at a minimum cost. In so doing, we must account for several factors, which are usually problem dependent. We should consider the number of parameters to be examined, the duration of prediction, and the type of information needed to answer the pertinent questions.

Careful planning of computer runs includes not only determining their order, but also establishing a systematic labeling procedure for them. This is particularly important because of the large number of runs usually required and the voluminous amount of information invariably generated for analysis.

(5) Analyzing the Results

When we have analyzed the results of the simulation study and made pertinent inferences from it, we can evaluate its success. This step caps all the efforts previously discussed. Considering the amount of effort that we expend on the simulation study up to this point, it is tempting to become a biased arbiter of the results. On the contrary, this is the time to ask critical questions and even ponder over the implications of the results. In other words, we must not become easy subscribers to our solutions.

CHAPTER 3

Introduction

GEOLOGY OF THE AREA

This field ' A' lies in the Northern part of the Cambay Basin. The sands present in the field are kalol sands .

The Cambay Basin is located in the western Indian state of Gujarat. It lies between $21^{0}00'$ and $24^{0}00'$ north latitude and $71^{0}30'$and $73^{0}30'$east longitude. The basin extends from north of Patan town through the Gulf of Cambay and then south beneath the Arabian sea. The Cambay Basin is a graben with a width of 40 to 80 km and a depth of 5 to 7 km. It is a linear NNW-SSE trending rift, which is about 425 kms long. The basin, including its flanks, covers an approximate area of 53,500sq km of which 2500 sq km lies in the Gulf of Cambay. It occupies part of the Indo-Arabian platform.

The basin is bounded on the West by the Saurashtra Peninsula, which is covered almost completely by Deccan trap basalts, except in the North-Eastern corner where Mesozoic rocks crop out. The basin extends northward and connects with the shallower Barmer and Kutch basins. On its North-East flank, Aravalli-Delhi(Precambrian) rocks crop out, just West of which is a thin fringe of Mesozoic outcrops. These outcrops bound the basin. The Aravalli Series-together with Deccan trap outliers-define the Eastern margin of the basin. Outcrops of the Deccan Trap along a line Rajpipla-Navsari-Mumbai determine the southeastern limits of the basin. The basin extends southwards into the Gulf of Cambay, and farther offshore into the Mumbai offshore basin. The basin is completely covered by alluvial plains of the Sabarmati,Mahi Sagar,Dadhar,Narmada and Tapti river, with scattered and meager exposures of Mesozoic and Tertiary strata on its fringes (Himmatnagar,Ghogha,Jhagadia etc).Major tectonic lineaments,trending NNW-SSE, also are evident in the Northern part of the basin, and probably are related to the Dharwar orogenic belt of peninsular India. The extension of the influence of the Dharwar orogenic belt in the Cambay Basin, located this far North is disputable. The Dharwar trend in the Konkan area is reflected in the alignment of the dikes parallel to the Panvel flexure(monoclonal flexure) to which they are genetically related. In this basin Mehsana horst appears to have controlled the deposition of lower stratigraphic sequences of the area.

STRUCTURAL SETUP: The Cambay basin is mainly affected by extensional tectonics as indicated by the grabens, half-grabens, synclines, synthetic fault blocks The major lineaments trend is in NNW-SSE direction, i.e. Dharwarian trend. The other trend runs NE-SW which divides the basin into number of blocks. A prominent feature of the Mehsana Block is the Mehsana horst which is bounded by the N-S trending faults. This horst divides the basin into the Eastern and Western depressions and is genetically related to the formation of half grabens. The faults are generally distinct normal faults and have played an important role in the hydrocarbon accumulations and to some extent the sedimentation pattern. At the end of Mesozoic time, during late Cretaceous period extensional faults developed along the ancient basement trends followed by outpouring of lava flow which formed the technical basement, i.e. Deccan trap. The basin started rifting perpendicular to two major eastern and western margin faults which were parallel to the axis of the basin. A number of uplifts and depressions developed parallel to the axial trend. The Mehsana Horst is a major uplifted horst formed during that time. As the rifting continued the longitudinal fault system developed both towards east and west deriving sediments from uplifted block of Deccan Basalt and deposited as Olpad Formation. In Upper Palaeocene time, transgressive facies of older Cambay Shale filled the area. As rifting continued during Early Eocene time, the earlier generated faults reactivated and created more accommodation for deposition of Mandhali and Mehsana Member. The prograding sequences of kadi Formation can easily be recognized in the area. Kalol and Tarapur Formation rest conformably on Kadi Formation. Transgressive sequence of Tarapur Formation peneplained the area during Oligocene on which Miocene and Post Miocene sequences are deposited. The study area is characterized by different fault blocks seperated by fault systems.

COMPOSITE NATURE OF BASIN: The Cambay Basin is a composite basin characterized by two-stage structure-an Upper Cretaceous-Tertiary rift basin superimposed on an Upper Jurassic-Lower Cretaceous platform basin.The basin type,sedimentary fill and the structural styles in the pre-Upper Cretaceous basin are completely masked by thick Deccan Trap volcanic flows.

LOWER STRUCTURAL STAGE: The earliest appearance of the basin seems to have been during Upper Jurassic-lower Cretaceous time when the area was a gentle shelf bounded on the East by the Indian shield.A thin sequence of Upper Jurassic-Lower Cretaceous sediments was deposited on this shelf in environments alternating between shallow marine,brackish and deltaic with sediments derived by rivers draining Aravalli hills and adjacent uplands.Mesozoic strata may be observed at the surface as a discontinuous band of outcrops around the Cambay basin.

UPPER STRUCTURAL STAGE: The Mesozoic sequence is overlain by an almost complete sequence of Tertiary sediments ranging in age from Palaeocene to Holocene, with an intervening succession of thick Deccan Basalts.During Late Cretaceous and Tertiary, which form the upper structural stage of the basin, the Cambay basin in its northern part was an intracratonic graben with well-defined marginal faults striking NNW-SSE to almost N-S.

BASEMENT BLOCKS: The graben is divided into four tectonic blocks-the Narmada block, the Broach-Jambusar block, the Cambay-Tarapur block and the Ahmedabad-Mehsana block, all demarcated and separated by recognizable basement fault trends. Based on structural styles such as fault pattern, symmetry, size and orientation of depressions, the following tectonic blocks are presently recognized from South to North are-

Surat block

Narmada block

Broach-Jambusar block

Cambay-Tarapur block

Ahmedabad-Mehsana block

Patan-Tharad block

SURAT BLOCK: It is in the onshore of the cambay tertiary Basin and is characterized by NNW-SSE regional trend without any prominent faults. It is essentially a part of the Eastern flank of the Mumbai offshore. No oil and gas fields have been discovered in this block.

NARMADA BLOCK: Lying between the Narmada-Tapti rivers, the Narmada block is an Eastern continuation of ENE-WSW striking Satpura-Son lineament. it is a zone of high tectonic activity. this resulted in an ENE-WSW alignment of nearly all structures and faults in the Narmada block.Anklesvar, the largest anticline in the block is associated with faulting in the Deccan Trap on its southern flank. there are large number of oil and gas fields in this blocks.

