Lecture#2:

Reservoir Management Concepts

Dr. Dheiaa Alfarge

Introduction

- Integrated petroleum reservoir management has received significant attention in recent years.
- 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).

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).
- sound reservoir management is the key to a successful operation throughout a reservoir's life.

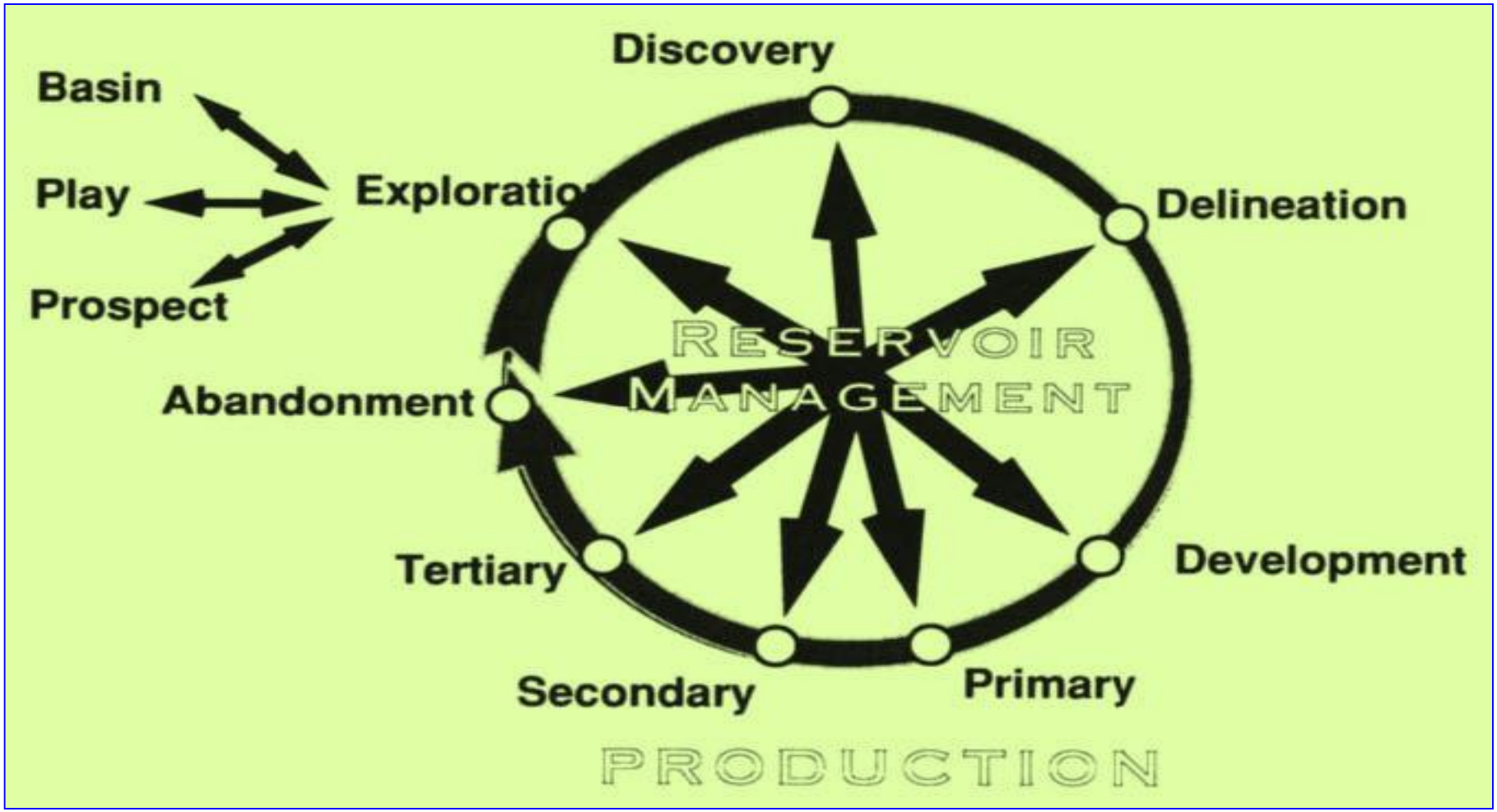

FIGURE 1. Reservoir Life Process ***(Copyright 0 1992, SPE, from paper 223508)***

Why Need Sound Reservoir Management?

- The objective is to provide a better understanding of the practical approach to asset management using multidisciplinary, integrated teams. This will promote better resource management practices by enhancing hydrocarbon recovery and maximizing profitability. (See Figures 2&3).

