Introduction to Aspects of Reserve Growth

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Chapter A *of*

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Overview

Since the early 1970's, potential petroleum-supply crises have been related to political events that disrupt the flow of imported oil. Twice in the last three decades, the routine of daily living in the United States has been changed by politically induced reductions in the supply of foreign oil.

A second but less publicized type of potential petroleum-supply crisis relates to fundamental geologic limitations on the world supply of oil and natural gas. Thus far, this concern has remained theoretical. However, world demand for oil and gas is predicted to continue to rise, and much petroleum (especially oil) has already been produced. Petroleum is a nonrenewable resource on the time scale of human activities.

Some people expect that in as short a time as one or two decades, geologic constraints rather than political constraints on the volumes of oil remaining to be discovered and on the rates at which oil can be produced will lead to a more or less permanent oil-supply crisis. Other observers point out that similar forecasts of gloom and doom have been with us almost since the beginning of commercial oil production. Such forecasts, they say, have proved to be poorly founded and will continue to be poorly founded because of a chronic tendency to underestimate (1) the abundance of oil in the ground, and (2) the pace and extent of technology advancement in the petroleum industry.

This debate is complex and emotional, and it certainly cannot be resolved here. However, we can speak to one data element that is important to the discussion between petroleum-supply optimists and pessimists. That element is remaining petroleum reserves—the "inventory" of petroleum that is on hand, in the ground, waiting to be produced and sold. The remaining petroleum reserves of a country or of the world depend upon the difference between the volume of oil and gas that has been discovered in commercial accumulations and the volume that has been produced. Volumes produced are in general reasonably well known, but volumes of petroleum that have been discovered and can be economically recovered are difficult to estimate, as discussed in the following section. As a result, no one really knows how much petroleum has already been discovered but not yet produced. For the world, the magnitude of this uncertainty is on the scale of many hundreds of billion barrels of oil or (for gas) oil equivalent.

Reserve Growth

Since 1977, operators of oil and gas fields in the United States have been required to submit an annual report to the U.S. Department of Energy, Energy Information Administration, that includes production figures and a careful estimate of remaining reserves for each field they operate. These sequential annual reports show that, at all stages in a field's development history, the estimate of remaining reserves (and thus of field size, which equals cumulative production plus remaining reserves) is more likely to be too low than too high. In other words, as years pass, successive estimates of field size tend to increase. This phenomenon is referred to as reserve growth (also known as field growth, reserves appreciation, or oil-field reserve appreciation).

Factors that contribute to reserve growth include:

• Delineation of additional oil and gas in-place, through areal extensions of fields and development of new pools and reservoirs within fields.

• Higher recovery percentages of the oil and gas in-place, resulting from infill drilling and the application of improved technology and advanced engineering methods.

• Revisions of reserve calculations (commonly upward), based on experience gained in the course of developing and operating a field.

Reserve-growth patterns of individual United States fields are highly variable. Indeed, the sizes of some fields are observed to decrease through time (negative growth). For United States fields taken as a whole, however, reserve growth is strongly positive and is a major component of remaining United States petroleum resources. Assessments of the remaining oil and gas potential of the United States and of the world are strongly affected by the assessor's models and forecasts of future reserve growth.

Preview of this Volume

Much work remains to be done before reserve growth is adequately understood. The reports that will be collected as chapters of this bulletin deal with a variety of aspects of reserve growth and contribute to an important area of study. These papers are presented with the goal of improving our ability to understand and forecast future reserve growth.

Two chapters focus on petroleum resource assessments. One chapter by J.W. Schmoker and T.S. Dyman analyzes trends in results of four successive U.S. Department of Interior (U.S. Geological Survey and U.S. Minerals Management Service) estimates of technically-recoverable natural gas resources, of which reserve growth is an important component, with a view toward better understanding the U.S. gas-resource base in the context of the next few decades. The second chapter by R.C. Crovelli and J.W. Schmoker presents an analytic probabilistic method for estimating future reserve growth of oil and gas fields. Like other U.S. Geological Survey reserve growth models, the method utilizes the age of fields as a surrogate for the activity that generates reserve growth. The advantage of this new method is that reserve-growth forecasts are developed and presented as probability distributions rather than single (point) estimates.

Three chapters interpret reserve-growth patterns in three very different sets of oil and gas fields. The first chapter by M.E. Tennyson analyzes the reserve-growth trends of 12 large California oil fields whose resources have continued to appreciate well past the ages at which most fields no longer show significant increases in ultimate recovery. Growth of reserves in these fields is due to increases in recovery factor achieved by development of enhanced recovery (steam flooding) technologies. The second chapter by T.S. Dyman and J.W. Schmoker tests well production parameters such as annual and cumulative production from a variety of areas and formations as tools to quantify and understand the heterogeneity of reservoirs. Examples include the Northern Great Plains Cretaceous shallow biogenic gas accumulation and the Morrow gas accumulation in the Anadarko Basin. If the assumption is made that reservoir heterogeneity as indicated by well production parameters correlates with the degree of reservoir compartmentalization, then a ranking of well production parameters for a group of fields might be interpreted as a ranking of opportunity for reserve growth from infill drilling. The third chapter by J.W. Schmoker presents and interprets production and reserves data for giant (larger than 100 million barrels of oil) U.S. oil fields. Giant fields account for a very small fraction of the total number of oil fields discovered in the U.S., but their importance to U.S. reserve growth—past and future—vastly exceeds their numerical proportion.

Two chapters address some of the geologic controls governing reserve growth. In one chapter by T.C. Hester, a log-based method for evaluating natural gas production potential in poor quality sandstone reservoirs is explained. The application presented is for the shallow biogenic gas accumulation in shaly sandstones of Cretaceous age in the northern Great Plains. This accumulation is known to exist, but production potential and potential reserves are very uncertain. The second chapter relates selected sedimentologic, diagenetic, lithologic, and tectonic characteristics of both clastic and carbonate reservoirs to production data. Such geologic parameters affect reservoir quality and might ultimately be used to characterize the potential for reserve growth.

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