BROACH-JAMBUSAR BLOCK: This block is a deep syncline containing more than 6,000m of Cenozoic sediments. This is the maximum known thickness of the basin. Gandhar ,one of the largest oil and gas fields in the basin, is present in this block. CAMBAY-TARAPUR BLOCK: Lying between the Mahi Sagar and Sabarmati rivers, the Cambay-Tarapur block is semi-circular in shape with a large number of structures on its peripheries. Faults with low magnitude are also prominent in this block .some of the fields in this blocks are Cambay, Ankol Juni, Kathana, North Kathana ,Nawagam and Dholka.

AHMEDABAD-MEHSANA BLOCK: This is the largest block in this basin and the field of my project is in this field. The block is limited to the south by the Nawagam-Wasna basement uplift, whereas its north boundary is arbitrary. The NNW-SSE aligned marginal faults of the basin are more pronounced in this block than in the other blocks. The block is segmented longitudinally into two major half-grabens, each with prominent down to basin fault hading eastward. A basement controlled topography high Mehsana horst is present in the middle of the block. The horst was formed probably by the rejuvenation along ancient faults after deposition of the Cambay shale, which seems to have been either exposed to erosion and removal of its upper part or deposited with reduced thickness over the high. The middle to upper Eocene Kadi and Kalol formations are also seen to pinch out on the flanks of this intra basinal high with the Miocene sediments on the crest. There is a large number of oil and gas fields in this block, namely kalol, Sanand, Ahmedabad, Bakrol, Wavel, NorthKadi, SouthKadi, Sobhasan, Bechraji, Santhal-Balol-Lanwa, Indrora, Jhalora, Viraj, Limbodra, Linch, Paliyad etc.

PATAN-THARAD BLOCK: This block lies north of the Ahmedabad-Mehsana block with a slight swing in the structural trend from NNW-SSE to NW-SE.The NE-SW trending Tharad ridge seperates it from the Sanchore depression.It is a comparatively shallow syncline containing about 2500m of Cenozoic sediments. The block is rather less explored compared to the other blocks of the basin.Only one oil field (South Patan) has been discovered so far in this block.

STRATIGRAPHY

Age	Formation	Member	Sand units
Pliocene to Recent	Gujarat Alluviam Jambusar Broach		
Lr.Miocene to Up. Miocene	Jhagadia Kand Babaguru		
Up. Eocene to Oligocene	Tarapur Shale		
Up. Eocene to Mid.Eocene	Kalol	Wavel	Kalol Sands
		Kansari Shale	
		Sertha	
	Nandasan Shale		
Lower Eocene	Kadi	Chhatral	Chhatral Sands
		Upper Tongue	
		Mehsana	UMS & MS Sands
		Lower Tongue	
		Mandhali	Mandhali Sands
	Viraj Shale	Neck Marker	
Palaeocene to Lr. Eocene	Older Cambay Shale	Linch equivalent Sand/Silts	Linch Sands
	Olpad		
Up. Cretaceous	Deccan Trap Group		

Figure 2:Generalised stratigraphy of a Cambay basin

CHAPTER 4

METHODOLOGY

(i)PREPARATION OF A GEOLOGICAL MAPS

Geological maps are generated from the well logging data. The following are the maps which are generated.

- Structure contour map
- Isolith map
- Isopay map
- Saturation map
- Porosity map

By using a planimeter , the amount of reserves are to be calculated.

ISOPAY MAP

Contour interval	Average value	Area	volume
0-2	1	0.23	0.23
2-4	3	0.32	0.96
4-6	5	0.3	1.5
6-8	7	0.33	2.31
8	9	0.38	3.42
		1.56	8.42

Area-Weighted thickness=8.42/1.56=5.39 mts.

Average Porosity=0.29

Average oil saturation=0.69

OIIP=(Area(Km^2)X Thickness(Km)X PorosityX Oil SaturationXDensity)/FVF

OIIP=(1.56X5.39X0.29X0.69X0.832)/1.29 =1.08 MMT

(ii)PREPARATION OF A GEOLOGICAL MODEL USING A BUILDER

(A)Preparation of a Static Model

Geological maps are the inputs to the model. So, the following maps are to be imported to the simulator .

(i)Structure contour map

(ii)Isolith map

(iii)Isopay map

(iv)Porosity map

(v)Saturation map

Size and number of grid blocks

Grid size and the number of grid blocks are not independent of each other. In a fixed system (i.e., a defined reservoir), specifying the grid size determines the number of grid blocks. There is no hard and fast rule for selecting the grid size for a simulation study. This does not mean that we have unlimited freedom in selecting the grid size. The degree of freedom is often limited by the amount of input data available, the information we want to gain from the study, and the investment we are willing to make in terms of computational overhead. In any case, there are a number of factors that impose lower and upper bounds on our choice of grid block size.

A grid of proper dimensions has to be selected. A grid of 25x30x1 is selected in which each grid block has the dimensions of 100x100 mts.

