Integrated Petroleum Reservoir Management

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A Team Approach

Contents

Foreword

Although elements of petroleum reservoir management have been practiced almost since reservoirs were first recognized, the concept of an integrated approach took form only within the past one or two decades. Many individual articles and at least one manual on the subject have been published in the open literature, and it is probable that proprietary presentations of reservoir management concepts are to be found within the internal libraries of some oil- and gas-producing companies. In the present volume, the authors present the first treatment of the subject to be published in book form.

The roots of petroleum reservoir management are to be found in reservoir engineering, taken in its braodest sense as the technology that deals with the movement of fluids into, out of, and through the geological formations of the earth by means of wells and well systems. However, reservoir management and reservoir engineering are not identical. The latter is one of the elements that enters into achieving the former. Reservoir management infers the existence of goals toward which the reservoir technology is directed. At the heart of petroleum reservoir management is the idea that goals and the technological implementations to acheive those goals will be specific to each individual reservoir. This point is emphasized throughout the book by means of examples and case histories.

The book brings out the importance of the reservoir model and discusses its uses, not only as a tool for integrating the total database that is available on a reservoir, but also for predicting the consequences of alternate future constraints and/or implementation procedures that might be invoked. In short, the individual reservoir has its formalized expression in the model that is constructed to simulate it.

The book also emphasizes that petroleum reservoir management depends upon teamwork and continuous interactions among team players whose expertise may include specializations such as geology, geophysics, drilling, logging, well behavior, recovery mechanisms, subsurface fluid behavior, production operations, facilities engineering, economics, decision strategy, environmental issues and other applicable subjects. The manner in which the team players are brought together, the formulation of a plan, its periodic revision, and its evaluation are presented as parts of the reservoir management process to ensure effective use of the technological spectrum that is available to the team.

CHAPTER 1

Introduction

Integrated petroleum reservoir management has received significant attention in recent years. Various panel, forum, seminar, and technical sessions have provided the framework for information sharing and the exchange of ideas concerning many practical aspects of integrated, sound reservoir management.[1–7] The need to enhance recovery from the vast amount of remaining oil and gas-in-place in the United States and elsewhere, plus the global competition, requires better reservoir management practices.

Historically, some form of reservoir management has been practiced when a major expenditure is planned, such as a new field development or waterflood installation. The reservoir management studies in these instances were not integrated (i.e., different disciplines did their own work separately). During the past 20 years, however, a greater emphasis has been placed on synergism between engineering and geosciences. However, despite the emphasis, progress on integration has been slow.

SOUND RESERVOIR MANAGEMENT

A reservoir's life begins with exploration that leads to discovery, which is followed by delineation of the reservoir, development of the field, production by primary, secondary, and tertiary means, and finally to abandonment (see Figure 1–1).[8] Integrated, sound reservoir management is the key to a successful operation throughout a reservoir's life.

A vast amount of hydrocarbon remains unrecovered in the United States and elsewhere in the world. The good news is that many leading-edge technological advances have now been made in geophysics, geology, petrophysics, production, and reservoir engineering. Mainframe super computers, more powerful personal computers, and workstations are providing ever increasing computing power. Integrated life cycle database-management

- The team members must work as a well-coordinated "basketball team" rather than a "relay team." Reservoir engineers should not wait on geologists to complete their work and then start the reservoir engineering work. Rather, a constant interaction between the functional groups should take place. For example, it is better to know early if the isopach and cumulative oil/gas production maps do not agree rather than finalize all isopach maps and then find out that cumulative production maps are indicating another interpretation of the reservoir. Using an integrated approach to reservoir management along with the latest technological advances will allow companies to extract the utmost economic recovery during the life of an oil field. It can prolong the economic life of the reservoir.[1]

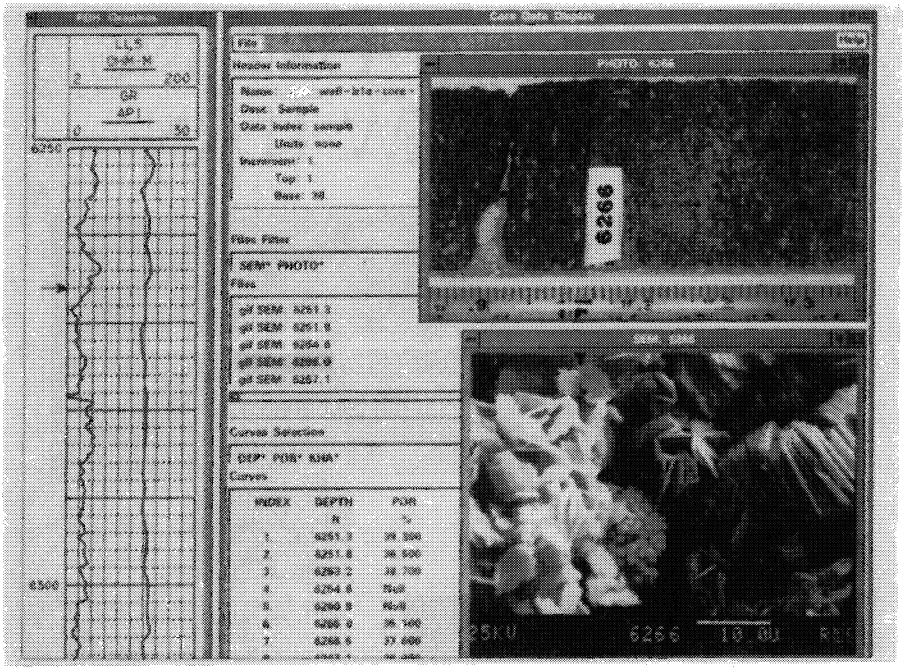
In summary, the synergism of the team approach can yield a "whole greater than the sum of its parts."

