Chapter DS

DATA SOURCES AND COMPILATION

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DATA SOURCES

The USGS World Petroleum Assessment 2000 was based on geological analysis and exploration and discovery history. This combined geologic and historical approach is especially useful because, in some areas of the world, exploration is still in the early stages or was not continuous through time, while other areas are relatively mature with respect to exploration. Geology and exploration/discovery history were characterized in terms of an assessment unit (AU), which was the basic entity for organizing data for the volumetric assessments of undiscovered oil and gas resources.

Geological, geochemical, and geophysical information were derived from published literature, studies by USGS personnel, unpublished data from various organizations, a consortium of petroleum-industry representatives, discussions with colleagues and peers, and commercial databases. Discovered field sizes and exploration/discovery-history data were derived almost exclusively from commercial databases.

Published Literature

Extensive searches for published information were conducted, and all sources of available data regarding the areas of interest were studied, evaluated, and used in the assessment procedure. Selected key references are cited in each of the AU sections of this publication.

Studies by USGS Personnel

U.S. Geological Survey personnel gather, assimilate, and maintain a variety of geologic information. In addition, many USGS scientists have intimate knowledge of, or expertise in, geology of other parts of the world, and this knowledge has been incorporated into regional geologic analyses. Research on reserve growth and petroleum migration was also undertaken in support of this assessment. Additional data were obtained from four previous world assessments undertaken by the USGS (Masters and others, 1984, 1987, 1991, and 1994).

Geologic maps were compiled from a variety of sources and digitized using a geographic information system (GIS). The completed maps show total petroleum system (TPS) and AU boundaries. Country boundaries, major cities, rivers, and water bodies are also shown. Cartographic layers of cultural and water-body data were provided by, and used with the permission of, Environmental Systems Research Institute (1992, 1996). Locations of oil and gas fields and wells were used for purposes of the assessment. Only field-centerpoint locations, provided by, and used with the permission of, Petroconsultants (1996a) are displayed on the maps included in this publication.

Unpublished Data

Additional data were provided by the Department of Defense, GeoDesign, Global Center for Energy Studies, and other proprietary U.S. government and international sources. These data supplemented those from the commercial databases used in this assessment.

Consortium

A consortium of major and independent oil and gas companies participated in regional geologic studies for the World Petroleum Assessment 2000. Industry representatives provided information that is not generally available, particularly for areas where data from the published literature or databases are not reliable.

Discussions With Colleagues and Peers

Information was also obtained from colleagues from the International Energy Agency, U.S. Energy Information Agency, American Association of Petroleum Geologists, and a variety of other sources.

Commercial Databases

Historical and volumetric oil- and gas-field data and well data were derived from databases purchased by the USGS. These databases include Petroconsultants, Inc.,

1996 Petroleum Exploration and Production database (Petroconsultants, 1996a); Petroconsultants, Inc., 1996 PetroWorld 21, Version 2.4, Q2 1996 (Petroconsultants, 1996b); other area reports from Petroconsultants, Inc.; and NRG Associates, Inc. Significant Oil and Gas Pools of Canada database (NRG Associates, 1995).

Geochemical data were derived from the GeoMark Research, Inc. OILS database (GeoMark Research, 1998). These data are current through 1997 and include compositions and chemical properties of crude oils throughout the world.

Data from these commercial databases are proprietary and are not disclosed in this assessment. Derivative representations of the data are presented, however, as summary statistics and plots. To further ensure the confidentiality of such data, discovered volumes are given only if two or more fields are present in an AU, and statistical and graphical displays of field sizes are given only if four or more fields are present.

The USGS does not ensure the accuracy, completeness, representativeness, or currency of data reported in the commercial databases. Some discovered fields are not reported in the databases; likewise, some field volumes are either not reported or the reported volumes are questionable. Also, the number of fields, number of wells, and volumes of discovered oil and gas reported in some cases may not be accurate or are under-represented due to unreported data, field sizes reported for only portions of fields, field sizes reported for combined fields, or documentation (typographical) errors. Strong efforts were made to supplement reported field-size data through acquisition of selected proprietary databases, and to verify the accuracy of Middle East and Former Soviet Union data.

DATA COMPILATION

The data-compilation procedure for AUs is shown on figure DS-1. First, the geology of a province and the TPSs and AUs within the province were described

and mapped. Fields and wells were assigned to TPSs and AUs. Field and well data for each AU were compiled and the exploration/discovery-history plots and statistics were generated. In addition, a set of plots and statistics were generated after field sizes were adjusted to account for reserve growth. The geology, field-size distributions, and historical data were presented to the USGS assessment team and consortium members for review. Estimates of the number and sizes of undiscovered oil and gas fields greater than or equal to a minimum size and their coproduct ratios were recorded on assessment forms. These estimates were presented to a formal resource-assessment team of USGS geologists for final approval. Upon approval, undiscovered resources were calculated. Geologic descriptions, exploration/discovery history, and assessment results were subsequently documented.