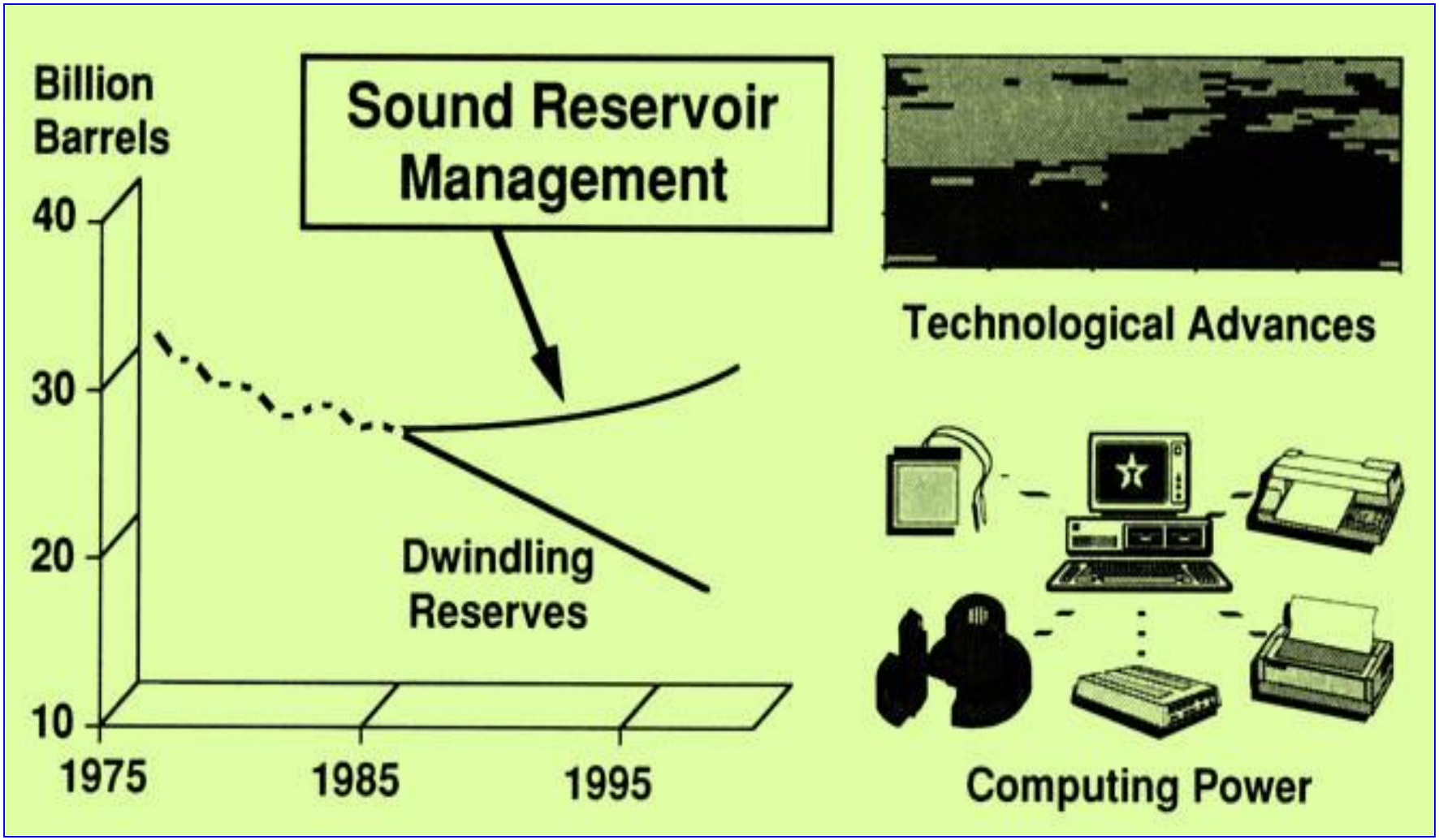

FIGURE 2. Why Need Sound Reservoir Management? ***(Copyright @1990, SPE)***

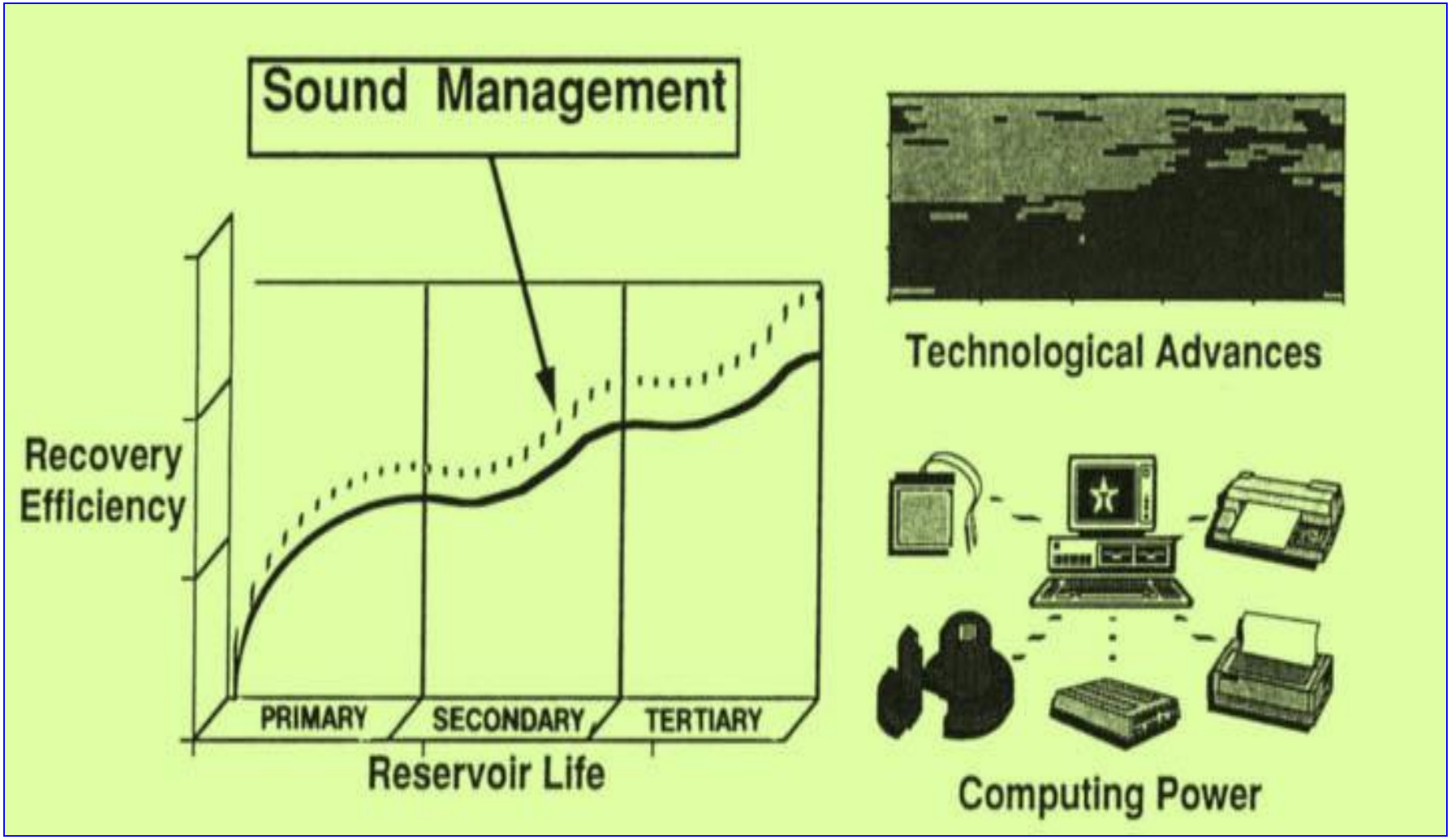

FIGURE 3. Why Need Sound Reservoir Management? ***(Copyright @ 1990, SPE , from paper 22350)***

Definition Of Reservoir Management

- The Webster Dictionary defines management as the "judicious use of means to accomplish an end."Thus, the management of reservoirs can be interpreted as the judicious use of various means available to a businessman in order to maximize his benefits (profits) from a reservoir.
- Reservoir management has been defined by a number of other authors. Basically, sound reservoir management practice relies on the utilization of available resources (i.e., human, technological and financial) to maximize profits/profitibility index from a reservoir by optimizing recovery while minimizing capital investments and operating expenses (see Figure 4).