Then every property has to be populated over the entire grid

GRID TOP

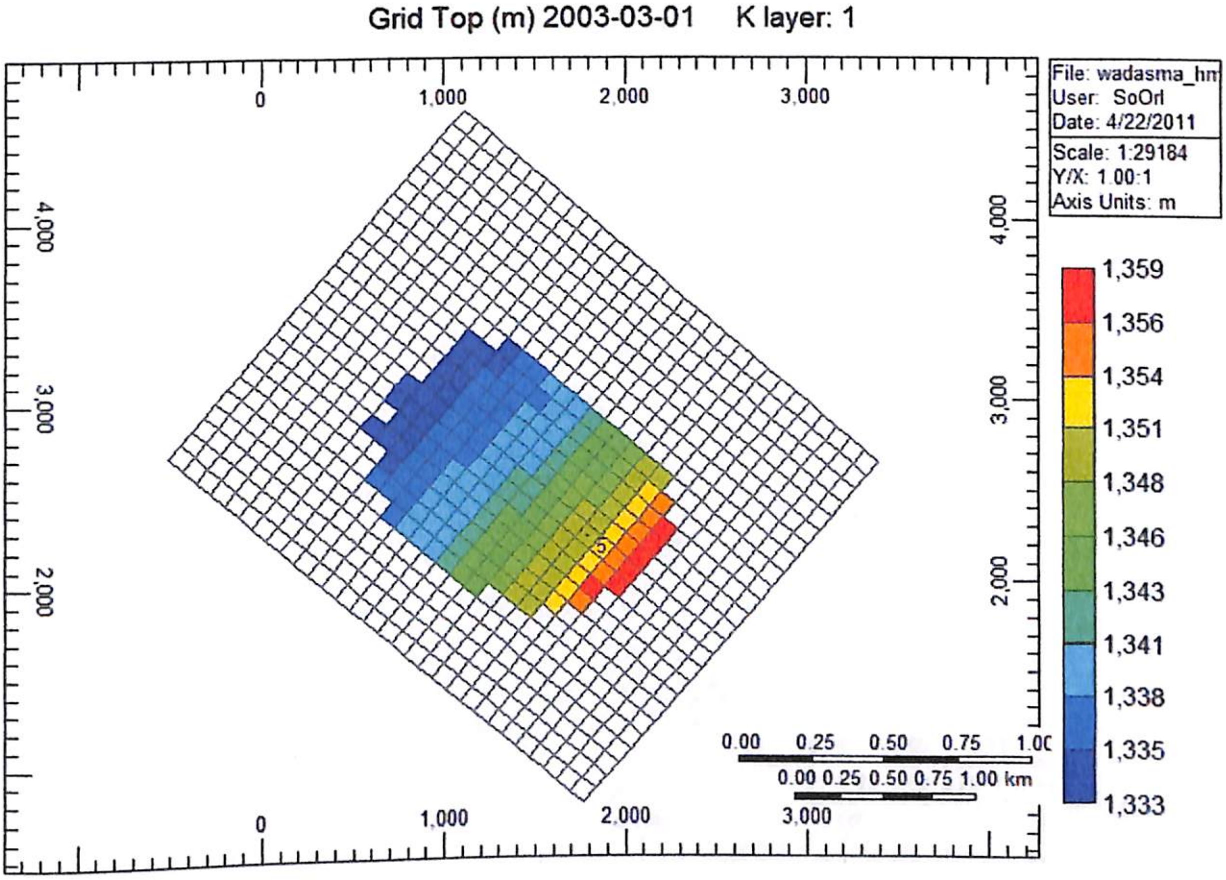

Figure 3:Grid top of a reservoir model

GRID THICKNESS

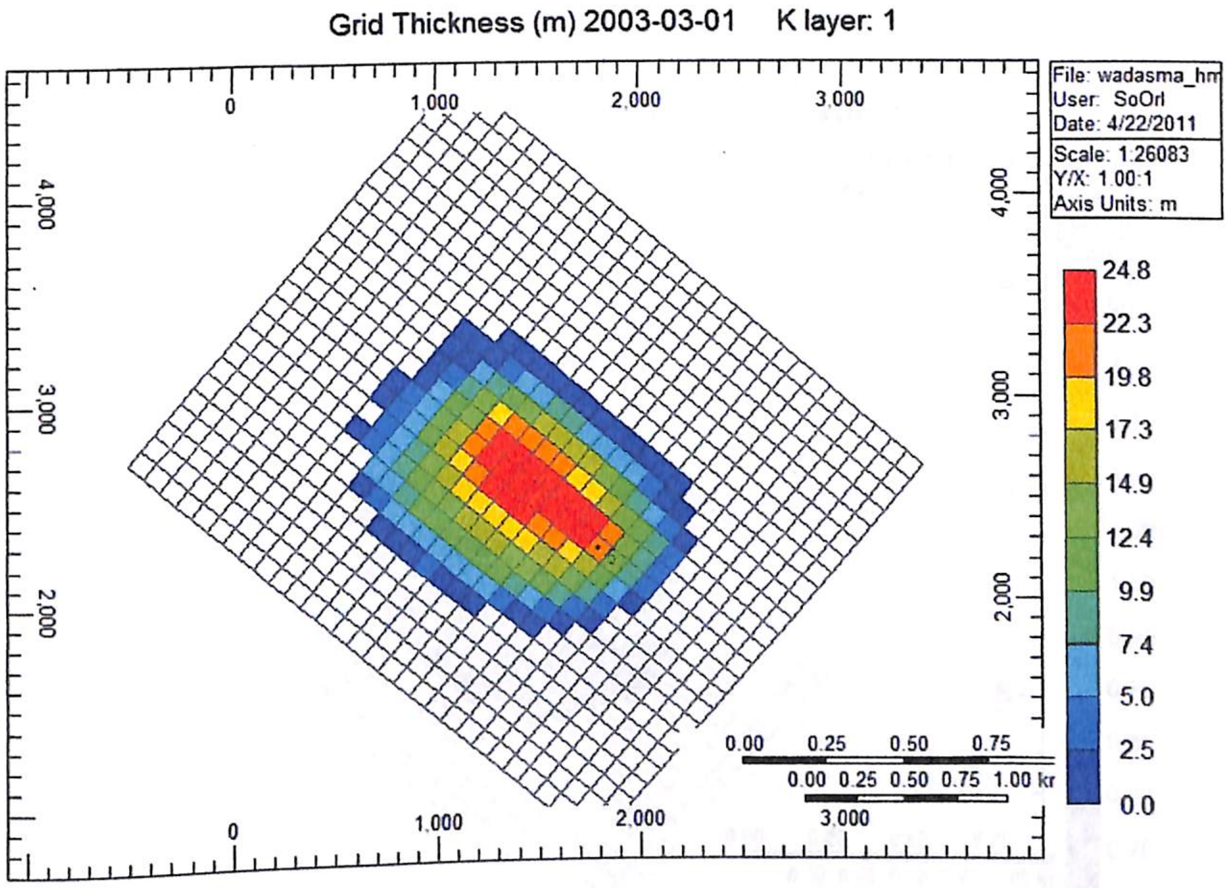

Figure 4:Grid thickness of a reservoir model

NET TO GROSS RATIO

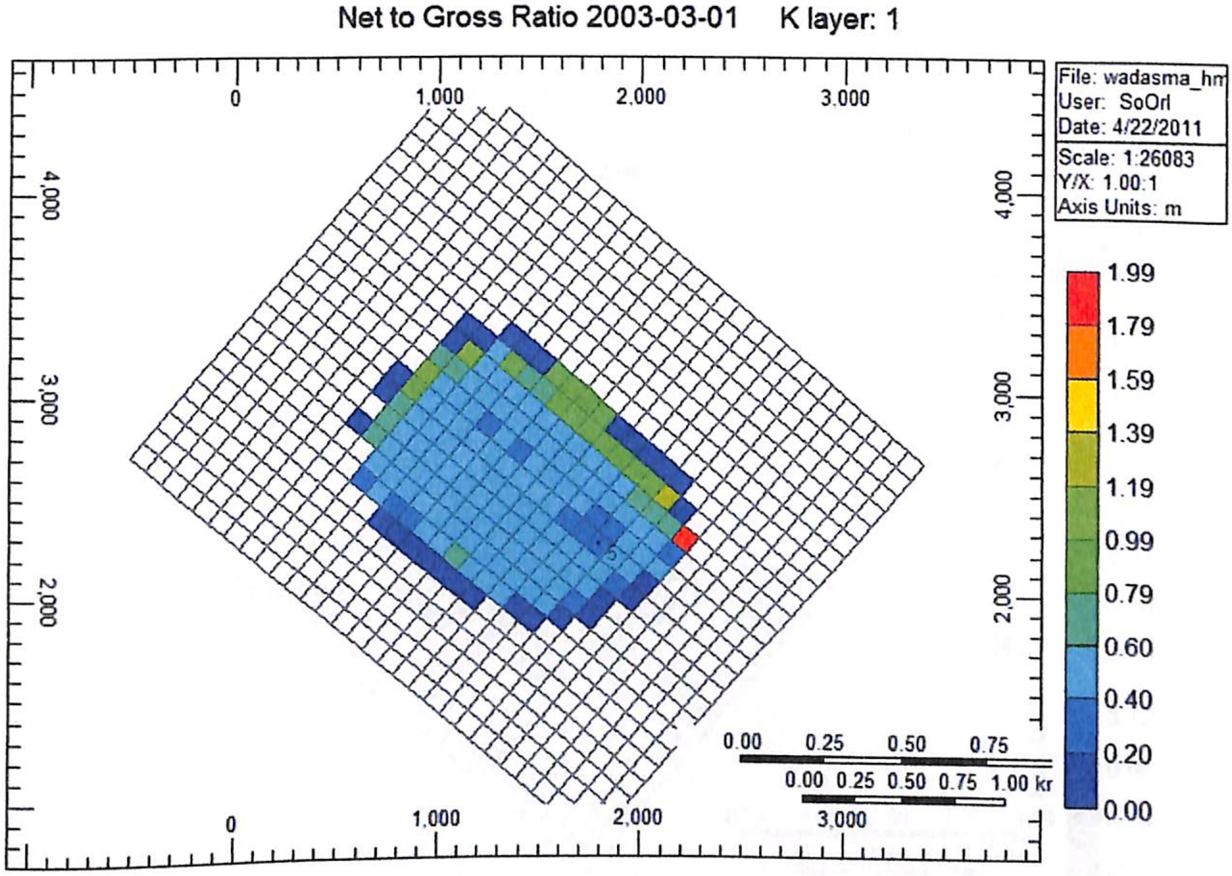

Figure 5:Net to Gross Ratio of a reservoir model

POROSITY

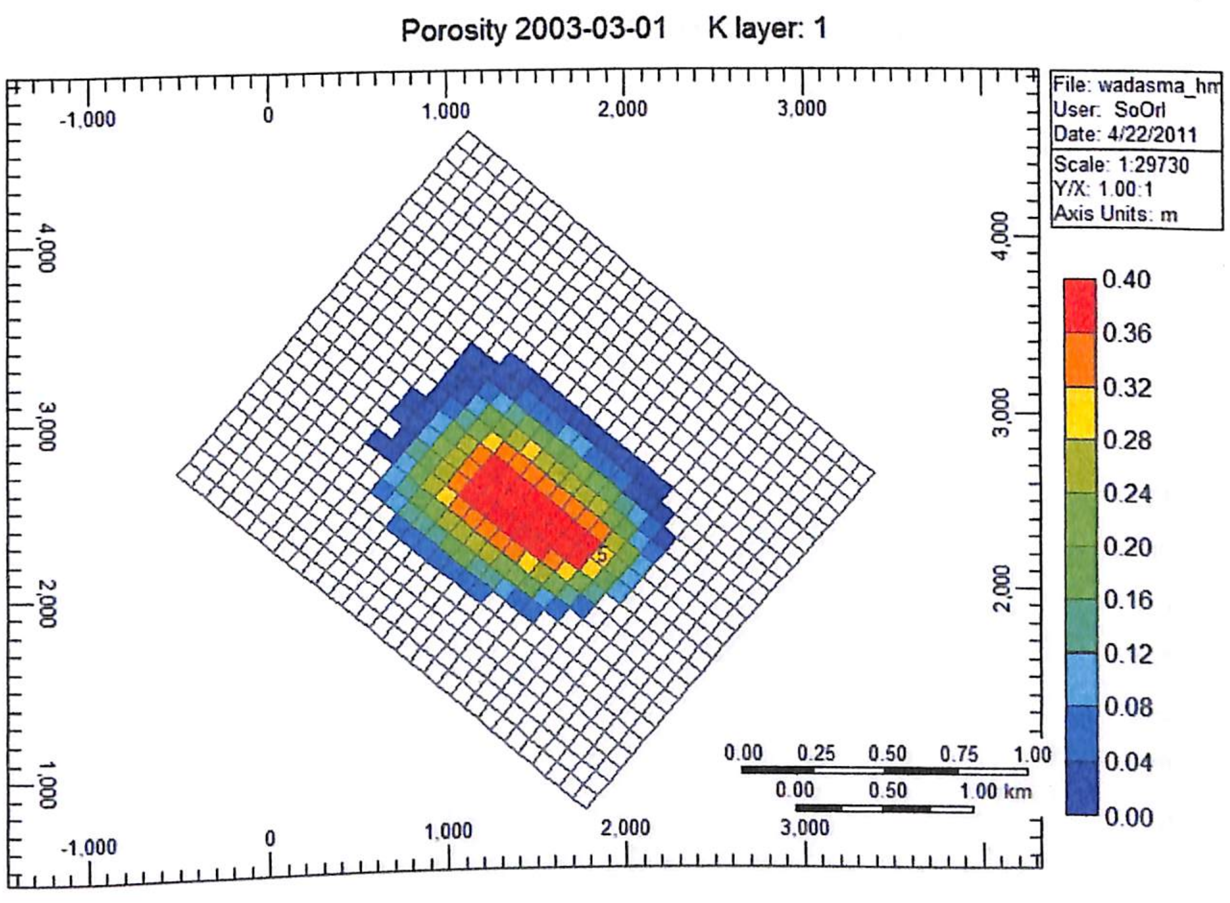

Figure 6:Porosity of a reservoir model

PERMEABILITY

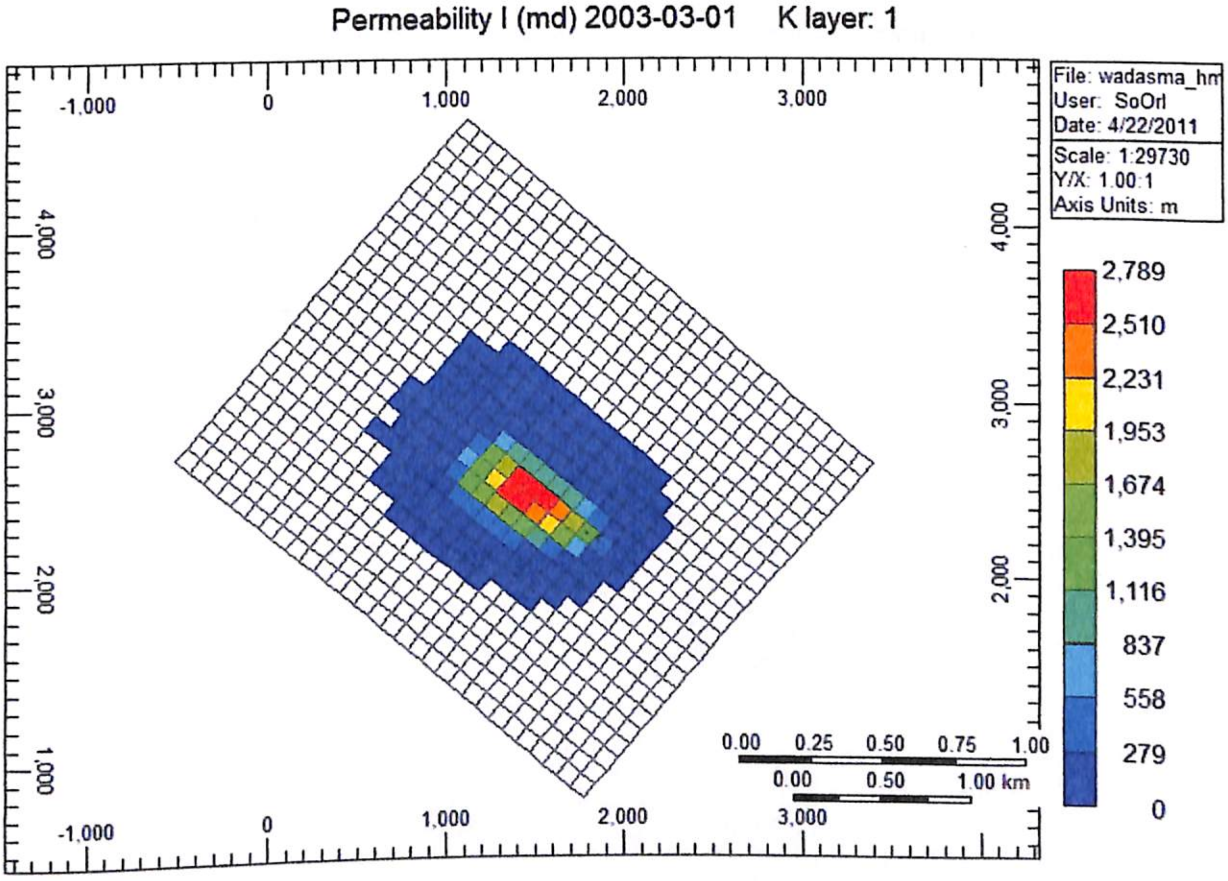

Figure 7:Permeability of a reservoir model

(B)PREPARATION OF A DYNAMIC MODEL:

Assigning" PVT properties" and" relative permeability Vs saturation" makes the static model into dynamic model.The PVT data is not available .So, I have generated by using correlations. Inorder to generate this data ,the following information is required.

Reservoir Temperature=88 ^{0}c

Oil density=836.4kg/m3

Gas Density=0.9280

PVT PROPERTIES

Press	Rs	Bo	Bg	Viso	Visg	Co
Kg/cm2	m3/m3	m3/m3	m3/m3	cp	cp	1/kg/cm2
1.033	0.756	1.02	1.244	2.9357	0.0118	0.000427
9.111	3.848	1.0302	0.1386	2.5973	0.0119	0.000427
17.189	7.504	1.0425	0.0722	2.3053	0.0121	0.000427
25.267	11.504	1.0563	0.0483	2.0682	0.0123	0.000427
33.344	15.759	1.0713	0.0359	1.8759	0.0126	0.000427
41.422	20.221	1.0873	0.0284	1.718	0.0128	0.000427
49.5	24.858	1.1042	0.0233	1.5867	0.0132	0.000427
