Chapter IN

INTRODUCTION

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INTRODUCTION

An understanding of the location and quantity of petroleum in the world is of vital strategic interest to those people who either produce or consume petroleum. As Youngquist (1997) observed: "*The importance of mineral and energy mineral resources cannot be overestimated. Most critical among the resources is energy. Energy is the key which unlocks all other natural resources. Without it the wheels of industry do not turn, no metals are mined and smelted. No cars, trucks, trains, ships or airplanes could be built, and if built, they could not move without energy. Without energy, houses would remain cold and unlighted, food would be uncooked. Fields could not be plowed nor planted with the ease and on the vast scale they are today by means of relatively little human labor. Military defense as we know it today would not exist. Without energy resources we would literally be back in the Stone Age. And without the use of energy and metals as we use them today, it is probable that the world's population would be reduced at least one-half, some estimates say 90 percent.*"

The U.S. Geological Survey (USGS) World Petroleum Assessment 2000 of the quantities of oil, gas, and natural gas liquids (NGL) that have the potential to be added to reserves within a 30-year time frame is the result of a five year effort (1995-2000) of a large team *(LS)*. The assessment is organized into several CD-ROM set. The first three CD-ROM's present detailed results of the assessment as well as extensive documentation of the methodology used. The final CD-ROM contains additional archival information helpful for those who wish to do further analysis of their own. Liberal use of abbreviations in the following discussions is mainly for the purpose of referencing various chapters of the CD-ROM that are pertinent to

the stated subject matter and are highlighted and linked in the text so that the reader can access them.

The first CD-ROM's are organized into a series of introductory sections including an Executive Summary *(ES)*; this introductory chapter *(IN)*; acknowledgments *(AK)*; a glossary *(GL)*; a table of conversion factors, abbreviations, and acronyms *(CF)*; a list of team members *(LS)*; and CD-ROM design notes *(CD)*. The introductory section is followed with a series of historical and documentation chapters on databases and methodology. These include a review of previous USGS world assessments *(RV)*; a description of the Total Petroleum System *(PS)*; initial province ranking and assessment hierarchy *(RH)*; and data sources and compilation *(DS)*. The methodology component discusses the basic assessment model *(AM)*, assessment operation procedures *(OP)*, the Monte Carlo simulation method *(MC)*, aggregation and allocation procedures *(AA)*.

A results section that is also a part of the first CD-ROM's summarize assessment results for field growth *(RG)* and undiscovered resources *(AR)*. An overview of regional assessments is provided in a series of eight reports: Region 1—Former Soviet Union *(R1)*; Region 2—Middle East and North Africa *(R2)*; Region 3—Asia Pacific *(R3)*; Region 4—Europe *(R4)*; Region 5—North America (exclusive of the United States) *(R5)*; Region 6—Central and South America *(R6)*; Region 7—Sub-Saharan Africa and Antarctica (Antarctica was not assessed) *(R7)*; and Region 8—South Asia *(R8)*. Lastly, they contain brief summaries of the 270 assessment units that are identified in the eight regions, including descriptions of general geology, source rocks, petroleum maturation and migration, reservoir rocks, traps and seals, and a listing of key references.

The last CD-ROM is an archive of supporting data for the assessment in forms useful for further analysis. These data include the input forms used in the assessment, statistics for discovered fields, geographic information system map coverages, logarithmically binned sizes and numbers of undiscovered fields, and assessment results for different hierarchical levels including assessment units (AU), Total Petroleum Systems (TPS), provinces, regions, countries, and onshore and offshore regions (*Disc* 4 Readme.txt).

The World Petroleum Assessment 2000 is built upon assessment of the geologically defined Total Petroleum Systems (TPS) and its subdivisions assessment units (AU). The forecast span is 30 years (1995-2025) *(GL, CF)*. Quantitative estimates are given for undiscovered petroleum resources in conventional accumulations and for world-level reserve (field) growth. Assessment units containing continuous-type resources *(GL)* are identified in the world but not quantitatively assessed.

Resource estimates were made for parts of 128 geologic provinces in 96 countries and 2 jointly held areas exclusive of the United States as shown on the Master List *(ML)*. For aggregation purposes, (1) the estimates for undiscovered recoverable resources for onshore United States and state waters rely upon the U.S. Geological Survey's 1995 National Assessment (U.S. Geological Survey, 1995), and (2) the estimates for the United States Outer Continental Shelf rely on the Minerals Management Service's 1996 offshore assessment (Minerals Management Service, 1996). The Master List of TPS and AU *(ML)* shows the 159 TPS and 270 AU of which 149 TPS and 246 AU were assessed during this study (TPS and AU Maps).