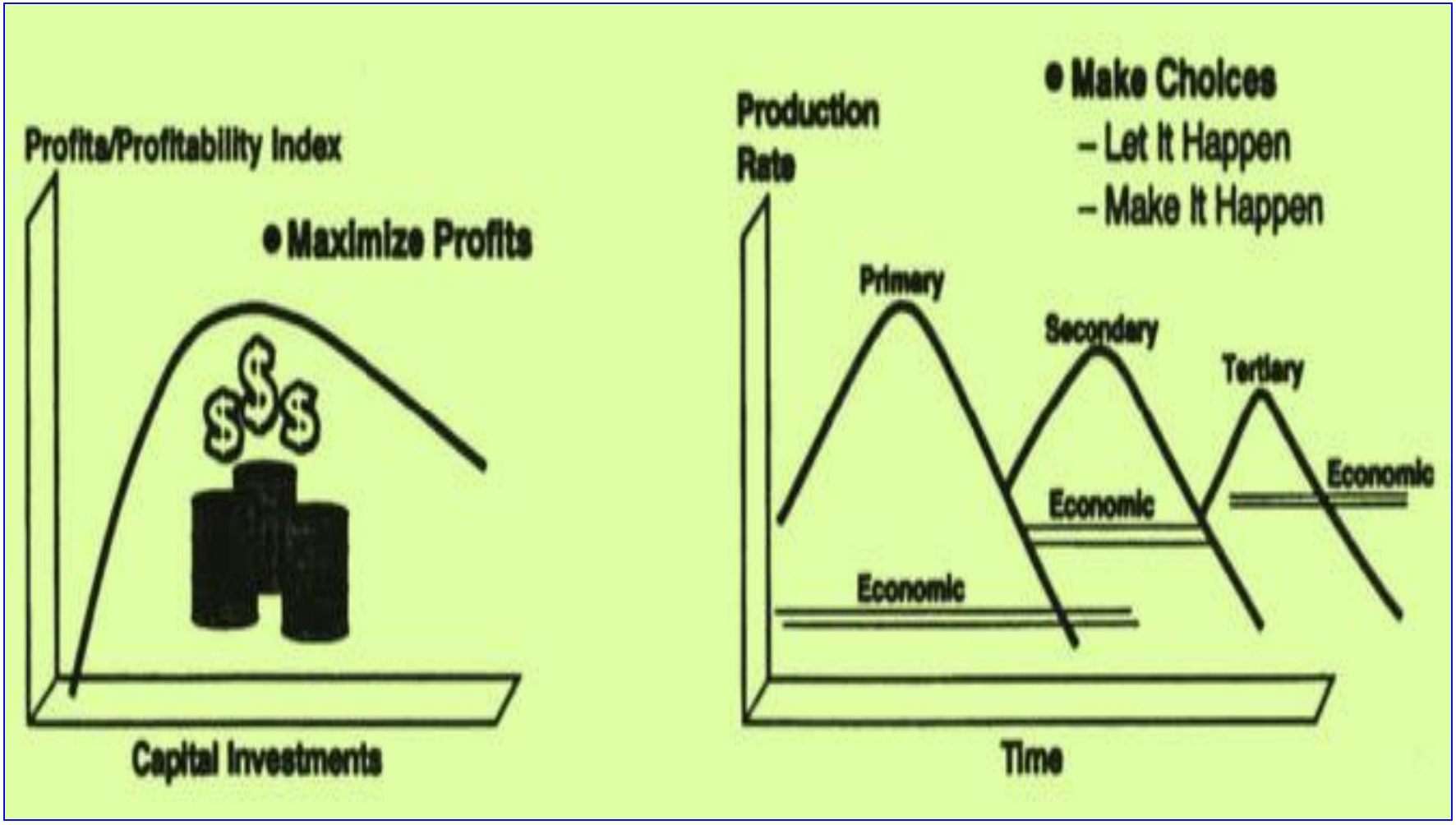

FIGURE 4. What Is Reservoir Management? ***(Copyright @ 1992, PE, from paper 22350)***

- Reservoir management involves making certain choices. Either let it happen, or make it happen.(As shown in Figure 4).
- Many reservoir engineers, geologists, and geophysicists who realize that the maximum coordination of their disciplines is essential to the future success of the petroleum industry. So, they follow the principles of reservoir management for maximizing economic recovery of oil and gas.

History Of Reservoir Management

- Most people considered reservoir management synonymous with reservoir engineering.
- As recently as the early 1970s, reservoir engineering was considered the most important technical item in the management of reservoirs.
- After understanding the value of geology, synergism between geology and reservoir engineering became very popular and proved to be quite beneficial.

- Reservoir management has advanced through various stages in the past 30 years.
- The techniques are better, the background knowledge of reservoir conditions has improved, and the automation using mainframe computers and personal computers has helped data processing and management.
- The developmental stages of reservoir management could be described as the following:

➢ Stage 1:Before 1970:

- Reservoir engineering was considered the most important technical item in the management of reservoirs.
- In 1962,Wyllie emphasized two key items:

1. Clear thinking utilizing fundamental reservoir mechanics concepts.
2. Automation using basic computers.

- In 1965, Essley described "reservoir engineering" and concluded that in spite of the technical advancement of reservoir engineering, vital engineering considerations are often neglected or ignored.

➢ Stage 2: 1970s - 1980s.

- Craig et al. (1977) and Hams and Hewitt (1977) explained the value of synergism between engineering and geology.
- Craig emphasized the value of detailed reservoir description, utilizing geological, geophysical, and reservoir simulation concepts.
- He challenged explorationists, with the knowledge of geophysical tools, to provide a more accurate reservoir description to be used in engineering calculations.

Fundamentals Of Reservoir Management

- The prime objective of reservoir management is the economic optimization of oil and gas recovery, which can be obtained by the following steps:

- Identify and define all individual reservoirs in a particular field and their physical properties.
- Deduce past and predict future reservoir performance.
- Minimize drilling of unnecessary wells.
- Define and modify (if necessary) wellbore and surface systems.
- Initiate operating controls at the proper time.
- Consider all pertinent economic and legal factors.

- Thus, the basic purpose of reservoir management is to control operations to obtain the maximum possible economic recovery from a reservoir based on facts, information, and knowledge.