57.578	29.648	1.1219	0.0197	1.4758	0.0135	0.000427
65.656	34.574	1.1405	0.017	1.3812	0.0139	0.000427
73.733	39.622	1.1599	0.0149	1.2994	0.0143	0.000427
81.811	44.782	1.1799	0.0132	1.228	0.0148	0.000427
89.889	50.045	1.2007	0.0118	1.1651	0.0153	0.000427
97.967	55.404	1.2221	0.0107	1.1093	0.0158	0.000427
106.044	60.854	1.2441	0.0098	1.0595	0.0164	0.000427
114.122	66.387	1.2667	0.009	1.0146	0.017	0.000427
122.2	72	1.29	0.0083	0.974	0.0177	0.000427
147.76	90.241	1.3673	0.0068	0.8675	0.02	0.000427
173.32	109.135	1.4498	0.0058	0.7854	0.0226	0.00036
198.88	128.604	1.5372	0.0051	0.7199	0.0252	0.000301
224.44	148.588	1.6292	0.0046	0.6662	0.0278	0.000258
250	171.845	1.7256	0.0043	0.6215	0.0304	0.000224

Relative Permeability curves :

When two or more immiscible fluids flow simultaneously through a porous medium, they compete and do not move at equal velocity. This results on the one hand from interactions between the fluids and the rock, and on the other from interactions among the fluids themselves. As previously mentioned, this manifests itself in interfacial tensions.

Interfacial tensions are not transport properties, and so we cannot use them directly to qualitatively characterize relative motion. We can, however, observe the relative ease with which each of the two competing fluids go through the porous medium—that is, we can measure the *relative permeability*.

Although relative permeability is not a fundamental property of fluid dynamics, it is the accepted quantitative parameter used in reservoir engineering. Relative permeability appears prominently in the flow equations used in reservoir simulation.

By definition, relative permeability is the ratio of the effective permeability, when more than one fluid is present, to the absolute permeability. *Effective* permeability is the measured permeability of a porous medium to one fluid when another is present. The effective permeability depends on the relative proportion of the two fluids present, or *fluid saturation*. Therefore, relative permeability is also a function of fluid saturation Core data is not available and this has been generated using correlations. These are prepared by the following end point data.

Connate Water Saturation : 0.2

Critical Water Saturation : 0.2

Irreducible oil saturation for oil water system: 0.4

Residual oil saturation for oil water system : 0.4

K_{ro} at connate water: 0.8

K_{rw} at irreducible oil: 0.3

Initial conditions:

The initial conditions of the reservoir are to be assigned.

Reference Pressure: 152.06 kg/cm2

Reference depth : 1351 mts

Water-Oil Contact : 1369 mts

Gas-Oil Contact : 1200 mts

Well and recurrent data

Once we have created the model, we will now incorporate the trajectory and perforation information into the model.

