

**THE PROBLEM OF RESERVOIR MANAGEMENT  
OF OIL & GAS FIELDS  
(THE CASE OF KIRKUK FIELD)**

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## ABSTRACT

THIS PAPER TOUCHES ON ONE OF THE MOST POTENT TECHNO – MANAGEMENT ISSUES IN OIL FIELD OPERATION , COINED AS “RESERVOIR MANAGEMENT” , DEALING WITH THE PROBLEM FACING THE PRODUCTION OF OIL AND GAS FROM FIELDS THROUGHOUT THEIR LIFE . THE PROBLEM ARISES FROM THE FACT THAT OUR RESERVOIR ENGINEERS , AND THOSE RESPONSIBLE FOR TECHNICAL MANAGEMENT OF OIL AND GAS FIELDS AND DECISION MAKERS AS A WHOLE , ARE OBLIVIOUS IN TAKING RESERVOIR MANAGEMENT , AS AN ART AND SCIENCE , SERIOUSLY .

THE SUBJECT MATTER HAS BEEN DISCUSSED IN FOUR CHAPTERS EXEMPLIFYING ITS VARIOUS ASPECTS .

THE ESSENCE OF THE PROBLEM LIES IN THE DAY TO DAY WORK IN AN OIL FIELD AND ITS PRODUCTION ; THEREFORE, WE CAN IDENTIFY SUCH A PROBLEM , WITH ITS TECHNICAL AND OPERATIONAL FACTORS , FROM THE PERFORMANCE OF THE FIELD AND BY REGULAR RESEARCH . WE WILL THEN BE ABLE TO FORMULATE THE OBJECTIVE OF OUR WORK WITH ITS TWO FOLD REQUISITES, THE FIRST BEING REGULAR AND COMPREHENSIVE ‘RESERVOIR STUDIES’ AND THE SECOND , THE USE OF MODERN TECHNOLOGIES.

THE THEORETICAL FRAMEWORK , AND SCIENTIFIC AND TECHNICAL BACKGROUND OF THE MEANING OF ‘RESERVOIR MANAGEMENT’ , AND ITS DIFFERENT PARAMETERS , ARE INTRODUCED IN SOME DETAIL TO SIMPLIFY AND EXPRESS THE TERMS NORMALLY USED IN OIL AND GAS RESERVOIRS AT THE LEVEL OF TECHNICAL MANAGERS AND PLANNERS AS WELL AS DECISION MAKERS .

ANALYTICALLY , THE STATUS OF THE PROBLEM CONCERNING THE GIANT KIRKUK FIELD , AMONG OIL AND GAS FIELDS OF NORTHERN IRAQ , IS EXPOUNDED TECHNICALLY AND MANAGEMENT WISE , BASED ON OUR PERSONAL EXPERIENCE AIDED BY SOME EXPERT OPINION .

THE CONCLUSIONS AND RECOMMENDATIONS EMERGING FROM THE DISCUSSION OF THE PROBLEM AND ANALYSIS OF THE SUBJECT , HAVE BEEN PROPOSED , SOMEWHAT BRIEFLY , IN ORDER TO MEAT THE OBJECTIVE OF THIS PAPER WHICH HAS BEEN SET TO REACH AN IDEAL SOLUTION OF THE PROBLEM WITH THE AIM OF BRINGING TO ATTENTION THE NECESSITY OF IMMEDIATE RESERVOIR MANAGEMENT APPLICATIONS , AND POSSIBLE RECTIFICATION OF ANY PREVIOUS MISMANAGEMENT .

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# CHAPTER ONE

## THE SUBJECT AND THE OBJECTIVE

### INTRODUCTION

IN PRESENTING THIS PAPER WE FOLLOWED THE PROCEDURE COMMENSURATE WITH THE COMBINED REQUIREMENTS OF 'SCIENTIFIC' AND 'MANAGEMENT' ASPECTS OF THE SUBJECT.

WE WERE ALSO MOTIVATED BY THE INTER RELATIONSHIP BETWEEN 'RESERVOIR MANAGEMENT' , WHICH DEALS WITH THE DEVELOPMENT AND PRODUCTION OF OIL AND GAS FIELDS , AND THE WELL KNOWN DOMAIN OF 'MANAGEMENT OPERATION' SO AS TO PRODUCE A PAPER THAT IS BOTH TECHNICAL AND MANAGERIAL IN CONCEPT , AND FORMS A RATHER COMPLEX PROBLEM IN OUR OIL SECTOR .

THE PAPER CONSISTS OF THE FOLLOWING FOUR CHAPTERS:

#### CHAPTER ONE:

IN THIS CHAPTER , FOLLOWING THE INTRODUCTION , WE ELUCIDATE THE ESSENCE OF THE PROBLEM OF RESERVOIR MANAGEMENT IN OIL AND GAS FIELDS, ATTEMPTING TO DIAGNOSE ITS VARIOUS TECHNICAL FACTORS. WE THEN FORMULATED, AT THE END OF THE CHAPTER, OUR OBJECTIVE IN ITS TWO FOLDS REPRESENTED BY 'RESERVOIR STUDIES' AND 'USE OF RECENT TECHNOLOGIES'.

#### CHAPTER TWO:

WE INTRODUCED IN THIS CHAPTER THE THEORETICAL FRAMEWORK AND TECHNICAL AND SCIENTIFIC BACKGROUND FOR THE MEANING OF 'RESERVOIR MANAGEMENT' AND ITS DIFFERENT ELEMENTS WITH SOME DETAIL TO CLARIFY AS SIMPLY AS POSSIBLE OIL AND GAS RESERVOIR TERMINOLOGIES COMMENSURATE WITH THE LEVEL OF OIL FIELD MANAGEMENT AND DECISION MAKERS .

#### CHAPTER THREE:

THIS CHAPTER WAS ASSIGNED TO ANALYZE THE STATUS OF THE PRESENT RESERVOIR MANAGEMENT IN THE OIL AND GAS FIELDS OF NORTHERN IRAQ WITH SPECIAL REFERENCE TO KIRKUK FIELD.

#### CHAPTER FOUR:

OBVIOUSLY, THE CONCLUSIONS AND RECOMMENDATIONS DRAWN OUT OF THE DISCUSSION WITHIN THE PAPER WERE KEPT FOR THIS LAST CHAPTER TO EMPHASIZE OUR OBJECTIVE OF REACHING AN APPROPRIATE SOLUTION OF THE PROBLEM IN QUESTION.

## THE PROBLEM

THE MAIN PROBLEM FACING ANY PLANNER , IN THE DEVELOPMENT AND PRODUCTION OF OIL AND GAS FIELDS , IS HOW TO ENSURE A GOOD RESERVOIR MANAGEMENT SCHEME FOR THE ACTUAL AND MOST EFFICIENT PRODUCTION OPERATION OF THE PROVEN RESERVES OF AN OIL FIELD AFTER ITS DISCOVERY.

THIS STEMS FROM THE FACT THAT ANY GEOLOGICAL STRUCTURE, HAVING ONE OR MORE RESERVOIRS CONTAINING COMMERCIAL QUANTITIES OF OIL AND/OR GAS BECOMES AN OIL FIELD READY TO BE DEVELOPED AND PUT ON PRODUCTION.

AS IS WELL KNOWN THAT AN OIL RESERVOIR IS THE ZONE OF ROCK LAYERS WITH GOOD POROSITY AND PERMEABILITY THAT CONTAINS OIL CAPABLE OF MOVEMENT FROM PORES AND FRACTURES, OR VOIDS IN THE ROCK, TOWARDS THE DRILLED WELLS REPRESENTING THE CONDUITS OF PRODUCTION TO THE SURFACE. BUT, THE PRODUCTION OF OIL IN THIS MANNER DEPENDS ON A NUMBER OF FACTORS THAT MUST BE KNOWN WITH PRECISION , AND APPROPRIATE MEASURES BE TAKEN TO CONTROL THEM , IN ORDER TO ULTIMATELY PRODUCE MAXIMUM POSSIBLE AMOUNT OF RECOVERABLE OIL FROM THE RESERVOIRS OF THE FIELD AT THE END OF ITS LIFE , I. E. MAXIMUM EFFICIENT RECOVERY OF OIL RESERVES . IF THOSE FACTORS ARE NOT IDENTIFIED AND UNDERSTOOD WITH EXACTITUDE AND IN TIME THROUGHOUT THE LIFE OF THE FIELD , THE IDEAL MANAGEMENT OF THAT FIELD AND ITS RESERVOIRS WILL BE AFFECTED DETRIMENTALLY , AND FACTUAL PLANNING FOR PROPER PRODUCTION RATES FROM IT BECOMES DIFFICULT AND MOST PROBABLY LEADS TO GREAT AND IRREVERSIBLE DAMAGES TO RESERVOIRS WITH ENORMOUS LOSS OF ITS MOST VALUABLE OIL WEALTH AS A RESULT OF BAD RESERVOIR MANAGEMENT .