- In 1963, Calhoun described the engineering system of concern to the petroleum engineer as being composed of three principal subsystems:

➢ Creation and operation of wells.

➢ Surface processing of the fluids.

➢ Fluids and their behavior within the reservoir.

- The first two subsystems depend on the third because the type of fluids (i.e., oil, gas, and water) and their behavior in the reservoir will dictate how many wells to drill and where, and how they should be produced and processed to maximize profits.
- The following question-and-answer section provides reservoir management philosophies:

    1. When should reservoir management start?.

    2. What, how, and when to collect data?.

    3. What kinds of questions should be asked if we want to ensure the right answer in the process of reservoir management?.

When should reservoir management start?

- The ideal time to start managing a reservoir is at its discovery.
- it is never too early to start this program because early initiation of a coordinated reservoir-management program not only provides a better monitoring and evaluation tool, but also costs less in the long run.
- For example, a few early drill stem tests (DST) could help decide if and where to set pipe.
- Many times we consider reservoir management at the time of a tertiary recovery operation.

What, how, and when to collect data?

- Before collecting any data, we should ask the following questions:

➢ Are the data necessary, and what are we going to do with these data? What decisions will be made based on the results of the data collection?

➢ What are the benefits of these data, and how do we devise a plan to obtain the necessary data at the minimum cost?

- The reservoir management team must prepare a coordinated reservoir evaluation program to show the need for the data requirement, along with their costs and benefits.
- It must be emphasized that early definition and evaluation of the reservoir system is a prerequisite to good reservoir management.

What kinds of questions should be asked if we want to ensure the right answer in the process of reservoir management?

- Some example questions follow:

- What does the answer mean?
- Does the answer fit all the facts; why or why not?
- Are there other possible interpretations of the data?
- Were the assumptions reasonable?
- Are the data reliable?
- Are additional data necessary?
- Has there been an adequate geological study?
- Has the reservoir been adequately defined?

The modern reservoir management process involves:

- goal setting: requires knowledge of the reservoir, availability of technology, and knowledge of the business, political, and environmental climate.
- Planning: involves depletion and development strategies, data acquisition and analyses, geological and numerical model studies, production and reserves forecasts, facilities requirements, economic optimization, and management approval
- Implementing: requires management support, field personnel commitment, and multidisciplinary, and integrated teamwork.

- Monitoring and Evaluating :Success of the project depends upon careful monitoring/surveillance and thorough, ongoing evaluation of its performance.
- Revising plans: If the actual behavior of the project does not agree with the expected performance, the original plan needs to be revised, and the cycle (i.e., implementing, monitoring, and evaluating) reactivated.

Synergy and Team

- Successful reservoir management requires synergy and team efforts.
- It is recognized more and more that reservoir management is not synonymous with reservoir engineering and/or reservoir geology.
- Success requires multidisciplinary, integrated team efforts.
- The players are everybody who has anything to do with the reservoir (see Figure 5).
- The team members must work together to ensure development and execution of the management plan.
- All development and operating decisions should be made by the reservoir management team.