MAPPING AND DESCRIBING TPSS AND AUS

Maps

Maps of TPSs and AUs were created on the basis of published literature and other available data in a GIS format. Information on field and well locations from Petroconsultants and NRG Associates were combined with digital geologic maps to aid in delineation of TPSs and AUs. Attributes such as field size, field type, total depth of wells, drilling objectives (stratigraphic units), and major producing reservoirs were posted as requested by the USGS investigator responsible for the AU. These data are not included in this publication because they are proprietary.

Geologic Descriptions

Total petroleum systems and AUs within each of the priority and boutique provinces were defined and characterized in terms of geology and exploration/discovery-history factors. Geology was characterized by descriptions of source rocks; overburden rocks; reservoir rocks; seals; traps; petroleum types; petroleum generation, migration, accumulation, and preservation; timing of geologic events; and accumulation distributions. Discovered field-size distributions,

exploration and discovery history, exploration strategy, future exploration concepts, and infrastructure were also described.

Geologic summaries of each AU were prepared. The summaries include the province, total petroleum system, and AU names and codes; brief descriptions of the AU setting, source rocks, petroleum maturation, petroleum migration, reservoir rocks, traps, and seals; and key references.

Allocating Fields and Wells to TPSs and AUs

Once defined, boundaries of TPSs and AUs were used to allocate wells and fields to their respective units. These allocations were entered into the oil- and gas-production databases so that exploration/discovery-history data for each unit could be retrieved, plotted, and analyzed. Fields were assigned to only one TPS and one AU. Wells, however, were assigned to more than one if they penetrated more than one TPS or AU. In places, well allocations were based on location rather than geology, due to unreported objective or bottom-hole information. Field and well allocations were reviewed to ensure proper assignments where TPSs or AUs overlapped.

Exploration and Discovery History

Plots and statistics showing exploration and discovery history by year and exploration/discovery history and coproduct ratios by depth were made for each AU to aid in the assessment. Known field sizes were derived from estimated total recoverable volumes of oil, gas, and natural gas liquids reported in the Petroconsultants and NRG Associates databases. Reported gas includes both non-associated and associated-dissolved gas. Known field sizes (that is, estimated total recoverable volumes) are the sum of cumulative production and remaining reserves. Petroconsultant's "Ultimate Recoverable Reserves" for fields were used to represent known petroleum for all countries except Canada. Dates for which these volumes

were reported are variable. NRG Associates' "Initial Reserves" for oil, gas, and condensate pools were aggregated to provide known volumes for Canadian fields. Sizes of Canadian fields are current through 1993. NRG Associates' remaining reserves are defined as "proven reserves" whereas Petroconsultants' are defined as "proven plus probable reserves," resulting in relatively smaller sizes for Canadian fields. Some Canadian AUs, however, were assessed using pool-level data rather than field-level data.

Coproduct ratios (gas to oil ratio, GOR; NGL to gas ratio; and liquids to gas ratio, LGR) were calculated using field-level oil, gas, and NGL volumes. Coproduct ratios for some Canadian AUs, however, were calculated using pool-level volumes. Oil and gas fields were treated separately; an oil field is defined as a field with a GOR less than 20,000 cubic feet/barrel whereas a gas field has a GOR equal to 20,000 cubic feet/barrel or greater. Oil and gas pools are defined similarly. Plots were generated for fields that had been assigned to an AU (thereby having a reported longitude and latitude) and had a reported discovery date. If these criteria were not met, they were excluded from the exploration/discovery-history plots and statistics. Oil fields containing less than 1 MMBO and gas fields containing less than 6 BCFG were not included in the plots or statistics.

Reservoir and well data used in the analysis of exploration/discovery history include formation name, age, lithology, depth, API gravity of hydrocarbon liquids, well name, and well-completion date. Only the number and completion dates of new-field wildcat wells, rather than all exploratory wells, were used in the analysis of exploration/discovery history. The number of new-field wildcat wells drilled per year indicates the exploration effort for finding new fields. A new-field wildcat well is an exploratory well drilled at least two miles from a producing field to test a separate trap. Exploratory wells, however, are drilled not only to discover new fields but also to discover new reservoirs or pools in existing fields. The number of exploratory wells drilled per year is therefore a less reliable indicator of overall exploratory effort in a given area than is the number of new-field wildcat wells.