ONE OF THE MOST IMPORTANT PREREQUISITES OF RESERVOIR MANAGEMENT IS CARRYING OUT AND REVIEWING 'RESERVOIR STUDIES' CONTINUOUSLY AND IN SHORT APPROPRIATE INTERVALS FOR EACH OIL FIELD . THE REASON FOR THIS BEING THAT AT DIFFERENT STAGES OF THE PRODUCTION HISTORY OF THE FIELD , THERE ENSUE INTERNAL CHANGES IN THE PERFORMANCE OF OIL RESERVOIRS RESULTING FROM THE FACTORS AFFECTING SUCH PERFORMANCE, LIKE PRODUCTION RATES, THE MOVEMENT OF OIL/WATER AND GAS/OIL CONTACTS, RESERVOIR PRESSURE BEHAVIOR AS WELL AS EXTERNAL FACTORS INTENDED FOR THE MAINTENANCE OF CURRENT LEVEL OF PRODUCTION OR PLANNED TO INCREASE IT FURTHER. THAT IS WHY LIMITING OR ECONOMIZING IN THE NUMBER OF RESERVOIR STUDIES AND/OR DELAYING THEM WILL DEPRIVE THE OIL FIELD OF APT OPPORTUNITIES TO BE DEVELOPED

PROPERLY AND HENCE THE PROBLEM OF RESERVOIR MANAGEMENT WE ARE CONCERNED WITH IS OBVIOUSLY CREATED .

THE PROBLEM OF RESERVOIR MANAGEMENT DOES NOT STOP AT THE THRESHOLD OF RESERVOIR STUDIES ONLY; IT SPILLS OVER TO OTHER REALMS OF OIL FIELD DEVELOPMENT SUCH AS INDIFFERENCE OR OBLIVION IN THE INTRODUCTION OF MODERN TECHNOLOGIES WHICH ARE DESIGNED TO ENHANCE THE EFFICIENCY OF ULTIMATE OIL RECOVERY AND TO LOWER DEVELOPMENT AND OPERATIONAL COSTS THROUGH BETTER RESERVOIR PROCEDURES AND IMPROVED OIL FIELD PRACTICE TOWARD AN IDEALIZED OIL PRODUCTION SYSTEM.

## LIMITS OF THE PROBLEM

IT IS WELL KNOWN THAT THE OIL SECTOR IN IRAQ IS RESPONSIBLE FOR DEVELOPING OIL AND GAS FROM DIFFERENT FIELDS WIDELY SPREAD THROUGHOUT THE OIL OPERATION REGIONS SPANNING FROM EXTREME NORTH TO EXTREME SOUTH OF THE COUNTRY , PRODUCING OIL FROM MANY FIELDS AND GAS FROM ONLY ONE FIELD SO FAR . BUT, PRODUCTION FROM ANY OF THESE FIELDS REQUIRES SPECIAL RESERVOIR MANAGEMENT FOR THAT INDIVIDUAL FIELD IN AS MUCH AS ALL THOSE FIELDS DIFFER IN THEIR GEOLOGICAL NATURE. THIS CALLS FOR A SEPARATE DEVELOPMENT PLAN FOR EACH FIELD, WITHIN THE OVERALL RESERVOIR MANAGEMENT PLAN ENVISAGED BY CENTRAL DIRECTIVES AND GUIDELINES FOR ANY GROUP OF FIELDS TO WHICH IT BELONGS, DEPENDING ON THE CHARACTERISTICS OF THAT FIELD. THE GUIDELINES , AS IS KNOWN , AIM AT APPROPRIATE PRODUCTION CAPACITIES REQUIRED FOR THE IMMEDIATE PERIOD OF PLANNING , BUT IT IS ESSENTIAL FOR SUCH A PLAN TO INCORPORATE THE MOST EFFICIENT RATE OF DEPLETION OF OIL RESERVES IN ORDER TO ULTIMATELY RECOVER ALL RESERVES POSSIBLE WITHIN THE PRODUCTION LIFE OF THE FIELD .

OBVIOUSLY , THERE ARE OIL FIELDS THAT ARE LARGE OR “GIANT” FIELDS , CONTAINING HALF A BILLION BARRELS OF OIL OR MORE , WHICH HAVE A SIGNIFICANT AND EFFECTIVE ROLE IN REACHING THE FINAL GOAL OF PRODUCTION PLAN . AND THERE ARE THOSE SMALL AND SECONDARY FIELDS THAT HAVE ONLY SUPPLEMENTARY ROLE. THEREFORE, WE SHALL CONCENTRATE ON PROBLEMS OF RESERVOIR MANAGEMENT OF ONE OF THE GREATEST PRODUCING FIELDS, I. E. THE GIANT FIELD OF KIRKUK WHICH IS REGARDED AS ONE OF THE LARGEST FIELDS NOT ONLY IN IRAQ BUT IN THE MIDDLE EAST AND THE WORLD ALIKE.

**RESERVOIR MANAGEMENT OF KIRKUK FIELD IS ONE OF THE MOST COMPLEX TASKS IN THE DOMAIN OF RESERVOIR ENGINEERING PRACTICED IN OIL INDUSTRY, AND IS NOT AT ALL EASY TO COPE WITH BECAUSE OF ITS GEOLOGICAL CHARACTERISTICS EXEMPLIFIED BELOW:**

- 1 – THE GREAT SIZE OF THE FIELD , CONSISTING OF A LONG AND SINOUS ANTICLINAL STRUCTURE , EXTENDING FOR MORE THAN ( 100 ) KM WITH AN AVERAGE WIDTH OF ONLY ( 3 – 4 ) KM , DIVIDED INTO THREE DOMES ( CALLED BABA, AVANA AND KHORMALA DOMES ) PRODUCING FROM THE FIRST TWO DOMES PRESENTLY IN THE HOPE OF STARTING PRODUCTION FROM THE THIRD DOME AS SOON AS POSSIBLE .**
- 2 – THE GEOLOGICAL NATURE OF THE ROCK LAYERS COMPRISING THE MAIN RESERVOIR OF THIS FIELD IS SO VARIED , WITH LATERAL AND VERTICAL LITHOLOGICAL CHANGES THROUGHOUT THE FIELD , THAT IT INCREASES THE INTRICASY OF GEOLOGICAL MODELING OF ITS RESERVOIR .**
- 3 –THE FIELD IS ALSO KNOWN FOR ITS WIDELY EXTENDING LONGITUDINAL AND TRANSVERSE FAULTS THAT DISSECT THE FIELD IN MANY PARTS ADDING FURTHER CHALLENGE TO ITS RESERVOIR SIMULATION.**
- 4 – THE MAIN OIL RESERVOIR , WITHIN THE TERTIARY ERA OF THE GEOLOGICAL COLUMN , IS EXTENSIVELY FRACTURED CREATING A THREE FOLD SYSTEM OF RESERVOIR BEHAVIOR , WHEREBY OIL PRODUCTION COMES FROM ALL OF THE FOLLOWING PHENOMENA : ONE , THROUGH FRACTURES ; TWO , FROM THE MATRIX OF THE ROCK ; AND THREE , BY IMBIBITION FROM THE MATRIX BLOCKS SUBMERGED INTO WATER . THIS COMPLEXITY OF PRODUCTION SYSTEM CONTRIBUTES TO THE DIFFICULTY OF THE OVERALL STUDY OF OIL RESERVE RECOVERY FROM KIRKUK FIELD .AND YET IT MUST BE REALIZED THAT THIS PARTICULAR CHARACTERISTIC OF THE RESERVOIR OF BEING FRACTURED IS , AT THE SAME TIME , A MAJOR CONTRIBUTOR TO THE PROLIFIC PRODUCTION FROM THIS FIELD .**
- 5 – THE ABOVE MENTIONED PHENOMENA ARE FURTHER UNDERSTOOD TO CONTRIBUTE TO THE SENSITIVITY OF KIRKUK MAIN RESERVOIR TO RATE OF PRODUCTION OF OIL FROM IT . THIS ADDS ANOTHER COMPLICATION TO THE SUBJECT , LEADING TO THE FACT THAT ANY PRODUCTION RATE ASSIGNED TO KIRKUK FIELD MUST BE BASED ON COMPREHENSIVE RESERVOIR STUDIES, CAREFUL PLANNING AND MODERN RESERVOIR MANAGEMENT TO ALLEVIATE ANY DETRIMENTAL EFFECTS ON ULTIMATE EFFICIENT OIL RECOVERY. ALSO, THE SAME PHENOMENA CALL FOR THE**

**IMMEDIATE INTRODUCTION OF MODERN TECHNIQUES DEVELOPED IN THE OIL INDUSTRY INTO THE PRODUCTION OPERATIONS OF KIRKUK FIELD.**

