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# A MODEL FOR RESOURCE ASSESSMENT AND EXPLORATION/PRODUCTION PROCESSES

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# PREFACE

Over the last few years, many studies (WAES, WEC, CIA, oil companies, etc.) have popularized the idea that world oil production will reach a maximum in the 1980's or 1990's and progressively decline. If cumulative production up to the maximum is calculated and compared to the remaining resources to be recovered or produced (taken from the WEC Delphi Study, for instance) it is possible to assume other types of evolution for world oil production as well, in particular a plateau extending over a few decades. Because of the continuing importance of oil in the world economy, such an evolution would be far more desirable than a prompt decline. But of course it is important to assess whether this is even possible and/or realistic.

The IREP model (IIASA Resources, Exploration and Production model) has essentially been designed, in the initial version which is presented here, to explore such a possibility. Preliminary ideas for the resource model came from the Enerdym model (which was developed with Igor Zimin), especially the conceptual aspects of describing the "life" of a resource, from its initial status of "speculative resource" to its possible production.

The IREP model is composed of a number of submodels: resource assessment (the most developed to date), an exploration submodel primarily aimed at obtaining an idea of the effort necessary (drilling, investment, etc.) to discover the assumed resources, and a production submodel directly linked to the exploration submodel but allowing the examination or various scenarios influenced by politico-economic decisions.

In addition, the IREP model can also be used as a sensitivity analysis tool to explore how changes in some parameters--generally linked to the progress of exploration and/or knowledge of petroleum prospects or basins--can influence oil resources and their future production potential. As such, this model is not only a tool which can be used in a preliminary way for forecasting or assessing, but also a working tool for enabling a better understanding of world oil assessment.

The resource assessment submodel has been developed in detail and tested with an application case. Results--although preliminary--are encouraging, and it was thought that this work could usefully be presented and offered for discussion. The input data for the application case will be refined, and more importance should be attached to the potential validity of the approach than to the first results, shown here in a sample run.

Michel Grenon

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# A MODEL FOR RESOURCE ASSESSMENT AND EXPLORATION/PRODUCTION PROCESSES

## 1. INTRODUCTION

The forecasting of oil supply, including oil from non-OPEC sources, is based mainly on two types of analysis (Adelman and Jacoby 1979). An example of the first type of method is "Disaggregated pool analysis". This requires the geological interpretation and statistical analysis of the exploratory process, and the economic evaluation of the pools found. By this method a forecast of the total recoverable reserves to be discovered, and the distribution of the pool size itself, and of the sequence of discoveries by size, can be made. These attributes, together with cost factors, determine the economic viability of a reservoir. "Disaggregated pool analysis" requires detailed information on previous discoveries and their resources. Therefore for regions where the exploration has not yet begun, or is in an initial stage, this method cannot be used.

The other method, which is called "aggregated country analysis", is based on historical data and forecasting of rig activities and assumptions made on proven reserves added per rig-year. Reserve additions then become an input to the calculation of capacity expansion and likely oil production. On this basis an evaluation of new capacity and production plans can be made. "Aggregated country analysis" does not analyze the main property of the country being studied, which is the ability to contain oil or "oil in place". The production plan should also be made with regard to the undiscovered resources.

The proposed model may be considered an attempt to combine the attractive sides of both the above methods. One of the uses of this model will be to suggest alternative production plans, based on an assessment of resources in the country and future discoveries and exploration.

The sequence of procedures of the model is shown in a condensed form in Figure 1. As shown in the diagram, the problem is analyzed by a model consisting of a number of stages which are described in the following sections.

## 2. DETERMINING THE FUTURE PRODUCTION RATE

Although it is an unusual approach, we begin the analysis with the determination of the future production rate. This gives us the possibility of checking whether the desirable potential level of production can be supplied and, if so, under which conditions.

The determination of the future production rate relates to general problems of forecasting and is based on the extrapolation of historical data.