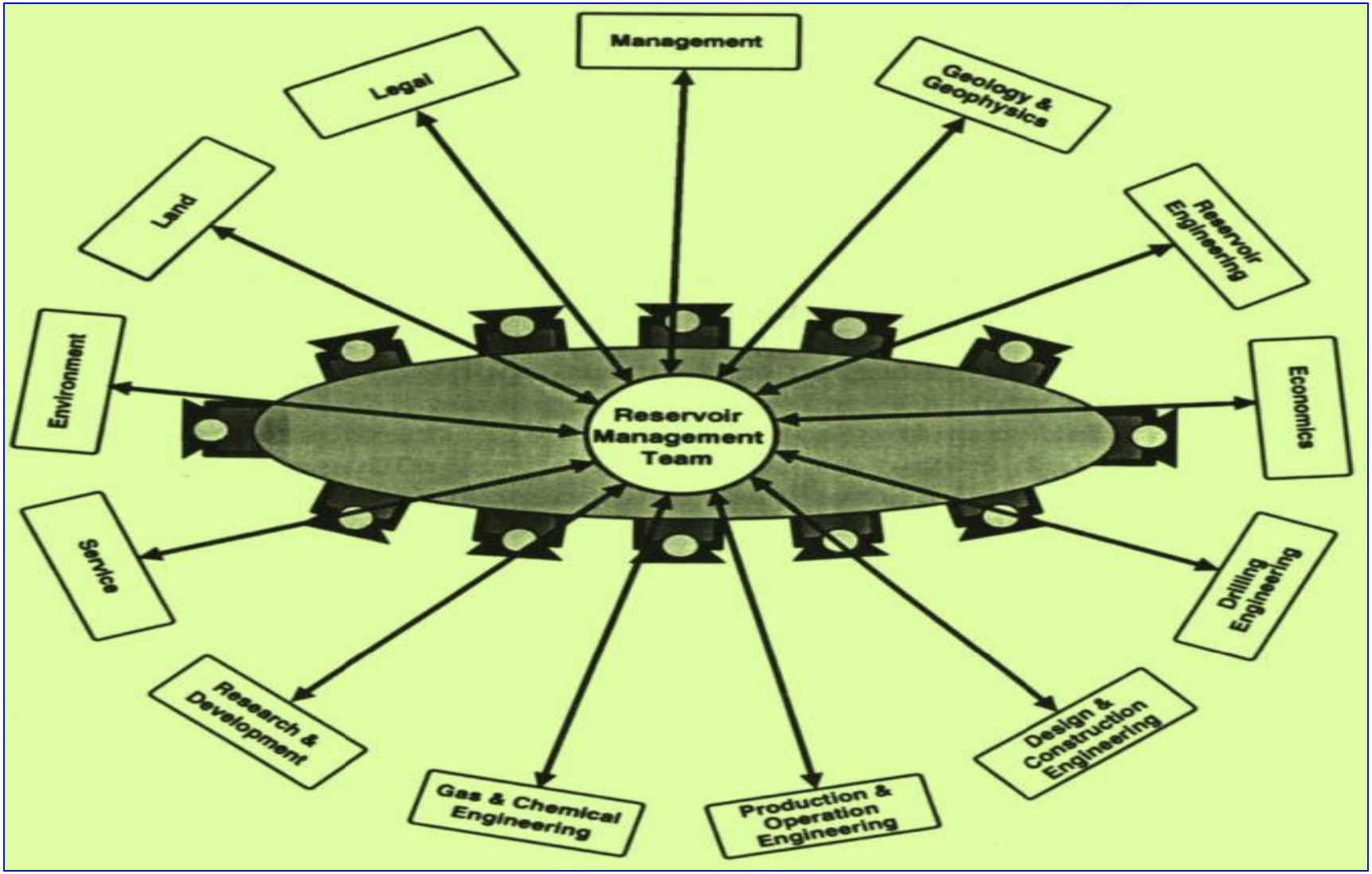

FIGURE 5. Reservoir Management Team ***(Copyright @ 1992, SPE, from paper 22350)***

- A team approach to reservoir management can be enhanced by the following:

➢ Facilitate communication among various engineering disciplines , geology, and operations staff by:

(a) Meeting periodically.

(b) Interdisciplinary cooperation in teaching each other's functional objectives.

(c) Building trust and mutual respect.

➢ To some degree, the engineer must develop the geologist's knowledge of rock characteristics and depositional environment, and a geologist must cultivate knowledge in well completion and other engineering tasks.

- Each member should subordinate their ambitions and egos to the goals of the reservoir management team.
- Each team member must maintain a high level of technical competence.
- The team members must work as a well coordinated “basketball team” rather than a “relay team.”

- 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

Functional Heads and a Production Manager

- **Functional heads**: provide functional guidance and perform evaluations.
- **Production manager**: provides project direction and focuses on business needs.
- There are two system for reservoir management,the old and the new system.
- In the old (conventional) system, various members of the team (i-e., geologist, reservoir/production/ facilities engineers, operations staff, and others) work on a reservoir under their own bosses/functional heads

- In the new/multidisciplinary system , the team members from various functions work on a given reservoir under a team leader and sometimes operate as a self managed team. The team members concentrate on their duties more like generalists than functional specialists.
- In order to make effective decisions, the production manager has to recognize the dependence of the entire system upon the nature and behavior of the reservoir.

Which Factors should be carefully considered?.

1. Formation of the team.
2. Selection of team members.
3. Appropriate motivational tools.
4. Composition of the team

Integration Of Geoscience & Engineering

- Sessions and Lehman presented the concept of increased interaction between geologists and reservoir engineers through multifunctional teams and cross-training between the discipline.
- Sessions and Lehman presented Exxon's three case histories where the geology-reservoir engineering relationship was promoted through both a team approach and an individual approach.
- The results of the three cases (project-based approach, team-based approach, and multiskilled individual approach) were very positive.

Why We Use 3-D Seismic In Reservoir Management?

- Robertson of Arco points out that the geologic detail needed to properly develop most hydrocarbon reservoirs substantially exceeds the detail required to find them.
- The initial interpretation of a 3D-seismic survey affects the original development plan.
- The 3D-seismic data guide interwell interpolations of reservoir properties.
- The reservoir engineer can use the seismic volume to understand lateral changes.
- The 3D-seismic analysis can be used to look at the flow of fluids in a reservoir.

- As described by Harris, both engineering and geological judgment must guide the development and use of the simulation model.
- The geologist usually concentrates on the rock attributes in four stages:

1. Rock studies establish lithology and determine depositional environment, and reservoir rock is distinguished from non reservoir rock.
2. Framework studies establish the structural style and determine the three dimensional continuity character and gross-thickness trends of the reservoir rock.