- 6 – THE REMAINING RECOVERABLE OIL RESERVES OF KIRKUK IS ENORMOUS REPRESENTING A SIGNIFICANT PERCENTAGE OF IRAQI OIL RESERVES. HENCE, THE PRIORITY THAT MUST BE GIVEN TO ITS MOST EFFICIENT DEVELOPMENT FOR THE REST OF THE LIFE OF THIS FIELD CAN NOT BE EMPHASIZED MORE.**

## **THE OBJECTIVE**

**THIS PAPER AIMS AT RAISING A POTENT TECHNICAL ISSUE FROM A MANAGEMENT ANGLE BY FORWARDING POSSIBLE SOLUTIONS TO THE PROBLEM OF RESERVOIR MANAGEMENT FOR KIRKUK FIELD THROUGH TWO MAIN AVENUES OF APPROACH MENTIONED EARLIER, THUS:**

- 1 – TO SET UP A REVIEW MECHANISM FOR CARRYING OUT PERIODICAL RESERVOIR STUDIES BY OUR RESERVOIR ENGINEERS AND/OR WELL KNOWN INTERNATIONAL COMPANIES OF EXPERTISE , AND FOR CONTINUOUS OBSERVATION OF RESERVOIR BEHAVIOR BY WELL PLANNED FIELD MEASUREMENTS PROCEDURE .**
- 2 – TO INTRODUCE, AS EARLY AS POSSIBLE, THE MOST RECENT TECHNICALLY ADVANCED MEANS OF OIL FIELD DEVELOPMENT, INCLUDING NEW TECHNIQUES IN DRILLING AND COMPLETION OF WELLS , AND INCORPORATING THE BEST SCIENTIFIC METHODS AVAILABLE IN RESERVOIR ENGINEERING PROFESSION OVERSEEING THE MOST EFFICIENT RECOVERY OF OIL RESERVES.**

**FORMULATING OUR STUDY , WE ATTEMPTED TO SHARE THE OPINION OF SOME SPECIALISTS IN RESERVOIR ENGINEERING , WHO EXPRESSED THE SAME CONCERN AS WE HAVE POSTULATED IN THE FIRST POINT ABOVE ; ON THE SECOND POINT , WE RELIED UPON WHAT HAS BEEN ISSUED IN RECENT PUBLICATIONS ON MODERN OIL TECHNOLOGIES OR SUBMITTED IN SEMINARS AND CONGRESSES WE HAVE ATTENDED , IN ADDITION TO OUR OWN CUMULATIVE EXPERIENCE IN THE OIL INDUSTRY , ABOUT NEW DEVELOPMENTS AND METHODS IN DRILLING AND PRODUCTION OPERATIONS IN OIL FIELDS OF DIFFERENT PARTS OF THE WORLD . ALL THOSE PUBLICATIONS SHOW CONTINUOUS DEVELOPMENT IN ADVANCING WAYS AND MEANS TO ENHANCE THE EFFICIENCY OF OIL RESERVE RECOVERY FROM ITS RESERVOIRS .**

## CHAPTER TWO

### SCIENTIFIC AND THEORETICAL FRAMEWORK

#### OIL FIELDS

THE REASON FOR OUR ATTEMPT TO APPLY “GENERAL MANAGEMENT” CONCEPT TO TECHNICAL “RESERVOIR MANAGEMENT” IS THE GREAT RESEMBLANCE BETWEEN THE TASK OF “MANAGEMENT OPERATIONS” AND THAT OF “RESERVOIR MANAGEMENT” PRINCIPLES IN AS MUCH AS AN OIL FIELD , AFTER ITS DISCOVERY , BECOMES AN ENTITY REQUIRING CAREFUL HANDLING AND MANAGEMENT IN ACCORDANCE WITH AN APPROPRIATE AND REALISTIC PLANNING FOR THE EFFICIENT PRODUCTION OF OIL RESERVES , AND PROPER ARRANGEMENT AND FUNCTION OF ALL SURFACE AND SUBSURFACE INSTALLATIONS , WITH CONTINUOUS OBSERVATION AND RECTIFICATION MECHANISM .

TO ELUCIDATE OUR POINT FURTHER, WE INTRODUCE BELLOW THE SCIENTIFIC AND THEORETICAL BACKGROUND FOR RESERVOIR MANAGEMENT AND THE PROBLEM FACING IT FROM THE BEGINNING OF OIL PRODUCTION AND THE CONTINUATION OF SUCH PRODUCTION THROUGHOUT THE LIFE OF THE FIELD:

#### WHAT IS AN OIL FIELD?

AN OIL FIELD IS AN UNDERGROUND GEOLOGICAL STRUCTURE OF ROCK LAYERS THAT CONTAINS COMMERCIALY RECOVERABLE OIL RESERVES. THE MOST IMPORTANT ELEMENTS OF AN OIL FIELD ARE THE FOLLOWING:

- 1 – THE EXISTENCE OF ONE OR MORE “RESERVOIRS”, I. E. ROCKS , LIKE LIMESTONES OR SANDSTONES , WITH PARTICULAR CHARACTERISTICS OF POROSITY AND PERMEABILITY WHICH ALLOW THE ACCUMULATION OF OIL AND, USUALLY , SOME WATER AND PERHAPS SOME GAS , IN ROCK VOIDS , AND IS CAPABLE OF MOVEMENT THROUGH AND OUT OF THE MATRIX OF THE ROCK TOWARD THE DRILLED WELLS WHICH FORM CONDUITS OF PRODUCTION .
- 2 – JUXTAPOSITION OF RESERVOIR ROCKS WITH RESPECT TO SOURCE OR “MOTHER” ROCKS OR ROCKS THAT HAVE GENERATED ORIGINAL OIL UNDER APPROPRIATE GEOLOGICAL CONDITIONS REPRESENTED BY THE SLOW DEPOSITION OF ROCK MATERIAL AND ITS BURIAL IN GREAT DEPTH UNDER ANAEROBIC CONDITIONS WITH HIGH PRESSURE AND

TEMPERATURE THROUGHOUT GEOLOGICAL TIMES , SUCH AS BLACK SHALE AND MUD .

- ʳ – THE FORMATION OF “OIL TRAPS” BY THE FOLDING OF RESERVOIR ROCK LAYERS INTO ANTICLINES OR DOMES , OR ANY OF DIFFERENT TYPES OF TRAPS , LIKE FAULT TRAPS, STRATIGRAPHIC TRAPS.. ETC. , IN ORDER TO ACCUMULATE OIL IN THESE STRUCTURES READY TO BE PRODUCED .
- € – TO CONSERVE THE ACCUMULATED OIL WITHIN THE STRUCTURE, A KIND OF SEAL AGAINST ITS ESCAPE OR MIGRATION FROM THE TRAP IS REQUIRED. THIS IS PROVIDED BY A NON PERVIOUS COVERING LAYER CALLED “CAP ROCK”.

THAT IS HOW AN OIL, OR GAS, FIELD IS FORMED IN NATURE WITHIN THE EARTH'S CRUST.

AT THIS JUNCTURE, WE DO NOT INTEND TO GO THROUGH THE DIFFERENT STAGES OF HOW TO EXPLORE FOR A PROSPECTIVE STRUCTURE OR AN OIL FIELD BY GEOLOGICAL AND/OR GEOPHYSICAL METHODS, FOLLOWED BY EXPLORATORY DRILLING AND EVALUATION. IN STEAD, WE SHALL CONCENTRATE ON HOW TO PRODUCE THE TRAPPED OIL FROM ITS RESERVOIR MOST EFFICIENTLY, SO AS TO REMAIN WITHIN THE DOMAIN OF OUR SUBJECT, VIZ. “RESERVOIR MANAGEMENT” .

## HOW IS OIL PRODUCED?

AFTER THE DISCOVERY OF A STRUCTURE, AND ESTABLISHMENT OF PROVEN OIL IN ONE OR MORE RESERVOIRS, ALL DATA OBTAINED FROM THE FIRST EXPLORATORY WELL AND OTHER APPRAISAL WELLS, ARE STUDIED TO ARRIVE AT THE “ORIGINAL OIL IN PLACE” IN THAT OR THOSE RESERVOIRS OF THE FIELD. HOWEVER , THE EXACT KNOWLEDGE OF ACTUAL “RECOVERABLE OIL RESERVES” MUST AWAIT FURTHER INFORMATION ABOUT THE PERFORMANCE OF THE RESERVOIR AFTER ACTUAL PRODUCTION FROM IT ; AND IN THE LIGHT OF CAREFUL STUDY OF SUCH INFORMATION A PRELIMINARY DEVELOPMENT PLAN FOR THE INITIAL PRODUCTION OF THE FIELD CAN BE DRAWN TO INCLUDE THE NUMBER OF PRODUCING WELLS TO BE DRILLED AND SURFACE INSTALLATIONS REQUIRED FOR THE TREATMENT OF OIL AND PUMPING IT THROUGH PIPELINES TO LOCATIONS OF CONSUMPTION OR EXPORT TERMINALS .