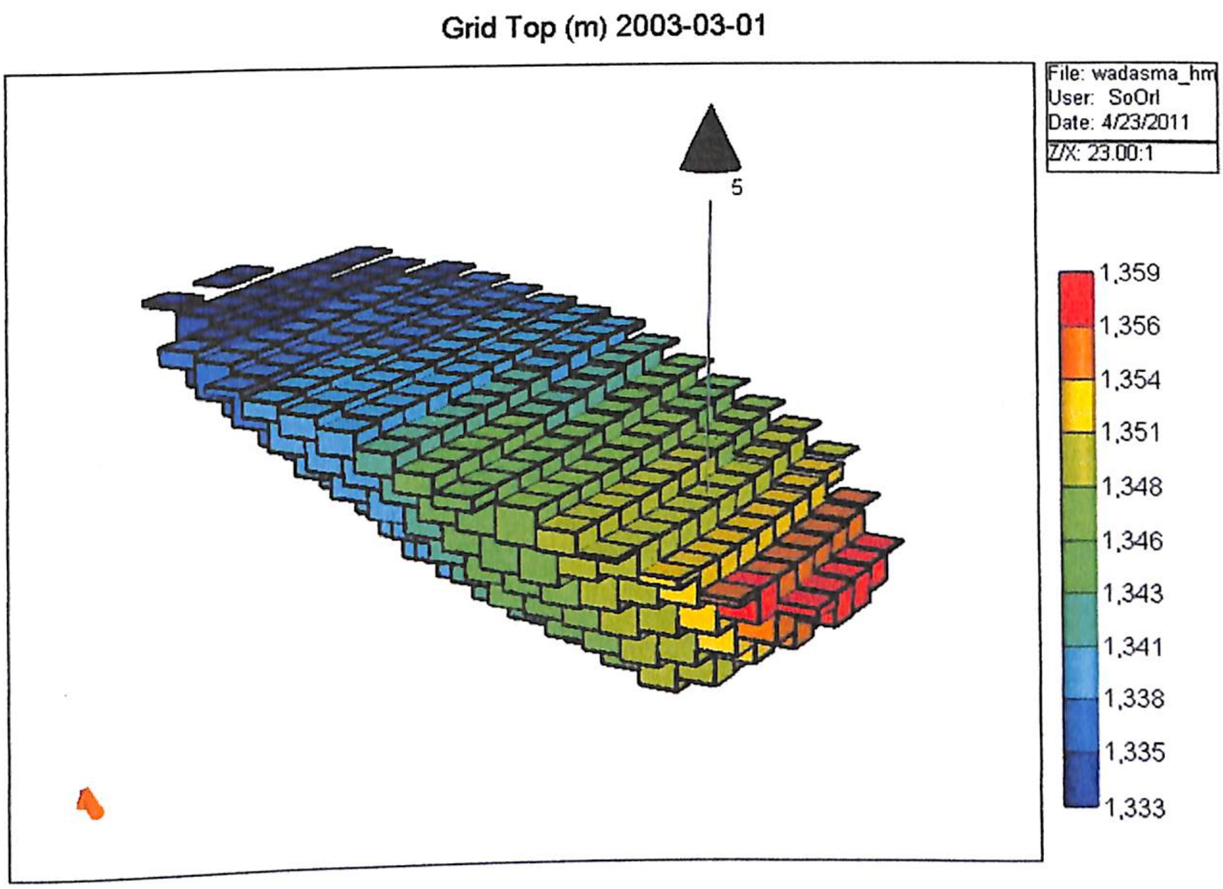

Figure 8:Reservoir mode with a producer

(C)Initialization:

The model has to be initialized with the I-MEX simulator. Initialization means running the model for one time step and we will get the amount of reserves. The amount of reserves from the model are about 1.137 MMT.

(D)Comparison of the Reserves

Reserves estimated from volumetrics=1.08 MMT

Reserves estimated from the model=1.137 MMT

% difference in reserves=(1.137-1.08)/1.137

=5.01%

The error was acceptable and can continue further.

Once the model reserves matches with the volumetric reserves ,we have to give the field production and pressure data to the model .Now we will run this model again using the IMEX simulator.

BEFORE HISTORY MATCHING

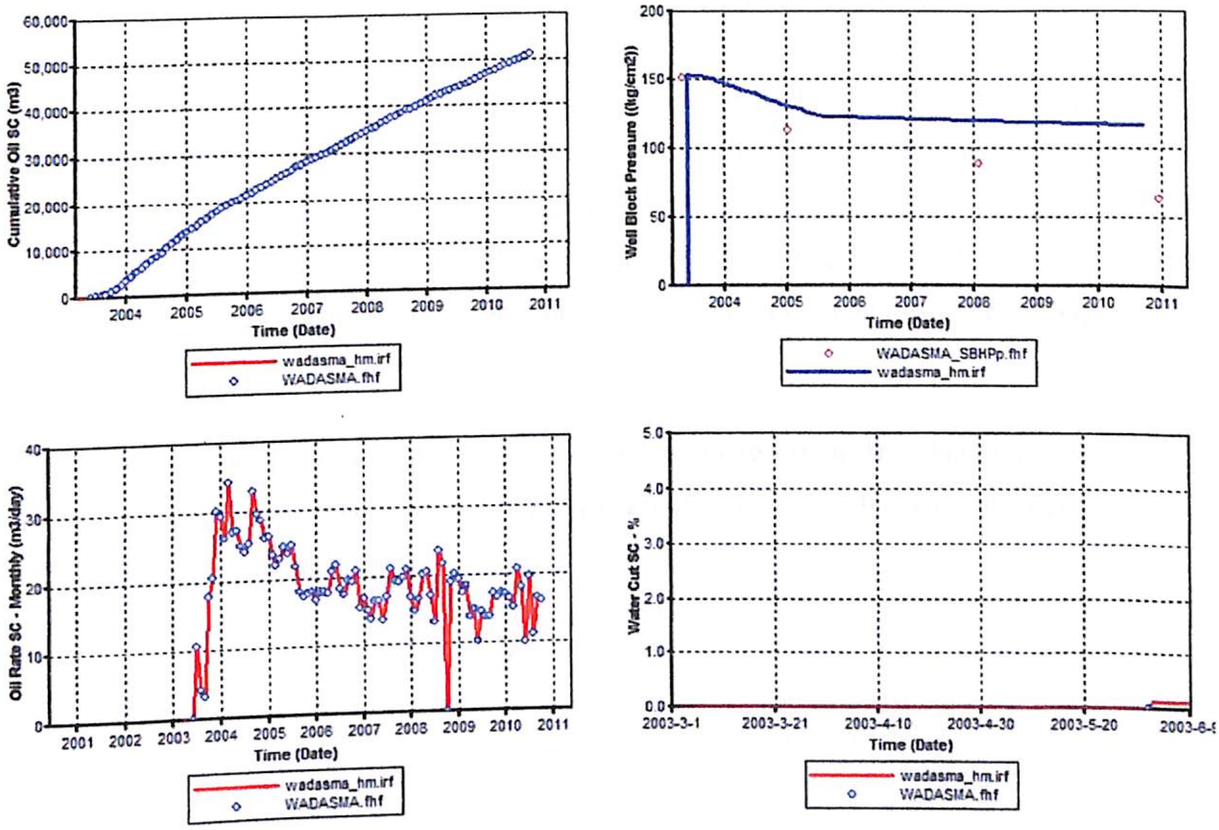

Figure 9:Graphs showing Comparison between Field history and model before history match

(E)HISTORY MATCHING

The production rate and cumulative production of oil of the model and the field history are matching. This is because we have taken oil rate as a primary constraint ,which means we made the model to forcibly take the oil at a particular rate and so it matches.

Other than that ,water cut% also matched properly. This is an isolated field having a single well .So, there is a well head installation. There is no scope for proper surface facilities. So , There is no information about the gas data. So, we cannot compare the GOR data. The only parameter in which there is a much difference between the field and the model is the reservoir pressure. The rate of decline of pressure in the model is very less when compared to the field data.