Two sets of plots and statistics were typically generated, one using known field sizes and one using field sizes upon which a reserve-growth function was applied (grown). Plots for some Canadian AUs were made using pool-level data. The following plots were made (see the AU sections of this publication):

- Cumulative number of new-field wildcat wells vs. drilling-completion year
- Number of new-field wildcat wells vs. drilling-completion year
- Oil- or gas-field size (MMBO or BCFG) vs. oil- or gas-field rank by size (with respect to discovery-history segments, described later in this chapter)
- Number of oil or gas fields vs. oil- or gas-field size classes (MMBO or BCFG) (with respect to discovery-history segments)
- Volume of oil or gas (MMBO or BCFG) vs. oil- or gas-field size classes (MMBO or BCFG)
- Oil- or gas-field size (MMBO or BCFG) vs. field-discovery year
- Oil- or gas-field size (MMBO or BCFG) vs. cumulative number of new-field wildcat wells
- Cumulative oil or gas volume (MMBO or BCFG) vs. field-discovery year
- Cumulative oil or gas volume (MMBO or BCFG) vs. cumulative number of new-field wildcat wells
- Cumulative number of oil or gas fields vs. field-discovery year
- Cumulative number of oil or gas fields vs. cumulative number of new-field wildcat wells
- Reservoir depth, oil or gas fields (m) vs. field-discovery year
- Reservoir depth, oil or gas fields (m) vs. cumulative number of new-field wildcat wells
- Gas/oil, oil fields (CFG/BO) vs. mean reservoir depth (m)

- NGL/gas, oil fields (BNGL/MMCFG) vs. mean reservoir depth (m)
- Liquids/gas, gas fields (BL/MMCFG) vs. mean reservoir depth (m)
- Number of reservoirs in oil fields vs. API gravity (degrees)

All plots were scaled with respect to grown field-size data and completion year of the oldest new-field wildcat well. In some cases, however, no new-field wildcat wells were reported as completed prior to the oldest field, therefore the date of the oldest field was used to scale the axes. The number of new-field wildcat wells reported for some areas was known to be inaccurate (under reported); for these areas, plots with respect to number of new-field wildcat wells were not made.

Reserve Growth

Because this assessment includes a 30-year forecast, it is important that the reserve growth of fields be considered in evaluating existing and undiscovered field sizes. Increases in reported field sizes through time are commonly observed. To address this subject, a library of reserve-growth functions that model these observed changes was used. The functions are based on United States reserves data and include those created by the USGS for the national assessment (described in chapter RG) (Gautier and others, 1995). In addition, the Minerals Management Service's function for the U.S. Outer Continental Shelf was employed (Lore and others, 1996). The growth function names and codes are the U.S. Outer Continental Shelf (MMS), the entire lower 48 United States (Lower 48 or Lower 48 All), Pacific Coast (US Region 2), Colorado Plateau and Basin and Range (US Region 3), Rocky Mountains and Northern Great Plains (US Region 4), West Texas and Eastern New Mexico (US Region 5), Gulf Coast (US Region 6), Midcontinent (US Region 7), and Eastern (US Region 8).

Growth functions were applied for two different types of analyses (1) to aid in estimating grown sizes of undiscovered fields and (2) to determine the contribution

of reserve growth of existing fields to world resources. The contribution of reserve growth from existing fields is discussed in chapter RG.

The assessor (USGS geologist responsible for assessing the AU) selected a growth function to be applied to known field sizes. The function was chosen to best serve as an analog for reserve growth in areas of interest. The grown field sizes were then plotted to provide a discovery-history profile from which undiscovered field sizes were estimated. The undiscovered field sizes therefore are compensated for reserve growth. In some cases, only the known field sizes or pool sizes were used in the assessment process, and those were noted accordingly.

Discovery-History Segments

Discovery-history segments are the first-, second-, and third-thirds (or first- and second-halves) of the number of existing oil or gas fields within an AU ranked according to date of discovery. The segments are used to help understand the discovery process. If an AU contains fewer than 2 fields, no discovery-history segments were calculated. Assessment units containing 2 to 13 fields are separated into discovery halves and those containing more than 13 fields are separated into discovery thirds. Additionally, AUs with more than 13 discovered fields are classified as established, those with 1 to 13 are classified as frontier, and those with no discovered fields are classified as hypothetical.

Discovery-history segments were used to standardize and increment time in the context of exploration maturity for comparative purposes. Not only can discovered fields be analyzed in terms of discovery-history segments, but all of the fields discovered to date may be perceived as constituting one or more segments whereas the undiscovered fields may comprise the remaining segment(s).