3. Reservoir quality studies determine the framework variability of the reservoir rock in terms of porosity, permeability, and capillary properties.

4. Integration studies develop the hydrocarbon pore volume and fluid transmissibility patterns in three dimensions.

- The geologist requires input and feedback from the engineer.(See Figure 6).

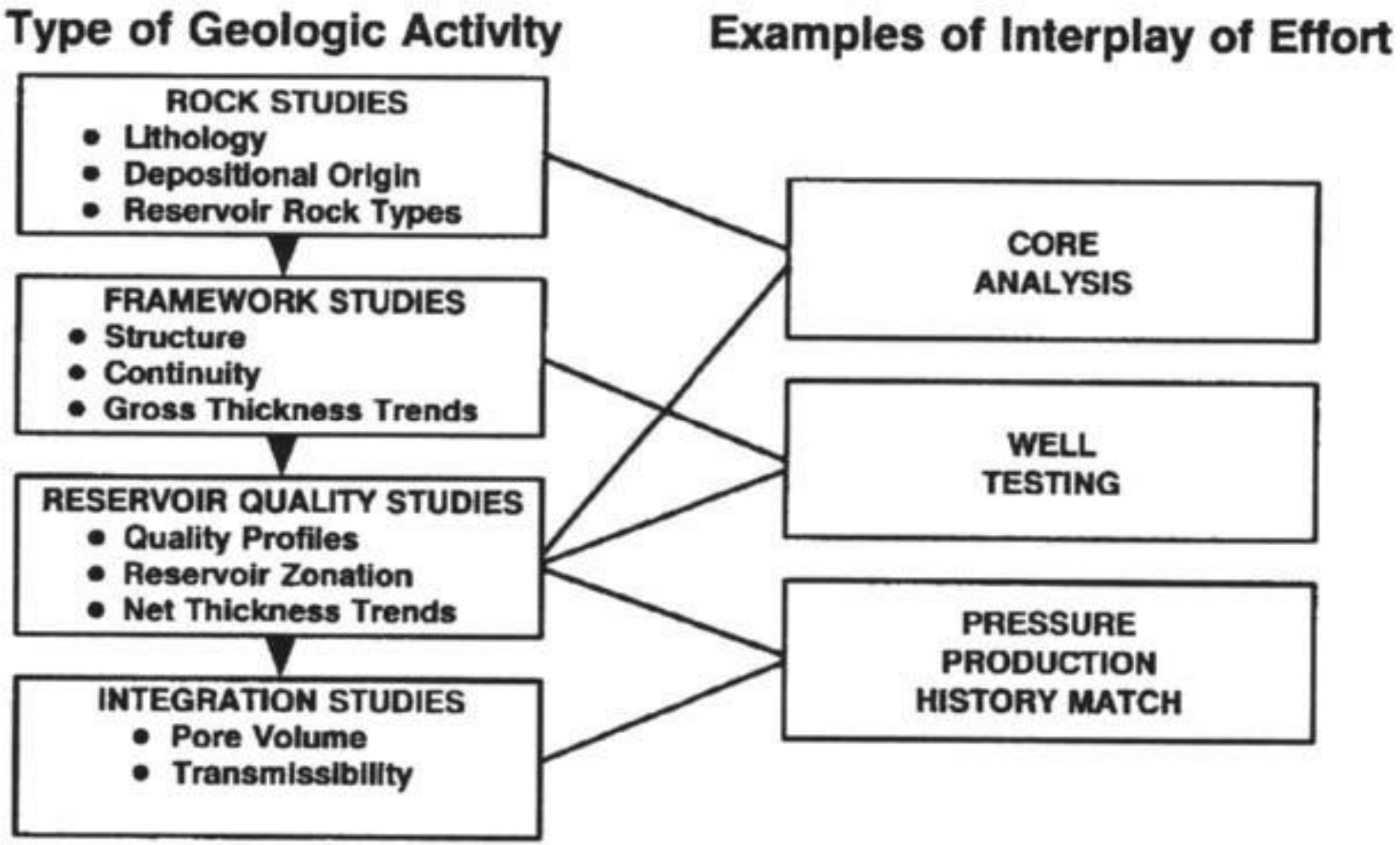

FIGURE 6. General Geological Activities in Reservoir Description and Input from Engineering Studies *(Copyright @ 1975, SPE , from JPT, May I 975)*

Integrating Exploration and Development Technology

- New developments in computer hardware, technology, and software are enhancing integration of multidisciplinary skills and activities.
- Recently, Oil and Gas Journal published a special report on "Integrating Exploration and Development Technology" using state-of-the-art computing and communication.
- 3-D seismic data along with computer-processed logs and core analyses characterize or describe more realistically and accurately the reservoir providing the 3-D computer maps.