Today, it is becoming common for large reservoir studies to be integrated through a team approach. However, creating a team does not guarantee an integration that leads to success. Team skills, team authority, team compatibility with the line management structure, and overall understanding of the reservoir management process by all team members are essential for the success of the project. Also, most reservoir management teams are being assembled only at key investment times. Missing today are ongoing multidisciplinary reservoir management efforts for all significant reservoirs.[2]

Synergy is not a new concept. Halbouty, chairman and CEO of Michael T. Halbouty Energy Co. in Houston, a long-time advocate of synergy and team approach, recognized this concept as basic to future petroleum reserves and production.[14] According to Sneider, "synergy means that geologists, geophysicists, petroleum engineers and others work together on a project more effectively and efficiently as a team than working as a group of individuals."[15] Talash advocated that teamwork between reservoir and production/operation engineers is essential to waterflood project management.[16] The team approach to reservoir management is essential and involves the interaction between management, engineering, geoscience, research, and service functions.[1] We emphasize again that the team members should work as a well-coordinated "basketball team" rather than a "relay team."

Some independents, such as the Apache Intl. Corp., have used an innovative team approach to increase production on properties acquired from majors. A full-time interdisciplinary team is assigned to one mature acquisition after another to analyze and identify ways to extract additional production. "This keeps the team hungry," Apache CEO William Johnson

FIGURE 2–8. Integrating Exploration and Development Technology *(courtesy* OGJ, *May 1993*[25]*)*



Now, a time and cost-effective way to integrate exploration and production activities using existing hardware and software is available.[26] A fully open-data exchange system, which was jointly created by Finder Graphics Systems Inc., GeoQuest, and Schlumberger, is being distributed as the Geoshare standards. Members of the Geoshare user's group, which consists of many geoscientific software developers and oil and gas operators, will soon be able to transfer data and interpretations among their various data bases in support of E&P techniques.

Guthery, Landgren, and Breedlove concluded that the published Geoshare standard provides means for exchanging data and results between any petroleum applications, regardless of their formats, configurations or hardware platforms.[26] It is a completely open and expandable standard whose future lies with the Geoshare user's group.

Traditionally, finding and producing hydrocarbons were considered the essence of success in the upstream end of the petroleum industry. Now, companies are viewing their options as far more flexible, and a diversified portfolio of skills within an integrated and flexible business framework is emerging (see Figure 2–9).[27] Patterson and Altieri discussed

Geological and Numerical Model Studies

The geological model is derived by extending localized core and log measurements to the full reservoir using many technologies, such as geophysics, mineralogy, depositional environment and diagenesis. The geological model, particularly the definition of geological units and their continuity and compartmentalization, is an integral part of geostatistical and ultimately reservoir simulation models.

Production and Reserves Forecasts

The economic viability of a petroleum recovery project is greatly influenced by the reservoir production performance under the current and future operating conditions. Therefore, the evaluation of the past and present reservoir performance and forecast of its future behavior is an essential aspect of the reservoir management process (see Figure 3–5). Classical

FIGURE 3–5. Production and Reserves Forecasts *(Copyright © 1992, SPE, from paper 22350[1])*