So, the main parameter I have changed was the volume of the reservoir. By changing the volume modifier value and then making some of the grid blocks as null blocks, some better matching results were obtained.

Grid Top (m) 2003-03-01 K layer: 1

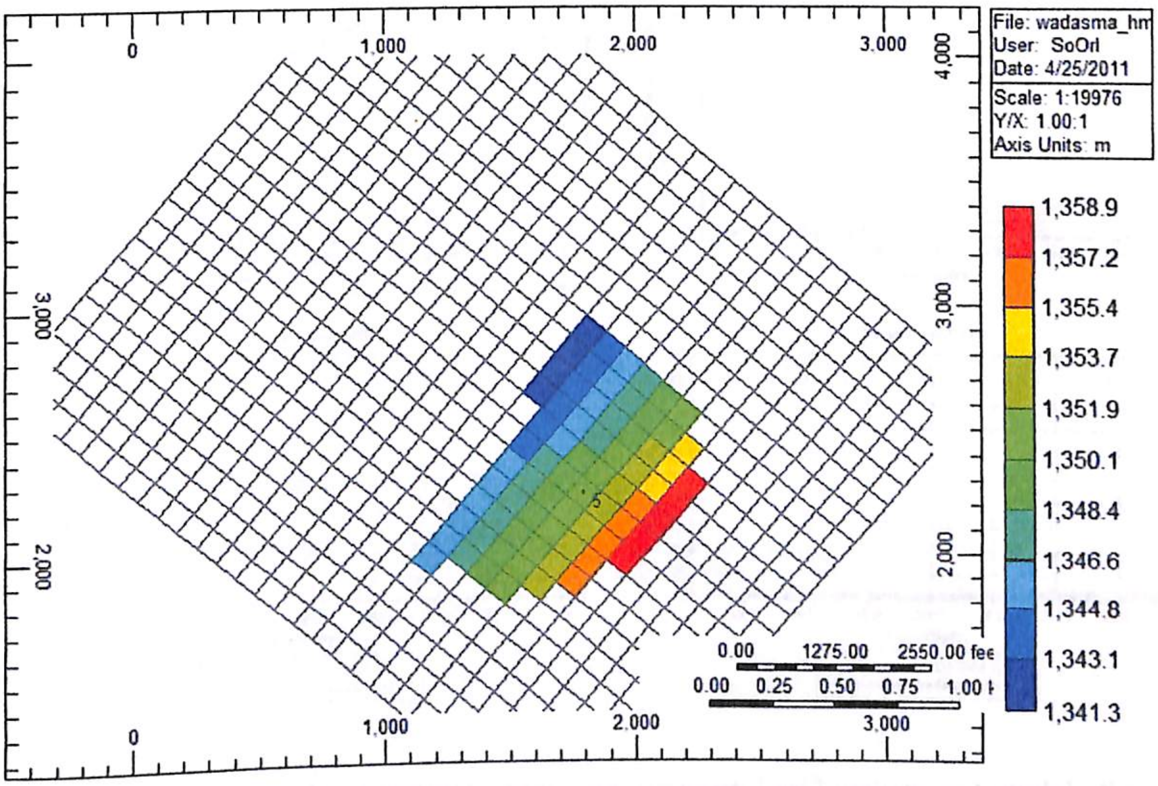

Figure 10:Grid top of a reservoir model after doing History matching

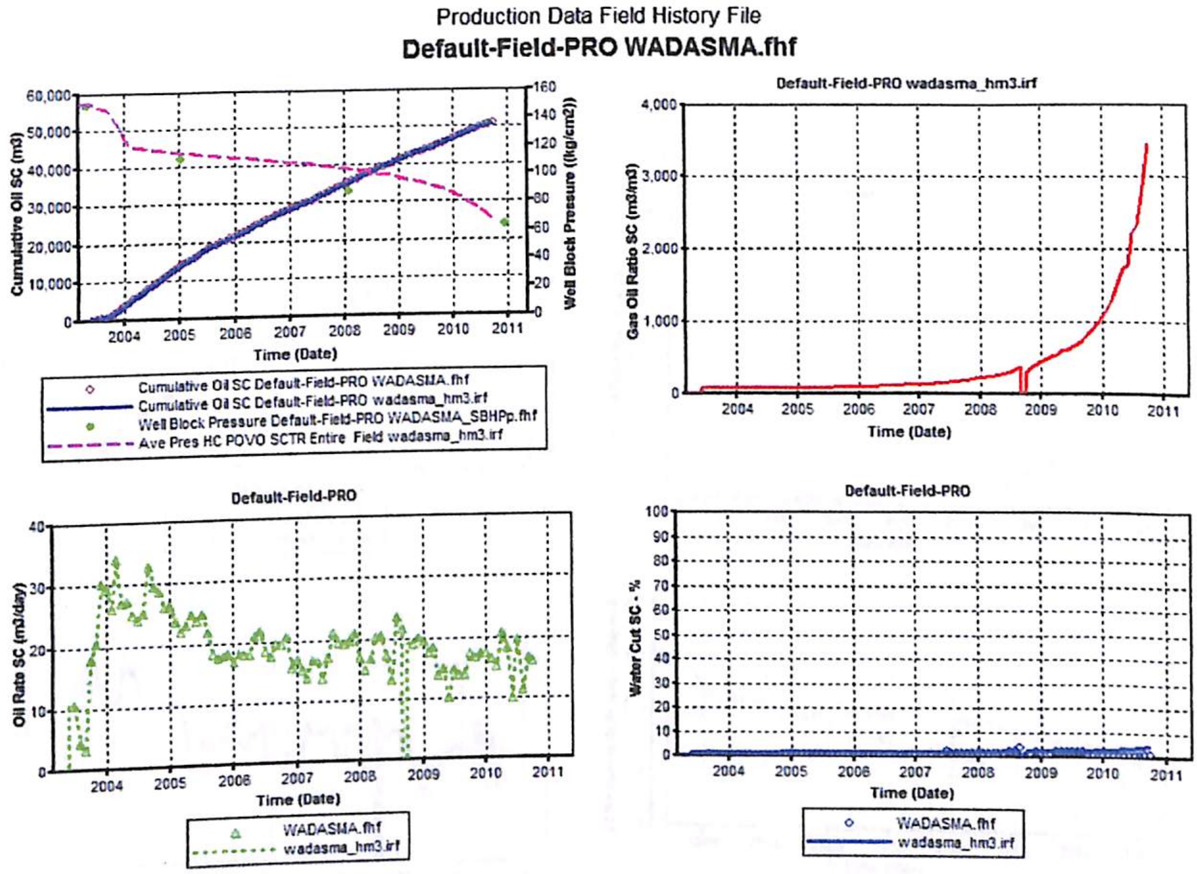

Figure 11:Graphs showing Comparison between Field history and model after history match