HERE, WE SHALL CONFINE OURSELVES ONLY WITH THE STAGE OF OIL PRODUCTION FROM ITS RESERVOIR THROUGH DRILLED WELLS, AIMING AT HOW TO DEAL WITH THE OIL RESERVOIR IN MOST EFFICIENT MANNER THAT WE TERMED AS “RESERVOIR MANAGEMENT”. FOR THE PURPOSE OF ELUCIDATING THE CONCEPT OF OIL PRODUCTION FROM A FIELD, WE MUST EXEMPLIFY THE FOLLOWING TERMINOLOGIES:

## **1 – OIL RESERVOIR**

IT IS THAT PART OF AN OIL FIELD WHICH CONTAINS RECOVERABLE OIL AND/OR GAS, USUALLY WITH CONNATE WATER, WITHIN THE PORES AND FRACTURES UNDER THE PREVAILING PRESSURE AND TEMPERATURE OF THE DEPTH OF THE RESERVOIR. THE FACT THAT SOME OR MOST OF THE PORES AND FRACTURES ARE CONNECTED TOGETHER , TO ALLOW THE FREE MOVEMENT OF FLUIDS THROUGH THE POROUS MEDIA , CAUSING THE FLOW OF OIL FROM THE VOIDS OF RESERVOIR ROCK TOWARDS THE DRILLED WELLS , IS CALLED PERMEABILITY . THIS MEANS THAT THE ORIGINAL OIL ACCUMULATED IN THE RESERVOIR IS AWAITING THE OPPORTUNITY OF BEING RELEASED FROM THE MATRIX OF THE ROCK TO THE SURFACE OR TO BE PRODUCED.

## **2 – OIL WELL**

FROM THE RESERVOIR POINT OF VIEW, AN OIL WELL IS THE CONDUIT THROUGH WHICH RESERVOIR FLUIDS REPRESENTED BY OIL, GAS AND WATER PASS FROM THE MATRIX OF THE ROCK TO BE PRODUCED AT THE SURFACE.

WE SHALL NOT GO INTO DETAILS OF DRILLING AND COMPLETION OPERATIONS OF OIL WELLS EXCEPT MENTIONING BRIEFLY THE TYPES OF WELLS WE ARE CONCERNED WITH IN THE SUBJECT OF RESERVOIR MANAGEMENT. THESE ARE:

- (1) – PRODUCTION , OR DEVELOPMENT , WELLS : THESE WELLS ARE DRILLED INTO APPROPRIATE DEPTHS , USUALLY MID POINT OF THE OIL COLUMN , IN THE RESERVOIR , AND AT WELL DISTRIBUTED LOCATIONS THROUGHOUT THE FIELD , IN ORDER TO PRODUCE CRUDE OIL , USUALLY DEVOID OF FREE WATER OR GAS IF PRESENT .
- (2) – OBSERVATION WELLS: THESE ARE WELLS DRILLED INTO THE OBSERVATION INTERVALS OF THE RESERVOIR SUCH AS OIL/WATER AND GAS/OIL CONTACTS TO MONITOR THE MOVEMENT OF THESE CONTACTS , OR PRESSURE CHANGES IN RESERVOIR FLUIDS. ALSO, SOME OF THE OTHER TYPES OF WELLS CAN BE CONVERTED INTO OBSERVATION WELLS WHEN THEY BECOME DISPENSABLE FROM PRODUCTION .
- (3) – INJECTION WELLS : FOR THE PURPOSE OF SUSTAINING PRODUCTION AND MAINTAINING RESERVOIR PRESSURE OR ENHANCING OIL RECOVERY , THERE WILL BE A NEED FOR INJECTING FLUIDS SUCH AS WATER , GAS OR CHEMICAL MATERIALS , INTO THE RESERVOIR THROUGH INJECTION WELLS DRILLED INTO THE OIL , WATER , OR GAS COLUMNS OF THE RESERVOIR .

AS FAR AS THE SHAPE OF THESE WELLS ARE CONCERNED, MOST OF THEM ARE ATTEMPTED TO BE STRAIT AND VERTICAL. BUT IN SOME CASES, TECHNICAL REQUIREMENTS DEMAND OTHER THAN VERTICAL COURSE. THERE ARE “DIRECTIONAL WELLS” , “HORIZONTAL WELLS” , “MULTILATERAL WELLS” OR “EXTENDED REACH” WELLS ... ETC. AIMED AT CERTAIN TARGETS OR POSITIONS IN THE RESERVOIR , OR REACHING INACCESSIBLE LOCATIONS IN ADDITION TO ENHANCING OIL RECOVERY MECHANISM OR FOR ECONOMIC REASONS.

### **3 – FLUID CONTACT LEVELS**

IN MOST OF THE OIL FIELDS OF THE WORLD, OIL IS FOUND IN CONJUNCTION WITH WATER OR GAS , OR BOTH , IN THE SAME RESERVOIR. OBVIOUSLY, WATER WITH HIGH SPECIFIC GRAVITY IS POSITIONED AT AT THE BOTTOM OF THE RESERVOIR, WHEREBY LIGHTER OIL IS SEGREGATED ON TOP OF IT, WHEREAS GAS , BEING THE LIGHTEST OF ALL , FINDS ITS POSITION AT THE VERY TOP ABOVE OIL. IN AS MUCH AS BOTH WATER AND GAS ARE IMMISCIBLE WITH OIL, THERE EXIST TWO CONTACT LEVELS SEPARATING THE THREE FLUIDS; BETWEEN OIL AND WATER , CALLED “OIL/WATER CONTACT” AND GAS AND OIL , NAMED “GAS/OIL CONTACT”. THESE LEVELS HAVE GREAT IMPORTANCE IN PRODUCTION OPERATIONS AND, HENCE, IN RESERVOIR MANAGEMENT AS SHALL BE CLEAR LATER.

### **4 – THE PHENOMENON OF IMBIBITION**

BECAUSE OF THE FACT THAT THE RESERVOIR WE ARE DEALING WITH CONSISTS OF FRACTURED ROCKS , WHEREBY POROUS BLOCKS OF ROCK MATRIX IS SURROUNDED BY FRACTURE VOIDS ; THEREFORE , THE PRODUCTION OF OIL FROM SUCH RESERVOIR COMES FROM TWO SYSTEMS , ONE DIRECTLY FROM THE PORES OF ROCK MATRIX AND TWO FROM FRACTURES , AS MENTIONED EARLIER . IN BOTH CASES, THE MOVEMENT OF OIL FROM EITHER THE MATRIX AND/OR THE FRACTURES CREATES EMPTY SPACES THAT ARE FILLED WITH WATER AT THE OIL/WATER CONTACT AND WITH GAS AT THE GAS/OIL CONTACT. LET US LOOK NOW AT THE OIL/WATER CONTACT MORE CLOSELY WHERE WE EXPECT DIFFERENT RATES OF RISE OF THIS CONTACT IN EACH OF THE FRACTURES AND THE ROCK MATRIX DURING OIL PRODUCTION, THE SPEED OF RISE BEING FASTER IN FRACTURES THAN IN MATRIX LEADING TO A SITUATION IN WHICH BLOCKS OF MATRIX BECOME SUBMERGED IN WATER ISOLATING THEM FROM DIRECT CONTRIBUTION TO PRODUCTION. THE ACTUAL PRODUCTION FROM THESE BLOCKS WILL THEN BE BY THE VERY SLOW PROCESS OF BUBBLING OF OIL DROPS FROM MATRIX PORES TO SURROUNDING WATER TO BE COLLECTED AT ITS SURFACE WHEREFROM IT IS PRODUCED. THIS PROCESS IS CALLED “IMBIBITION” AND IS

REGARDED AS THE ONLY AVENUE OF RECOVERING OIL TRAPPED UNDER WATER IN THE ABSENCE OF DIRECT PRODUCTION FROM THE MATRIX ITSELF BY DRILLING THROUGH THE MATRIX OR PERHAPS BY MINING FROM IT . IN SPIKE OF IT BEING VERY SLOW AND WITH LOW EFFICIENCY, IMBIBITION IS A FACT OF LIFE IN RESERVOIR PERFORMANCE AND, THEREFORE, AN IMPORTANT PHENOMENON TO BE COGNIZANT OF IN RESERVOIR MANAGEMENT.

#### **5- RESERVOIR PRESSURE**

IT SHOULD BE NOTED THAT THE ORIGINAL OIL ACCUMULATED WITHIN THE RESERVOIR IS UNDER PRESSURE OF DEPOSITIONAL BURIAL AT GREAT DEPTH THROUGHOUT GEOLOGIC TIMES. HOWEVER , WHEN THE FIRST WELL IS DRILLED AND PRODUCTION OF OIL STARTS , RESERVOIR PRESSURE BEGINS TO DECLINE AND , OF COURSE , FLUID CONTACT LEVELS MOVE , WITH OIL/WATER CONTACT RISING AND GAS/OIL CONTACT DROPPING . THE DECLINE IN RESERVOIR PRESSURE AFFECTS PRODUCTION DRIVE FORCE THEREBY NEEDING PRESSURE MAINTENANCE BY WATER AND/OR GAS INJECTION INTO THE RESERVOIR AS STATED ABOVE.