- The reservoir engineers use these maps along with rock and fluid properties and production/injection data to simulate reservoir performance and to design depletion and development strategies for new and old fields.
- The supercomputers made reservoir simulators work faster and more accurately.
- The computer networks that link the IBM mainframe computers, Cray supercomputers, Unix workstations, and PC token ring networks together provide the mechanism for effective communication and coordination from various geographical office locations

- While networks provide an efficient means to move digital data, retrieval and storing of data pose a major challenge in the petroleum industry today. The problems are:

➢ Incompatibility of the software and data sets from the different disciplines.

➢ Databases usually do not communicate with each other.

- 3-D visualization technique will enhance our understanding of the reservoir, providing better reservoir description and simulation of reservoir performance.
- It may very well be the most powerful and persuasive communication tool of the integrated teams for decades to come.

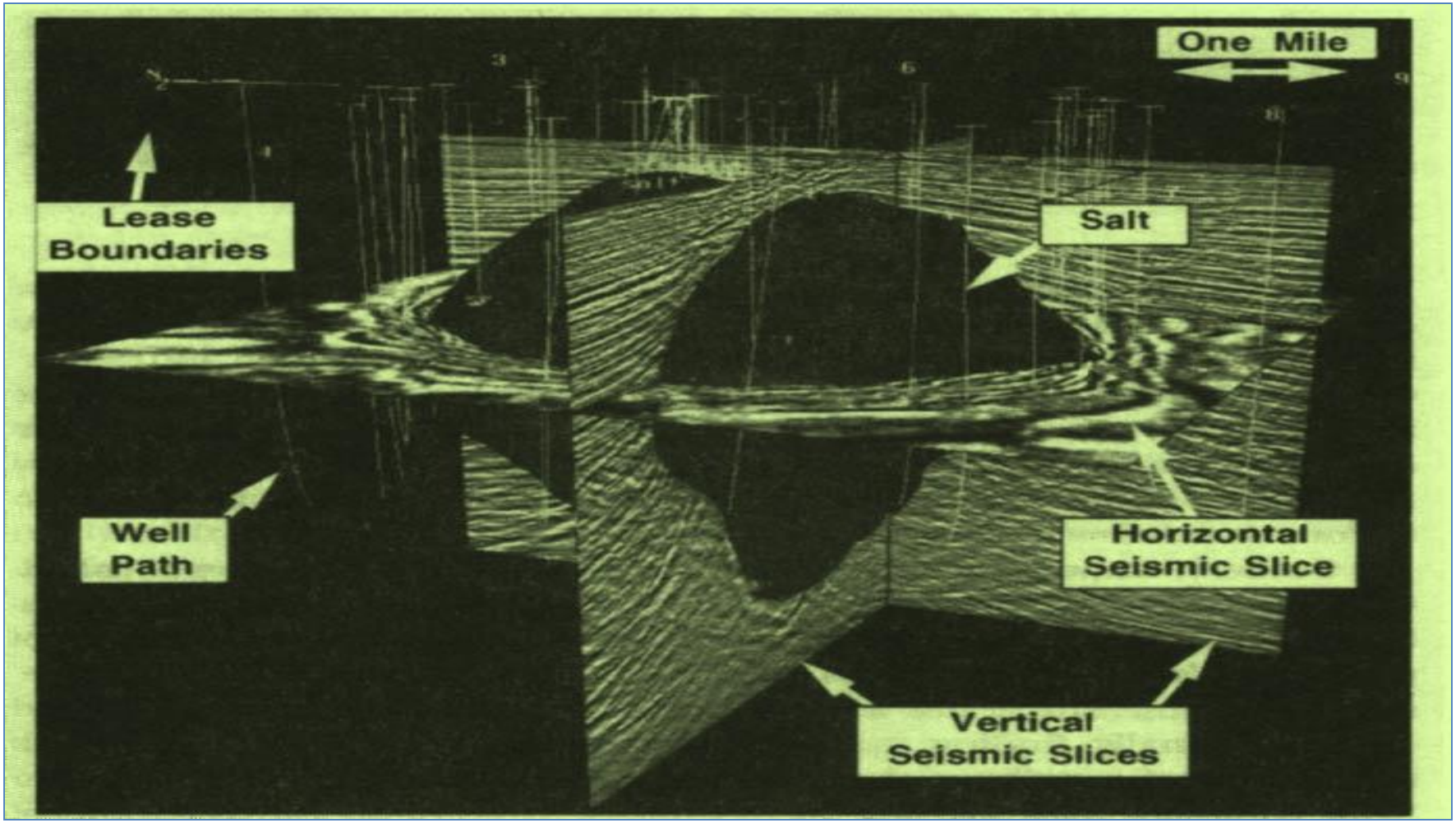

FIGURE 7. Integrating Exploration and Development Technology *(courtesy OGJ, May 1993, from Wyatt et al., "Ergonomics in 3-D depth migration, 62nd SEG Int. Mtg. and Exp., October 1992)*