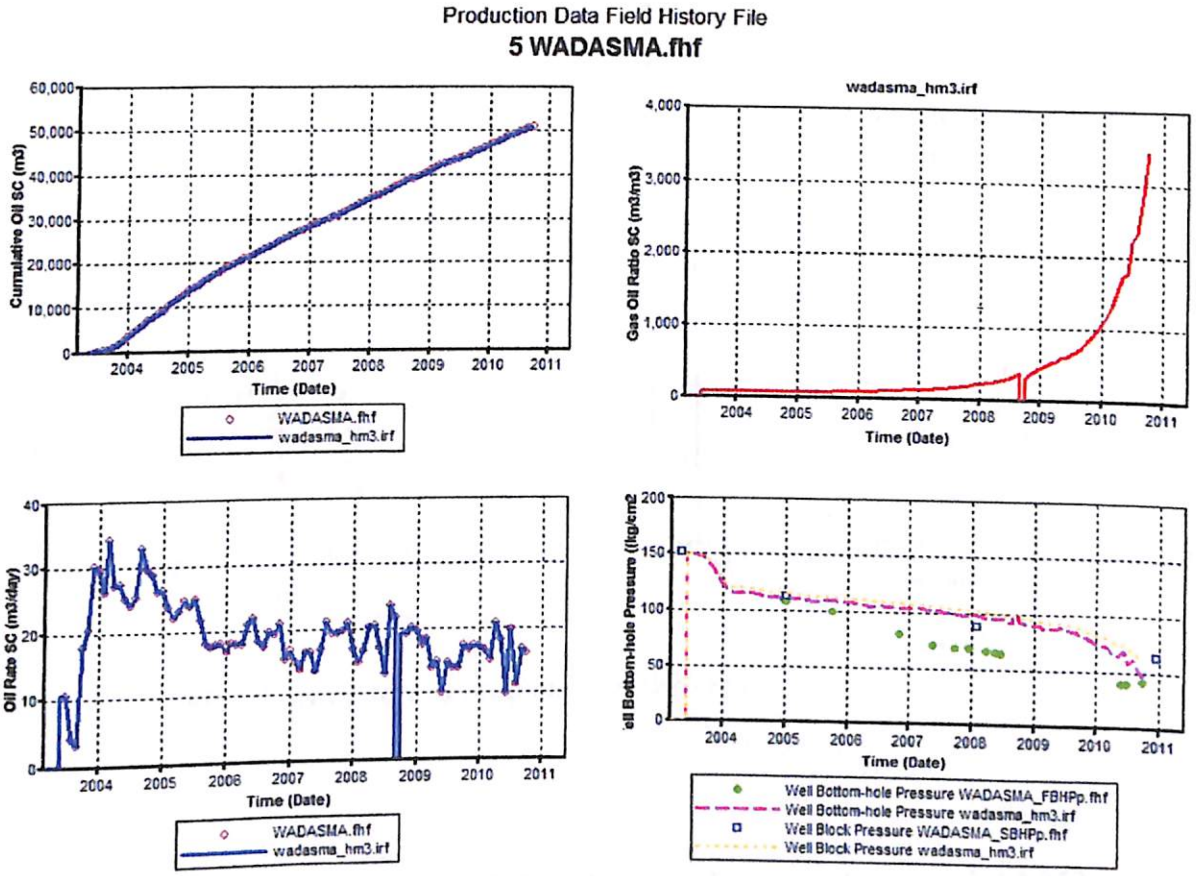

Figure 12:Graphs showing Comparison between well history and model after history match

(F)PREDICTION(Business as Usual)

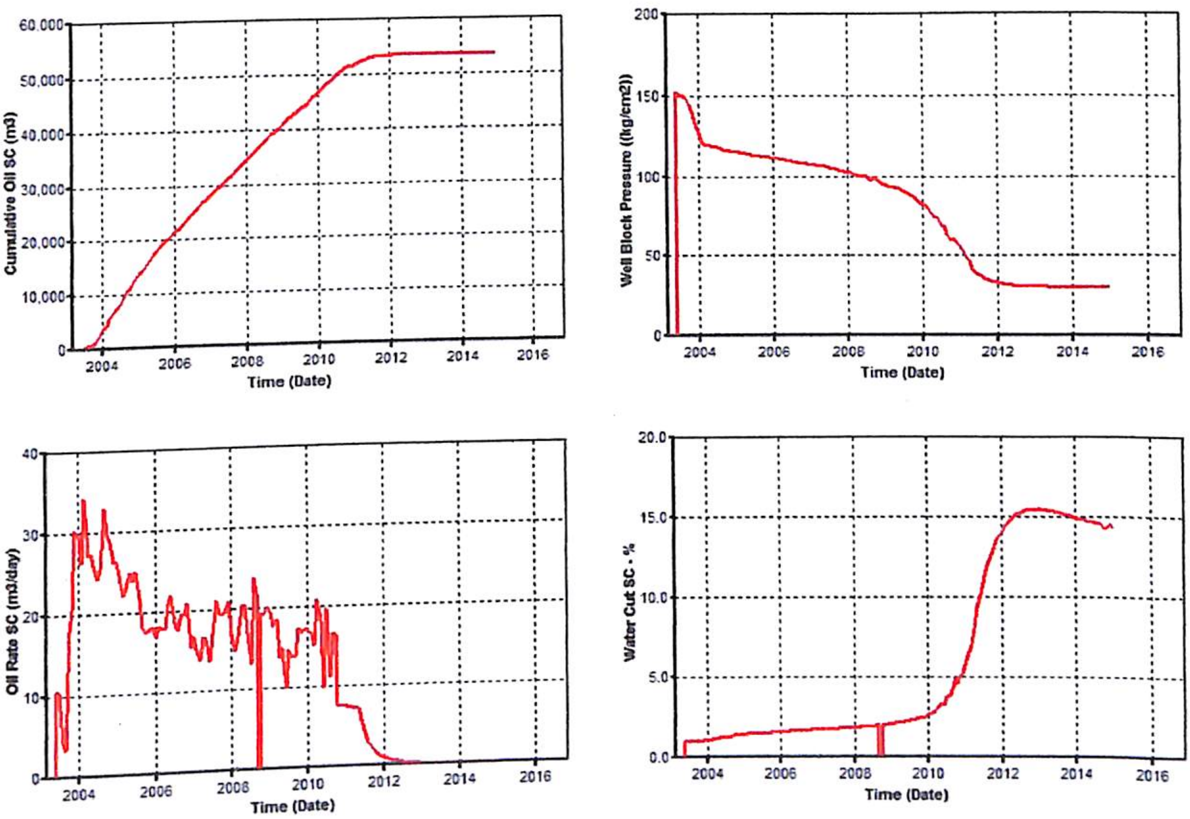

Figure 13:Plot showing future prediction of the well

The well will be shut down by 2012 with a cumulative production of 53,363 m^3(or) 0.044 MMT. The recovery factor is about 8%.

CONCLUSIONS

- The amount of reserves from the planimeter studies is 1.08 MMT.
- The amount of reserves from the model initialization is 1.137 MMT
- The amount of reserves from the model after doing history matching is 0.554 MMT.
- The well will produce up to January 2012 and produce about 53,363 m^3(or) 0.044 MMT which is about 8% recovery.

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