#### **6- OIL RESERVE**

AS FAR AS “RESERVOIR MANAGEMENT” IS CONCERNED, THE SIMPLEST DEFINITION OF “OIL RESERVE” WOULD BE “THE QUANTITY OF OIL THAT CAN BE ULTIMATELY RECOVERED FROM THE ORIGINAL OIL ACCUMULATED WITHIN THE RESERVOIR, ALSO CALLED ORIGINAL OIL IN PLACE”, IN AS MUCH AS NOT ALL THE OIL IN PLACE CAN BE EXTRACTED FROM THE RESERVOIR ROCK BY THE NORMAL PHYSICAL PRODUCTION MECHANISM THROUGH WELLS. THE PERCENTAGE OF OIL ULTIMATELY PRODUCABLE IS TERMED “RECOVERY FACTOR”, THE REST OF THE OIL REMAINING WITHIN THE ROCK PORES CAN NOT BE PRODUCED EXCEPT BY MORE DEVELOPED AND ADVANCED TECHNIQUES WITH VERY MUCH HIGHER COST.

#### **7 - RECOVERY FACTOR**

THIS TERM IS USED, AS WAS MENTIONED ABOVE, TO REPRESENT THE PERCENTAGE OF OIL THAT CAN BE FINALLY RECOVERED FROM THE ORIGINALLY ACCUMULATED OIL WITHIN THE RESERVOIR. THIS PERCENTAGE IS ARITHMETICALLY THE RESULT OF DIVIDING THE FIGURES OF RESERVE BY OIL IN PLACE MULTIPLIED BY (100) AND NORMALLY RANGES BETWEEN (10% – 70%) DEPENDING ON THE NATURE OF THE ACCUMULATED OIL AND ITS CONTAINER RESERVOIR .

THIS FACTOR IS OF UTMOST IMPORTANCE FOR GOOD RESERVOIR MANAGEMENT IN AS MUCH AS THE BASIC GOAL OF THIS MANAGEMENT IS TO

ULTIMATELY RECOVER THE GREATEST AMOUNT OF OIL ORIGINALLY PRESENT IN THE RESERVOIR, AIMING AT THE MOST EFFICIENT RECOVERY MECHANISM FOR THE OIL BY CONTINUOUSLY RAISING THIS FACTOR TO ITS POSSIBLE MAXIMUM.

#### **8 – MAXIMUM EFFICIENT RATE**

ONE OF THE MOST IMPORTANT DUTIES OF GOOD RESERVOIR MANAGEMENT CENTERS IN PROFICIENT PLANNING FOR THE PRODUCTION OF OIL FROM ITS RESERVOIR WITH MAXIMUM EFFICIENT RATE POSSIBLE , AVOIDING PRODUCTION RATES THAT CAN IMPAIR EFFICIENT RESERVOIR PERFORMANCE AND , HENCE , LOWER RECOVERY FACTOR . THIS IMPLIES THAT FOR EACH RESERVOIR THERE EXISTS AN EFFICIENT RATE OF PRODUCTION, UNDER A CERTAIN PREVAILING CONDITION THAT SHOULD NOT BE SURPASSED.

#### **9 – RESERVOIR STUDIES**

THESE ARE REPRESENTED BY CONTINUOUS AND PERIODICAL RESEARCH AND REVIEW CARRIED OUT ON OIL RESERVOIRS AIMING AT DETAIL DISCUSSION OF RESERVOIR PERFORMANCE DURING PRODUCTION AT ACTUAL RATES THROUGHOUT THE PREVIOUS INTERVAL, THEREBY ENABLING FUTURE PLANNING FOR NEW RATES IN ACCORDANCE WITH THE FORECASTED PERFORMANCE OF THE RESERVOIR FOR THE SUBSEQUENT INTERVAL.

NORMALLY, A RESERVOIR STUDY DISCUSSES THE FOLLOWING ASPECTS OR PHENOMENA:

- A – REMAINING OIL RESERVE CALCULATION: TO ARRIVE AT POSSIBLE NEW PRODUCTION RATES, COMMENSURATE WITH OTHER RELATED REQUIREMENTS, FOR THE NEXT PLANNING PERIOD.
- B – OIL/WATER CONTACT ( OWC ): TO FOLLOW THE EXTENT OF WATER FRONT ADVANCE AND ITS BEHAVIOR ALONG THE OIL FIELD WITH ANY IRREGULARITIES SUCH AS HUMPING OR CONING.
- C – GAS/OIL CONTACT ( GOC ): TO SEE THE BEHAVIOR OF THIS LEVEL OF GAS FRONT AND ITS SHAPE FOR POSSIBLE INVASION OF THE OIL COLUMN BY THE GAS CAP OR GAS CONING. TECHNICALLY THE GAS ZONE IS CALLED “GAS BUBBLE” .
- D – OIL ZONE : TO OBSERVE THE OIL ZONE HORIZONTALLY BY RECOGNIZING THE SURFACE AREA OF OIL SURROUNDED BY WATER OUTWARD AND GAS INWARD , AND VERTICALLY BY CONFIRMING THE OIL COLUMN IN DIFFERENT PARTS OF THE FIELD , TO ENABLE CHOOSING BETTER LOCATIONS FOR ALL TYPES OF WELLS THE MOST IMPORTANT BEING PRODUCTION WELLS . THIS ZONE IS ALSO CALLED “OIL RIM” .

**E – PRODUCTION RATES : FOR THE PREVIOUS INTERVAL OF THE PRODUCTION HISTORY , TO ALLOW THE SIMULATION OF RESERVOIR BEHAVIOR WITH HISTORY MATCHING THROUGH MATHEMATICAL MODELING IN ORDER TO FORECAST FOR FUTURE EFFICIENT PRODUCTION RATES . HOWEVER, WE DO NOT PROPOSE HERE TO GO INTO DETAILS OF SIMULATION MODEL CONSTRUCTION APART FROM STRESSING THAT THE GOAL OF AN IDEAL RESERVOIR MANAGEMENT IS ONLY REALIZED BY THE MOST PRUDENT ANALYSIS AND USE OF ALL RELEVANT DATA PROVIDED BY THE BASIC AND RECENTLY AVAILABLE REFERENCES ON THIS SUBJECT.**

**F – RESERVOIR PRESSURE : AND ITS PAST FLUCTUATIONS AND THEIR EFFECT ON PRODUCTION RATES AND TYPES OF PRESSURE MAINTENANCE PROJECTS , IN ORDER TO BE ABLE TO RECOMMEND FUTURE PROJECTS ENVISAGED TO ENCOUNTER PRESSURE DECLINE .**

**G – GAS/OIL RATIO ( GOR ) : THAT IS , TO OBSERVE THE VOLUME OF GAS PRODUCED FOR EACH BARREL OF OIL PRODUCTION . AND ANY CHANGE IN SUCH RATIO IN THE PAST AS WELL AS FORECASTED FOR THE FUTURE , TO EVALUATE ITS EFFECT ON RESERVOIR PERFORMANCE .**

**H – ANY OTHER ADDITIONAL INFORMATION RESULTING FROM PREVIOUS GEOLOGICAL AND RESERVOIR STUDIES AND FURTHER PLANS ENVISAGED FOR OBTAINING NECESSARY DATA TO BE INCLUDED IN FUTURE RESEARCH AND STUDIES.**

**WHAT WE HAVE STATED ABOVE ASSERTS THE URGENCY OF A COMPREHENSIVE “DATA BANK” FOR EACH OIL FIELD WHICH SHOULD BE REPLENISHED AND REVIEWED CONTINUOUSLY. SUCH DATA BANK IS OF UTMOST IMPORTANCE FOR A SUCCESSFUL RESERVOIR MANAGEMENT AS IT BECOMES AN ACTIVE AND READY DEPLOYMENT TOOL TO RECTIFY ANY PHENOMENON DETRIMENTAL TO EFFECTIVE RESERVOIR BEHAVIOR AND, HENCE, MOST EFFICIENT RATE OF PRODUCTION.**

## **MODERN TECHNOLOGIES**

**THIS SUBJECT INCLUDES THE POSSIBLE APPLICATION OF RECENTLY DEVELOPED TECHNIQUES , WITHIN WORLD OIL INDUSTRY , IN DRILLING, PRODUCTION AND RESERVOIR PROCEDURES THAT MAY BE UTILIZED IN THE OIL FIELD WE ARE CONCERNED WITH, AND THE ADVANTAGES GAINED FOR INCREASED PRODUCTIVITY OF WELLS AND ENHANCEMENT OF ULTIMATE RECOVERY EFFICIENCY OF THE RESERVOIR , COUPLED WITH LOWERING OF COSTS AND SOLVING SOME PROBLEMS THAT MIGHT FACE RESERVOIRS.**