Critical Decisions: A series of critical decisions went into planning and producing the World Petroleum Assessment 2000. These decisions, summarized below, were made early in the assessment process and directly affected the results shown on the CD-ROMs.

(1) We would consider geologic characteristics to be the primary criteria for resource assessment *(AK)*. Rationale: The world has many socio-economic parameters than can affect an assessment based solely on statistics, such as exclusion of areas for development, interruptions by regional or world conflicts, or technology limitations. Geologically defined and analyzed Total Petroleum Systems (TPS) are independent of such socio-economic factors. Additionally, statistics cannot capture ideas and concepts for future exploration. We have documented the geology of the various regions and their provinces throughout the world in a series of CD-ROM's that serve as a foundation for the assessment *(AK)* and will provide a basis for future research work.

(2) We would assess using Total Petroleum Systems (TPS) as the fundamental geologic entity *(PS)*. Rationale: TPS include the undiscovered resource component *(GL)* and are more inclusive than petroleum systems as commonly defined in the literature. Our databases, for example, do not permit a play level assessment as was done for the 1995 USGS National Assessment. Basin level assessments had been previously made for the world *(RV)* and a more detailed level of assessment, geologically defined, that was consistent with recent petroleum technology was desired.

(3) We would not attempt to assess ultimate recoverable resources; rather, we would forecast the potential for additional reserves to be added in a 30-year time

frame (1995-2025) in the current (priority) or emerging (boutique) petroleum provinces (*RH)*. Rationale: Thirty years is very long range for financial planners and technological changes beyond 30 years are difficult, if not impossible, to conceptualize and quantify.

(4) We would assess potential reserve (field) growth on a worldwide scale. Rationale: We have observed reserve growth in all petroleum databases that we have examined *(DS)*. Available data suggested that world reserve growth might well be large enough to be an issue of near-term societal importance. Therefore, we considered the World Petroleum Assessment 2000 to be incomplete if an effort was not made to forecast world potential reserve (field) growth *(RG)*. We recognize that not all fields grow through time and a methodology was therefore adopted to account for the large uncertainty in the estimates *(RG)*. We further appreciate regional differences among reserve growth potential and only report world-level scale until such time as more region, country, or province detailed studies are completed.

(5) We would identify continuous resources in selected regions but not quantitatively assess them *(AU Map)*. Rationale: Although aware of numerous potential continuous resources such as basin-centered gas, heavy oil, gas hydrates, and so forth, we felt that additional geologic data was needed to make reliable estimates and that they would be best evaluated in a subsequent round of assessment.

(6) We would use a team approach. Rationale: An assessment of this scale requires many types of expertise that require a synergistic team effort *(LS)* and the advice and support of many organizations *(AK)*.

(7) We would continuously calibrate our efforts with external organizations with respect to our geologic understanding of TPS. Rationale: The assessment is improved by learning of the latest developments and technology throughout the world through meetings of the World Energy Consortium quarterly meetings and other means *(AK)*.

(8) We would establish a methodology early in the process and have it thoroughly reviewed by knowledgeable organizations outside the USGS. Rationale: We would benefit considerably from the most recent knowledge and ideas of others. Our methodology was formally reviewed and endorsed by the American Association of Petroleum Geologists, specifically the Committee on Resource Evaluation *(AK)*. The National Academy of Science (National Research Council) and 38 other World Energy Consortium Members also monitored our efforts, as further discussed in the Acknowledgements and other chapters (*AK, MC, OP, AM*).

(9) We would establish an assessment methodology that could be used for subsequent local, national, and world assessments *(MC, AM)*. Rationale: A uniform methodology allows direct comparison of different assessments.

(10) We would document the assessment digitally (*AR, R1, R2, R3, R4, R5, R6, R7, R8, AA, MC, see Disc4 readme files)*. Rationale: Digital products permit greater flexibility in presentation and documentation relative to paper products. It is important that the basic data and assumptions used in the assessment be thoroughly documented and placed in view (see *Disc4 readme files)*.

(11) Only USGS employees would perform the formal assessment of petroleum resources. Rationale: The USGS is solely responsible for its estimates and is not subject to external influence during the assessment process.

An assessment and its supporting data are most useful if made widely available. We have distributed about 50,000 CD-ROMs of the geologic maps produced in this project at annual meetings of the American Association of Petroleum Geologists, the Geological Society of America, at the 1997 and 2000 meetings of the World Petroleum Congress, and a plethora of other gatherings. These products, as well as the geologic reports and other supporting papers, may be accessed through the website at:
http://energy.cr.usgs.gov or via
http://greenwood.cr.usgs.gov.

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