Presentation of Geology to Consortium and World Energy Assessment Team

Quarterly meetings of the World Energy Consortium members provided a forum for presentation and discussion of the geology and exploration history of geologic provinces so that the accuracy of the data and the reliability of geologic interpretations could be evaluated. Information obtained from the consortium was used in the assessment process. The assessment was conducted solely by USGS personnel after these meetings to ensure unbiased results.

SUMMARY

Maps, geologic descriptions, assessment input, and calculated results are provided for all AUs in this multi-CD-ROM set, but exploration/discovery-history plots are provided only where adequate data exist. Subsequent chapters describe the operational procedures and calculations for undiscovered oil and gas resources.

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Assessment Procedure for World Petroleum Assessment 2000

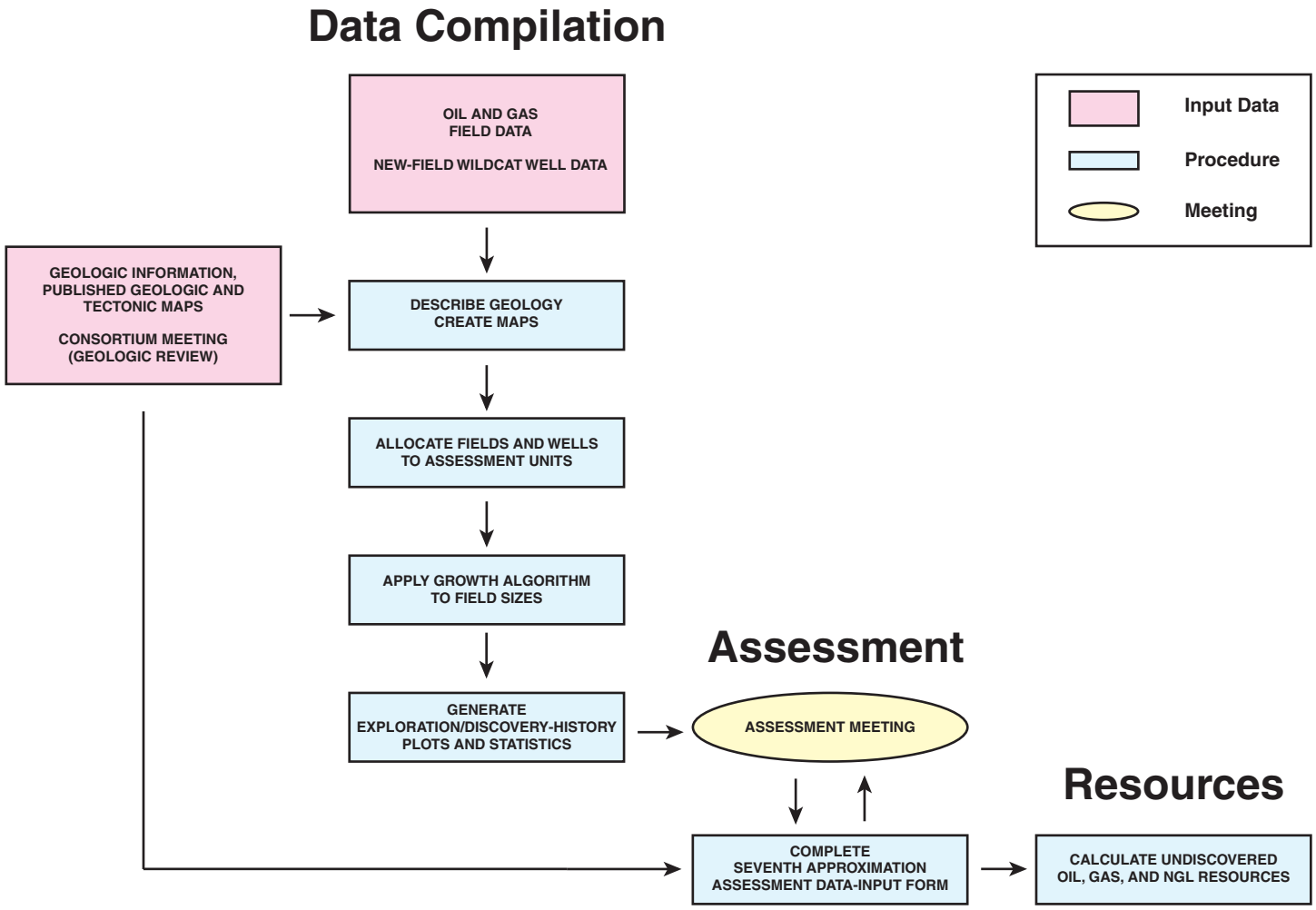

Figure 1. Simplified flow diagram of the assessment procedure.

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