**AMONG THESE TECHNOLOGIES, ON WHICH WE HAVE WRITTEN OTHER PAPERS, ARE THE FOLLOWING:**

**1 – HORIZONTAL DRILLING TECHNIQUE**

**OIL WELLS ARE NORMALLY INTENDED TO BE DRILLED VERTICALLY FROM THE SURFACE TO TOTAL DEPTH WITHIN THE RESERVOIR TO FORM, AS WE HAVE STATED EARLIER , A STRAIT CONDUIT COVERING THE PRODUCING INTERVAL OF THIS RESERVOIR . WHEREAS, HORIZONTAL DRILLING ADDS A NEW DIMENSION IN DIRECTION REPRESENTED BY A HORIZONTAL CHANNEL IN THE RESERVOIR FOR PRODUCTION, WHICH IN EFFECT MEANS THAT AN EXTENDED HORIZONTAL SURFACE AREA OF THE RESERVOIR WILL BE AVAILABLE FOR PRODUCTION AT A SMALL VERTICAL INTERVAL THICKNESS .**

**WE SHALL NOT ELABORATE ON THE ADVANTAGES OF SUCH TECHNIQUE WHICH CAN BE FOUND IN OIL INDUSTRY LITERATURE. SUFFICE IT TO SAY THAT HORIZONTAL WELLS HAVE PROVEN THEIR USEFULNESS BY INCREASING PRODUCTIVITY ( 2 – 3 ) FOLD COMPARED TO VERTICAL WELLS , HENCE BEING MORE ECONOMICAL , AND ENHANCE RECOVERY EFFICIENCY , IN ADDITION TO BEING BETTER PRODUCTION CONDUITS FOR THIN RESERVOIRS AND MATRIX BLOCKS OF FRACTURED RESERVOIRS . THIS LAST POINT HAS BEEN DISCUSSED IN A PAPER WE SUBMITTED TO A SCIENTIFIC CONFERENCE ON THE ADVANTAGES OF HORIZONTAL WELL IN KIRKUK FIELD .**

**2- COILED TUBING TECHNIQUE**

**THIS TECHNOLOGY IS MORE RELATED, BUT NOT RESTRICTED, TO HORIZONTAL DRILLING. IT INVOLVES THE USE OF FLEXIBLE TUBES ON PULLEYS WITH SOMEWHAT GREAT LENGTHS AS COMPARED TO THE NORMAL RIGID AND SHORT SINGLE STEEL DRILL PIPES THAT ARE CONNECTED WHILE DRILLING. HOWEVER, THE DIAMETER OF COILED TUBING IS MUCH LESS THAN THAT OF NORMAL DRILL PIPES, NOT EXCEEDING A FEW INCHES, BUT ARE EXPECTED TO BECOME LARGER DUE TO CONTINUOUS RESEARCH AND DEVELOPMENT ON THE COMPOSITION OF TUBING MATERIALS.**

**WRITTEN MATERIAL ON THIS SUBJECT HAS BEEN ABUNDANT RECENTLY BECAUSE OF THE SUCCESS CLAIMED BY THIS TECHNOLOGY , ESPECIALLY IN SUCH OIL FIELD OPERATIONS AS COMPLETION , TESTING AND WORKOVER OF WELLS , IN ADDITION TO DRILLING SMALL DIAMETER WELLS OR “SLIM HOLES” . IT HAS ALSO BEEN USED AS GATHERING OR FLOW LINES FOR WELLS OVER GROUND AND OFFSHORE. FURTHER DETAILS OF THIS TECHNOLOGY AND ITS POSSIBLE ROLE IN OUR OIL FIELDS, CAN BE FOUND IN ONE OF OUR PAPERS ON THIS SUBJECT AS WELL.**

### **3 – “DRILLING WITH CASING” TECHNIQUE**

THIS IS A NEWLY DEVELOPED TECHNOLOGY WHEREBY OIL WELL “CASINGS” ARE USED AS DRILLING STRINGS FOR REVOLVING AND DRIVING DRILLING BITS IN STEAD OF THE NORMAL “DRILL PIPES” AND “DRILL COLLARS” .

THE TWO FOLD ADVANTAGES OF THIS TECHNOLOGY ARE TECHNICAL AND ECONOMIC. TECHNICALLY, MANY PROBLEMS OF DRILLING OPERATIONS SUCH AS SLOUGHING OF THE WELL BORE CAN BE AVOIDED AND BETTER CONTROL ON MUD LOSSES WILL BE OBTAINED. ON ECONOMIC GROUNDS, LESS NUMBER OF CASINGS WILL BE USED AND BETTER WELL PRODUCTIVITIES ARE EXPECTED. AN EXTENDED REVIEW OF THIS SUBJECT, AND ITS POSSIBLE USAGE IN OUR FIELDS, IS ELABORATED IN ONE OF OUR PUBLISHED PAPERS.

### **4 – COMPLEX GEOMETRY WELLS**

BECAUSE OF LOWER PRODUCTIVITY OF WELLS IN HEAVY OIL FIELDS, THE NUMBER OF WELLS REQUIRED FOR THE PRODUCTION OF A CERTAIN SURFACE AREA OF THE FIELD WILL BE GREAT COMPARED TO THAT NEEDED FOR THE SAME RATE OF PRODUCTION OF LIGHT OIL. TO TACKLE SUCH A PROBLEM, NEW TECHNIQUES IN GEOMETRICAL WELL DESIGN HAVE BEEN DEVELOPED TO LOWER THE NUMBER OF WELLS PER UNIT AREA AND INCREASE THE PRODUCTIVITY OF INDIVIDUAL WELLS , ULTIMATELY LEADING TO BETTER RECOVERY EFFICIENCY OF HEAVY OIL PRODUCTION FROM ITS RESERVOIR.

GEOMETRICAL SHAPES OF THESE WELLS FALL INTO SEVERAL CATEGORIES; EITHER THE SHAPE OF “SEAGULL WING” OR “FISHBONE” AND MULTIPLE OF THESE SHAPES CALLED “STACKED” WELLS . WE HAVE PUBLISHED A PAPER ON THIS TECHNOLOGY EXPLAINING ITS IMPORTANCE AND POSSIBLE APPLICATION IN IRAQI HEAVY OIL FIELDS SUCH AS QAYYARAH FIELD NORTHERN IRAQ.

### **5– THE TECHNIQUE OF WATER INJECTION AT GAS/OIL CONTACT**

AS IS WELL KNOWN THAT , FOR PRESSURE MAINTENANCE PURPOSES , WATER IS NORMALLY INJECTED INTO THE WATER ZONE , BELLOW OR AT THE LEVEL OF OIL/WATER CONTACT , TO SUPPORT WATER DRIVE MECHANISM FOR OIL PRODUCTION .WHEREAS , GAS INJECTION , FOR THE SAME PURPOSE , IS CARRIED OUT , WITHIN OR AT THE GAS/OIL CONTACT LEVEL , FOR GAS CAP DRIVE . HOWEVER , A NEW TECHNIQUE HAS BEEN RESEARCHED ON WHEREBY WATER IS INJECTED AT THE GAS/OIL CONTACT TO ASSIST PRESSURE MAINTENANCE IN BOTH OIL COLUMN AND GAS CAP , THEREBY ENABLING DUAL PRODUCTION OF OIL AND GAS SIMULTANEOUSLY WITHOUT DETRIMENT TO

**ULTIMATE EFFICIENT RECOVERY OF BOTH OIL AND GAS . THIS WAS INCLUDED YET IN ANOTHER OF OUR PUBLISHED PAPERS .**

**6 – DOWNHOLE OIL/WATER SEPARATION**

**THIS TECHNIQUE HAS BEEN RECENTLY DEVELOPED TO DETACH WATER FROM OIL WITHIN THE WELL BORE BY INEXPENSIVE DOWNHOLE INSTRUMENTS RATHER THAN COSTLY SURFACE INSTALLATION OF WET-CRUDE PROJECTS .**

## CHAPTER THREE

### THE STATUS OF RESERVOIR MANAGEMENT

#### STATUS OF RESERVOIR STUDIES

IN ORDER TO ANALYZE THE STATUS OF RESERVOIR MANAGEMENT OPERATION APPLIED IN DEVELOPING OUR OIL AND GAS FIELDS, AND THE PROBLEMS THAT FACE SUCH MANAGEMENT, WE HAVE ATTEMPTED TO POLL THE OPINION OF RESERVOIR ENGINEERING SPECIALISTS TO RECOGNIZE THE PROBLEM THROUGH THE FOLLOWING POINTS:

- 1 – THE LACK OF COMPLETE GEOLOGICAL AND RESERVOIR DATA, AGRAVATED BY THE LACK OF REGULAR AND MORE FREQUENT COMPREHENSIVE RESERVOIR STUDIES, FORMS THE CENTRAL PROBLEM OF RESERVOIR MANAGEMENT IN OIL AND GAS FIELDS OF OUR NORTHERN IRAQ .
- 2 – THE IMPACT OF THE FIRST POINT ABOVE ON THE INABILITY TO ASSIGN EXACT AND APPROPRIATE RATES OF PRODUCTION FOR DIFFERENT RESERVOIRS OF ANY OIL FIELD IS SO GREAT THAT IT HAS BEEN DIFFICULT TO CONSTRUCT VIABLE AND EXECUTABLE SHORT , MEDIUM OR LONG TERM PLANS FOR THESE FIELDS .
- 3– THE RECIPROCAL EFFECTS OF LACK OF STUDIES ON THE FLUCTUATION OF PRODUCTION RATE GUIDELINES CONTROLLING PLANNING PROCESS , AND VICE VERSA , HAS BEEN OBVIOUS IN HINDERING THE REALIZATION OF ALMOST EVERY PLANNING GOAL ACHIEVEMENT .
- 4– ALSO , SINCE ALL COMPREHENSIVE RESERVOIR STUDIES HAVE BEEN CARRIED OUT BY FOREIGN EXPERTISE , WITH ONLY MARGINAL CONTRIBUTION FROM OUR NATIONAL PETROLEUM ENGINEERING STAFF , TECHNICAL DEVELOPMENT OPPORTUNITIES FOR THESE ENGINEERS , AND THE MOST NEEDED AVAILABILITY OF RESERVOIR ENGINEERING TOOLS , HAVE BEEN RESTRICTED IN CARRYING OUT SUCH STUDIES INSIDE IRAQ .

#### STATUS OF MODERN TECHNOLOGIES

IN THIS SUBJECT , WE HAD TO RELY ON OUR OWN CUMULATIVE EXPERIENCE IN THE OIL SECTOR FOR MORE THAN FOUR DECADES , WITH SPECIAL INTEREST IN MODERN OIL INDUSTRY TECHNOLOGIES , THROUGH READING ABOUT AND WRITING ON THIS IMPORTANT SUBJECT AS WELL AS ATTENDING RELATED LOCAL AND INTERNATIONAL SEMINARS AND CONFERENCES TO SUBMIT AND

**PUBLISH PAPERS ON THE POSSIBILITIES OF APPLICATION OF SUCH TECHNOLOGIES IN IRAQ .**

**WE FOUND IN THE MANAGEMENT OF IRAQI OIL FIELD DEVELOPMENT A CERTAIN AMBIVALENCE TOWARD THE USE OF MOST MODERN TECHNOLOGIES , AS AN EFFECTIVE TOOL IN OIL FIELD OPERATIONS AND RESERVOIR PERFORMANCE MANAGEMENT AND STUDIES WITH THE ULTIMATE OBJECTIVE OF EFFICIENT OIL RECOVERY ENHANCEMENT .**

**HERE , WE PRESENT ONLY TWO EXAMPLES FROM OUR NORTHERN OIL FIELDS , TO EXPRESS OUR PERSONAL OPINION ON THE SUBJECT , AS FOLLOWS :**

**1 – KIRKUK FIELD**

**WHAT WE PROPOSE TO INTRODUCE OF THE FACTS PERTAINING TO THIS GIANT OIL FIELD WILL NECESSARILY BE DEVOID OF FACTUAL FIGURES TO WHICH WE SHALL DENOTE WITH EMPTY PARENTHESES THUS ( ) , IN AS MUCH AS WE HAVE CHOSEN NOT TO INCLUDE SUCH FIGURES IN OUR PRESENT PAPER TO BE PUBLISHED .**

**FROM PURE STATISTICAL STAND POINT, AND WITH RESPECT TO ORIGINAL RECOVERABLE OIL RESERVES AND SUBSEQUENT PRODUCTION FROM 1934 TO END OF 2001 , WE CAN ANALYZE THE STATUS OF KIRKUK FIELD IN THE FOLLOWING MANNER :**

**ONLY TWO OF THE THREE DOMES ( BABA + AVANA DOMES , EXCLUDING KHORMALA DOME ) HAVE BEEN TAKEN INTO CONSIDERATION HERE .**

**- ORIGINAL OIL IN PLACE , IN ROCK MATRIX AND FRACTURES = ( ) MILLION BARRELS , OUT OF WHICH 95% IN MATRIX AND 5% IN FRACTURES .**

**- ORIGINAL RECOVERABLE OIL RESERVES = ( ) MILLION BARRELS .**

**- THIS MEANS THAT THE RECOVERY FACTOR = SLIGHTLY LESS THAN 60% .**

**- TOTAL OIL PRODUCED AT THE END OF 2001 = ( ) MILLION BARRELS WHICH REPRESENTS = ( )% OF RESERVES .**

**- NUMBER OF YEARS 1934 – 2001 = 66 .**

**- AVERAGE PRODUCTION RATE FOR THE PAST PERIOD = ( ) BARRELS PER DAY.**

**- THIS REPRESENTS DEPLETION RATE OF = 1.5% OF THE RESERVES PER ANNUM .**

**- THE REMAINING RESERVES AT THE END OF 2001 = ( ) MILLION BARRELS .**

**- THIS MEANS THAT ( ) BILLION BARRELS OF OIL IS AWAITING TO BE PRODUCED FOR THE REST OF THIS FIELDS LIFE WHICH WILL BE DETERMINED BY THE AVERAGE RATE OF PRODUCTION DURING THE NEXT PERIOD .**

IF WE ADD THE RESERVES OF THE THIRD DOME , WHICH IS EXPECTED TO BE DEVELOPED SOON , THE REMAINING RESERVES WILL BE GRATER AND , HENCE , THE LIFE SPAN OF THE FIELD WILL BE EXTENDED FOR THE SAME RATE TO BECOME LONGER THAN THE LAST 66 YEARS , OR THE NEXT RATE OF PRODUCTION WILL BE HIGHER .

IN SPITE OF ALL THIS, THE VIEWS THAT ARE GIVEN TO THE FUTURE FORECASTED PRODUCTION RATES FOR KIRKUK FIELD ARE VERY PESSIMISTIC! THE REASONS FOR THIS PESSIMISM MAY BE MANY , BUT WE STRONGLY BELIEVE IN THE TWO FOLD PROBLEMS INTRODUCED AS THE THESIS OF THIS PAPER , I.E. LACK OF COMPREHENSIVE RESERVOIR STUDIES AND HESITATION IN INTRODUCTION AND APPLICATION OF MODERN TECHNOLOGIES ESSENTIAL TO THE DEVELOPMENT OF THIS IMPORTANT FIELD . FOR EXAMPLE, HORIZONTAL DRILLING MAY BE BENEFICIAL FOR ENHANCING OIL RECOVERY FROM ROCK MATRIX; COILED TUBING MAY SOLVE SOME OF THE PRODUCTION PROBLEMS IN THE WELLS; THE TECHNIQUE OF “DOWNHOLE OIL/WATER SEPARATION” MAY CONTRIBUTE TO ALLEVIATE SOME OF THE WET CRUDE PRODUCTION PROBLEMS; OR THE USE OF THE MOST RECENT ADVANCES IN COMPUTER RESERVOIR MODELING MAY EXPRESS BETTER THE FACTUAL RESERVOIR PERFORMANCE. IN ANY CASE, SUCH NEW TECHNOLOGIES WILL DEFINITELY ADD FURTHER DIMENSIONS TO WHAT WE TERMED AS “RESERVOIR MANAGEMENT”.

## **2 – JAMBOUR FIELD**

IN AS MUCH AS OUR MAIN CONCERN IN THIS PAPER IS BETTER “RESERVOIR MANAGEMENT” OF KIRKUK FIELD, WE SHALL NOT GO INTO THE SAME DETAILS FOR JAMBOUR FIELD ; BUT , SUFFICE IT TO SAY THAT WE SINGLE OUT TO MENTION THIS FIELD IN ORDER TO CALL FOR MEANS OF RECTIFYING THE ON GOING MISMANAGEMENT OF THIS FIELD THROUGH THE CONTINUOUS PRODUCTION OF ITS DOME GAS , A PRACTICE WHICH HAS PROFOUND DETRIMENTAL EFFECT ON RESERVOIR DRIVE MECHANISM AND ULTIMATE OIL RECOVERY EFFICIENCY . THAT IS WHY WE HAVE SUGGESTED ONE OF THE MODERN TECHNOLOGIES TO BE APPLIED , OR AT LEAST PILOT TESTED , IN THIS FIELD FOR THE TWO FOLD PURPOSES OF PRESSURE MAINTENANCE IN BOTH OIL AND GAS COLUMNS TO ASSIST DRIVE MECHANISM ON THE ONE HAND AND DUAL PRODUCTION OF OIL AND GAS FROM THE FIELD ON THE OTHER . IT WAS ALSO SUGGESTED TO INJECT SURPLUS DRY GAS INTO THE GAS DOME OF JAMBOUR FIELD FOR CONSERVATION PURPOSES . THIS LAST TECHNIQUE WAS PRESENTED IN ONE OF OUR PAPERS.