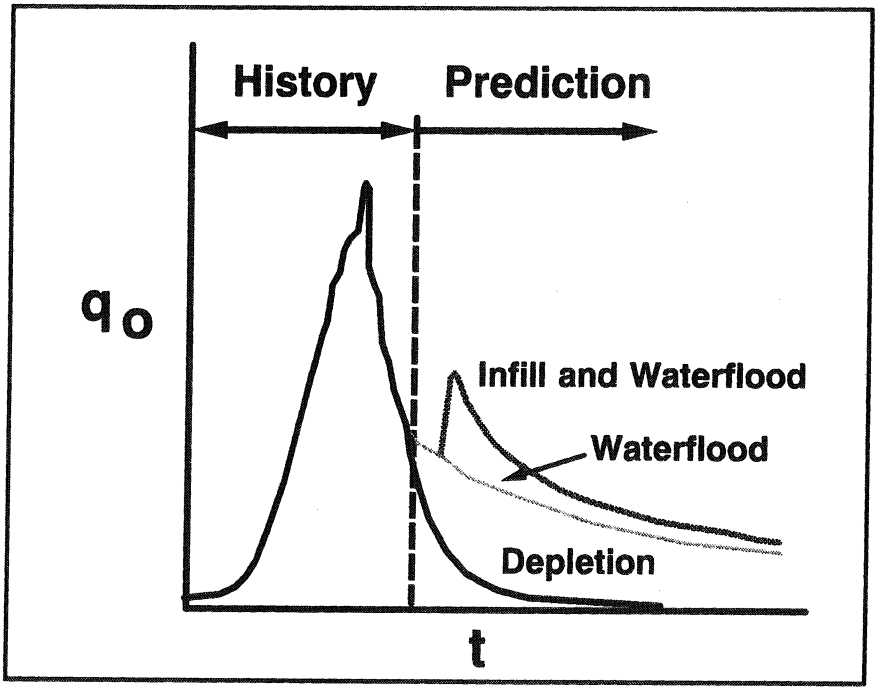
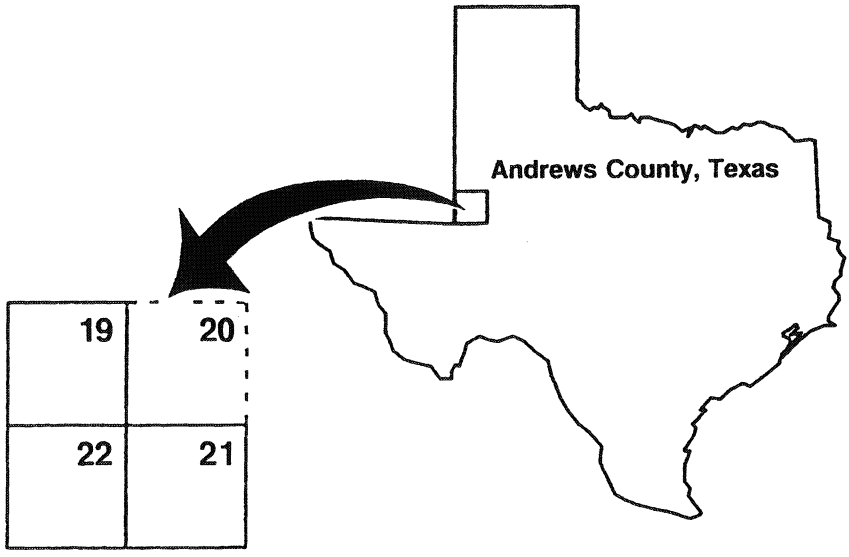


FIGURE 3–15. Location Plat, Columbus Gray Lease *(Copyright © 1990, SPE, from paper 20748[2])*



injection pattern of 80-acre, inverted nine-spot. The peak response occurred in 1984 at 1,000 BOPD, and then the production declined at 20% per year (Figure 3–16). The current flood pattern is shown in Figure 3–17.

Geology

The field is located on the eastern margin of the Central Basin Platform, 13 miles east of its edge. The San Andres formation, Guadalupian in age (Middle Permian), was deposited in an open marine, shallow-water shelf environment. Other San Andres fields on the Northern Central Basin Platform similar to Fuhrman Mascho include the Means, Shafter Lake, Seminole, and Emma fields.

The San Andres formation has a gross productive thickness of 300 ft in the lease area. It can be divided into two intervals based on porosity development and vertical continuity (see Figure 3–18). The Upper San Andres (USA) has an average thickness of 225 feet, and it is comprised of light-colored dolomites that are finely crystalline and probably vuggy or sucrosic. Also, it is anhydritic and contains scattered interbeds of gray or

TABLE 4–1. Reservoir Data

Classification	Data	Acquisition Timing	Responsibility
Seismic	Structure, stratigraphy, faults, bed thickness, fluids, interwell heterogeneity	Exploration	Seismologists, Geophysicists
Geological	Depositional environment diagenesis, lithology, structure, faults, and fractures	Exploration, discovery & development	Exploration & development geologists
Logging	Depth, lithology, thickness, porosity, fluid saturation, gas/oil, water/oil and gas/water contacts, and well-to-well correlations	Drilling	Geologists, petrophysicists and engineers
Coring		Drilling	Geologists, drilling and reservoir engineers, and laboratory analysts
Basic	Depth, lithology, thickness, porosity, permeability, and residual fluid saturation		
Special	Relative permeability, capillary pressure, pore compressibility, grain size, and pore size distribution		
Fluid	Formation volume factors, compressibilities, viscosities, gas solubilities, chemical compositions, phase behavior, and specific gravities	Discovery, delineation, development, and production	Reservoir engineers and laboratory analysts