## CHAPTER FOUR

### CONCLUSIONS AND RECOMMENDATIONS

#### CONCLUSIONS

OIL INDUSTRY DEVELOPMENTS CLEARLY INDICATE THE CRITICAL ROLE OF “RESERVOIR MANAGEMENT” IN ENHANCING OIL AND GAS RECOVERY EFFICIENCY THAT CONTRIBUTES TO ENORMOUS INCREASES IN ULTIMATE RECOVERY FROM RESERVOIRS , ESPECIALLY IN LARGE FIELDS SUCH AS GIANT KIRKUK FIELD . ANY PERCENTAGE INCREASE IN THE RECOVERY FACTOR IN SUCH A CASE , EVEN IF RELATIVELY SMALL , WILL MEAN A GREAT ADDITIONAL AMOUNT OF OIL TO BE RECOVERED . WHEN THIS IS REFLECTED ON ALL RECOVERABLE RESERVES OF IRAQ ( 115 BILLION BARRELS , AS PUBLISHED ) , IT WILL MEAN AN ENORMOUS ADDITIONAL QUANTITY OF OIL TO BE RECOVERED AND , HENCE , BILLIONS OF DOLLARS IN VALUE . FOR EXAMPLE , ( 1% ) INCREASE IN RECOVERY FACTOR AMOUNTS TO MORE THAN ONE BILLION BARRELS OF OIL WITH A VALUE OF APPROXIMATELY ( 35) BILLION DOLLARS ( AT THE CURRENT PRICE OF 30 DOLLARS PER BARREL ) . IT CAN BE IMAGINED , THEREFORE , THAT IF IT WOULD BE POSSIBLE , THROUGH GOOD MANAGEMENT , TO INCREASE THE RECOVERY FACTOR BY ( 10% ) , THE VALUE OF ADDED RESERVES SHALL RISE TO ( 350 ) BILLION DOLLARS . THIS SHOWS THE ENORMITY OF RESERVOIR MANAGEMENT IMPACT AS IS EXPOUNDED IN THIS PAPER .

FROM WHAT HAS BEEN DISCUSSED IN THIS PAPER , THE FOLLOWING ABRIDGED CONCLUSIONS CAN BE DRAWN :

THE PROBLEM OF RESERVOIR MANAGEMENT IN OIL FIELDS OF NORTHERN IRAQ MAY BE DIVIDED INTO TWO ASPECTS :

A – WITH RESPECT TO THE PROBLEM OF LACK OF INFORMATION AND LESS FREQUENT RESERVOIR STUDIES , IT CAN BE CONCLUDED THAT :

- 1 – VERY LITTLE EFFORT IS PUT FORTH TO SEEK FOR AND ORGANIZE INFORMATION AVAILABLE FROM DAILY FIELD OPERATIONS AND RESERVOIR REACTIONS.
- 2 – THERE IS AN APATHY TOWARD CARRYING OUT COMPREHENSIVE RESERVOIR STUDIES ON MAJOR OIL FIELDS , AND THE LONG TIME LAPS ( MORE THAN 5 YEARS ) BETWEEN SUCH STUDIES MISSES AMPLE OPPORTUNITIES FOR BETTER UNDERSTANDING AND MANAGEMENT OF RESERVOIR PERFORMANCE .

**3 – UNCERTAINTIES AND LARGE DISCREPANCIES IN FORMULATING PRODUCTION GUIDELINES AND PLANS HAVE CREATED MANY PHENOMENA WITHIN THE RESERVOIRS DETRIMENTAL TO EFFICIENT ULTIMATE RECOVERY OF OIL AND GAS FROM SUCH RESERVOIRS.**

**4 – THE LACK OF VIGOROUS AND CONTINUOUS FIELD OBSERVATION SYSTEM HAS CONTRIBUTED TO THE AGGRAVATION OF THE PROBLEMS STATED ABOVE.**

**B – AN ALMOST NON- EXISTENCE OF MODERN TECHNOLOGY APPLICATIONS IN OUR OIL AND GAS FIELDS IS REGARDED AN ACUTE RESERVOIR MANAGEMENT PROBLEM , THUS :**

**1– AS WELLS ARE THE ONLY CONDUITS OF OIL AND GAS FLOW FROM RESERVOIR TO SURFACE , ANY NEW DEVELOPMENT IN DRILLING TECHNIQUES AIDING BETTER PRODUCTION MECHANISM AND EFFICIENT RECOVERY OF OIL FROM THE RESERVOIR WILL NECESSARILY HELP RESERVOIR MANAGEMENT .**

**2 – METHODS OF RESERVOIR PRESSURE MAINTENANCE ARE DIVERSIFYING, AND THE SELECTION OF NEWLY DEVELOPED TECHNIQUES MOST APPROPRIATE TO OUR RESERVOIRS WILL BE BENEFICIAL , WHEN APPLIED IN TIME .**

**3 – ENHANCED OIL RECOVERY METHODS ARE ALSO WELL KNOWN AND ADVANCING CONTINUOUSLY ; THUS , IF THE APPLICATION OF SUCH METHODS IS NEGLECTED , NO PROFICIENT RESERVOIR MANAGEMENT WILL BE REALIZED .**

## **RECOMMENDATIONS**

**IN THE LIGHT OF THE CONCLUSIONS ABOVE , AND AS AN ATTEMPT TO SOLVE THE INHERENT PROBLEM OF RESERVOIR MANAGEMENT IN OIL AND GAS FIELDS OF NORTHERN IRAQ , WE WISH TO FORWARD THE FOLLOWING RECOMMENDATIONS :**

**A – CONCERNING THE PROBLEM OF LACK OF INFORMATION AND STUDIES :**

**1 – IT IS ESSENTIAL TO MAKE IMMEDIATE USE OF ALL INFORMATION AVAILABLE FROM DRILLING AND WORKOVER OPERATIONS , THROUGH THOROUGH ANALYSES BY SPECIALIST GEOLOGISTS AND RESERVOIR ENGINEERS , WITHOUT ANY DELAY THAT WILL INHIBIT ITS IMPORTANCE .**

**2 – IT CAN NOT BE EMPHASIZED MORE THAT REGULAR AND WELL TIMED RESERVOIR STUDIES, THAT ARE BASED ON MOST RECENT DEVELOPMENTS IN THE OIL INDUSTRY, ARE THE BACK BONE OF SUCCESSFUL RESERVOIR MANAGEMENT. BECAUSE OF THE RAPID PACE**

OF TECHNOLOGICAL ADVANCE, THE TIME LAPS BETWEEN THESE STUDIES MUST NOT EXCEED FIVE YEARS.

- 3 – THE GUIDELINES ENVISAGED OR DECIDED UPON BY THE HIGHER MANAGEMENT FOR ANY PRODUCTION PLAN MUST BE BASED ON THE ACTUAL PAST RESERVOIR PERFORMANCE CONCLUDED BY THE MOST RECENT RESERVOIR STUDIES AND TECHNICAL EXPERT OPINION AND NOT ENFORCED BY THE HIGHER MANAGEMENT .
- 4 – CONTINUOUS AND PERIODIC OBSERVATION OF ALL FLUID MOVEMENT AND ANOMALOUS PHENOMENA WITHIN THE RESERVOIR AND ITS SURROUNDING SHOULD BE CARRIED OUT WITH EXACTITUDE BY ALL POSSIBLE NEWLY DEVELOPED FIELD MEASUREMENT TECHNIQUES AND PROGRAMS.

**B – DENYING PRODUCING OIL AND GAS FIELDS OF THE ADVANTAGES OF MODERN TECHNOLOGIES IS OUR MAJOR CONCERN. TO RECTIFY THIS SITUATION , WE RECOMMEND :**

- 1 –TO BE CONTINUOUSLY AWARE OF AND IN CLOSE CONTACT WITH THE MOST RECENT DEVELOPMENTS IN ADVANCED WORLD OIL INDUSTRY THROUGH TECHNICAL AND SCIENTIFIC RESEARCH PUBLICATIONS AND RELATED SEMINARS AND CONFERENCES ON NEW METHODS AND TECHNIQUES .
- 2 –TO SEARCH DILIGENTLY FOR AND CHOSE PROFESSIONALLY THE MOST APPROPRIATE TECHNIQUES APPLICABLE TO INDIVIDUAL RESERVOIRS OF OUR OIL AND GAS FIELDS COMMENSURATE WITH THEIR KNOWN GEOLOGICAL AND RESERVOIR PROPERTIES .
- 3 – TO EXPEDITE THE INTRODUCTION OF MODERN TECHNOLOGIES INTO OUR OIL OPERATIONS AND APPLY THESE TECHNOLOGIES IN THE FIELD , EVEN AS PILOT PROJECTS THAT CAN BE EXPANDED TO REAL AND PRACTICAL RESERVOIR APPLICATIONS LATER .

***\* ALL VIEWS EXPRESSED IN THIS PAPER ARE SOLEY OF THE AUTHOR AND NOT OF NORTH OIL COMPANY.***