The information collected on oil production allows us to draw production curves. We may treat the data on production differently depending upon whether the general tendency in the production process or a precise picture of changes in the annual production rate is needed.

With respect to this, it is possible to use different interpolation methods. Also the choice of the interpolation method depends on the degree of accuracy of the available data (i.e. if significant jumps in the rate of production over a small period of time are present, then the existence of error can be assumed).

In this case "polynomial interpolation" is the most desirable and polynomials of various degrees may be tried. As a series of experiments shows, a polynomial of the second degree is appropriate when reproducing the tendency of the production process.

The "cubic-spline interpolation" method is optimal in the case of existing precise data on oil production for a relatively long period of time (at least fifteen to twenty years). Here the resulting production curve passes through all points reflecting the annual rate of production.

Since production is an inertial process, having a delay of five to six years, we can extrapolate a production curve for that period of time. Delay times may be different for different countries (the period of time over which the mathematical methods of extrapolation may be applied should be the subject of additional study).

When extrapolation is required, the production curve obtained from the "cubic-spline interpolation" method contains more information and is generally more useful for prediction than the "second degree polynomial interpolation" method. Production curves obtained by "second degree polynomial interpolation" may be used for the extrapolation of processes on the basis of inadequate or inaccurate information.

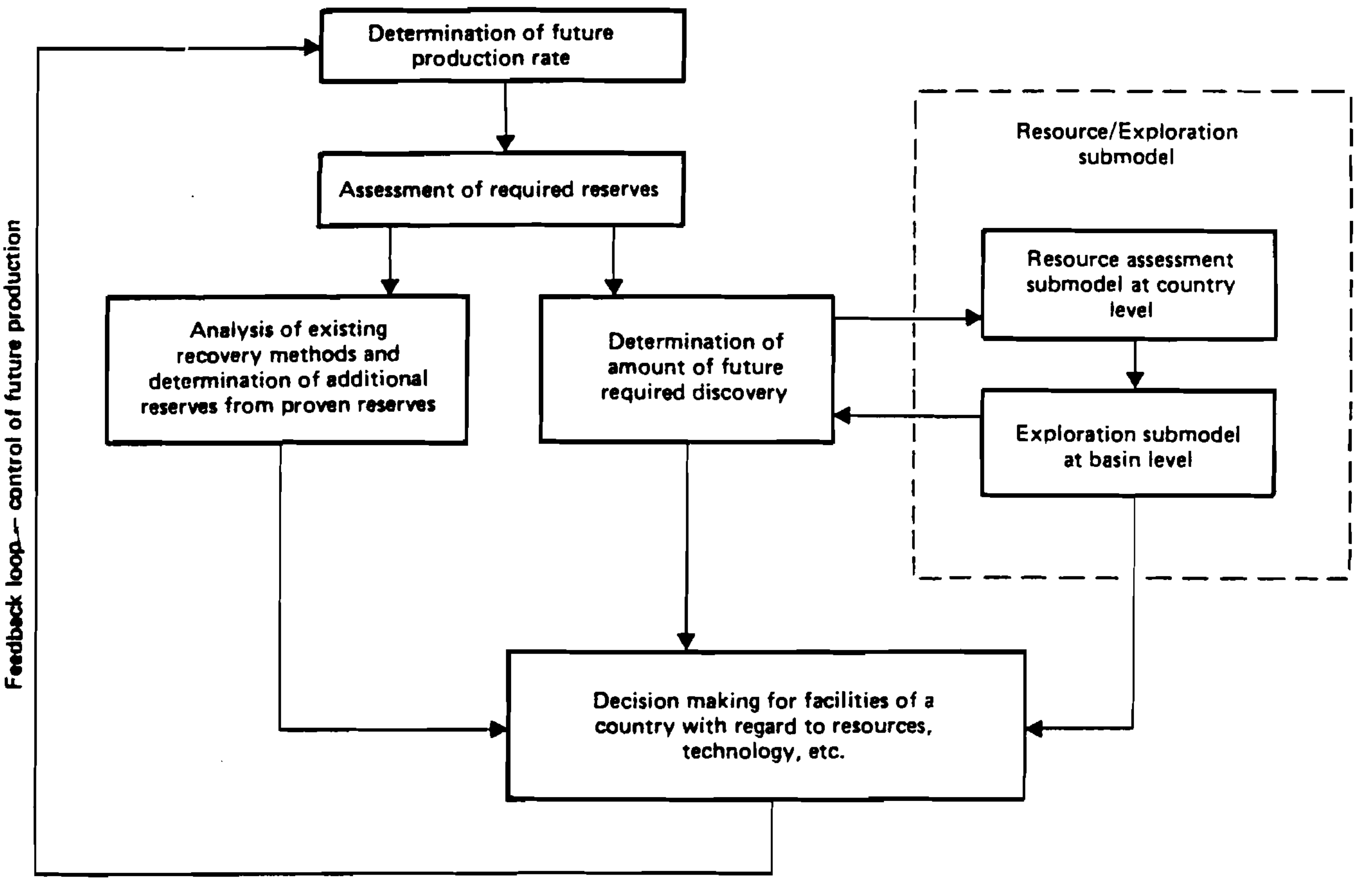


Figure 1. Outline of model procedures

The determination of the production curve for subsequent periods can be made on the basis of tabular functions reflecting the subjective judgement of experts.

We propose to explore three alternative levels of production which are chosen according to the following criteria:

1. domestic demand;
2. additional production for export;
3. adaptation of exports to the requirements of development (i.e. the development plan).

In general, the above criteria must apply to any country, although it is necessary to take into consideration national peculiarities.

There are two possible (complementary) ways of achieving the proposed production level:

-- through the improvement of existing technologies, i.e. additional recovery;

-- through the discovery of new deposits, i.e. the intensification of exploration.

## 3. ASSESSMENT OF REQUIRED RESERVES

The resources required to achieve the proposed production level can be determined as the integral of the function P(t) (the production curves), throughout the period under consideration, added to the rate of production at the final instance and multiplied by the chosen reserve to production ratio (RPR), expressed in number of years. This is done in order to keep the level of production constant over the period, which depends on the reserve to production ratio:

$$\text{Required reserves} = \int_{t\ \text{initial}}^{t\ \text{final}} P(t)dt + P(t\ \text{final})\ RPR$$

In order to ensure that the required reserves will be available, we have to make an assessment of the country's resources (oil in place), i.e. to simulate the discovery process and to calculate undiscovered resources.

## 4. THE RESOURCE ASSESSMENT SUBMODEL

The model is designed for the purpose of assessing the undiscovered resources in the country under consideration. According to the most useful definition (USGS Bulletin 1976), using the McKelvey Classification Diagram of Reserves and Resources, undiscovered resources are "unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geological knowledge and theory". Therefore the geological characteristics of prospective areas are taken as the basis of analysis.

Information on the traps, reservoir rocks, source, migration and generation of hydrocarbons should be collected and analyzed to enable decisions to be made concerning the richness of the prospective petroleum basins. In addition, the size and thickness of the basins should be delineated.

Undiscovered resources are assessed by the volumetric method (Myer 1978 and Levorsen 1967). We designate the amount of recoverable oil per unit volume of sediment as the richness factor (R.F.). With this designation the amount of undiscovered resources may be calculated as follows:

$$\text{Un. Resources} = \text{R.F.} \times \text{Area} \times \text{Thickness}$$

It is obvious that parameters for the R.F., the Area and the Thickness are very uncertain for a region where drilling has not yet been implemented, or has led to no discovery.

For unexplored basins these values are given by geologists as the description of the potential sedimentary volume and depth of burial. This information is used to construct the probability distribution of the Area and the Thickness parameters.

The R.F. may be defined by analogies to similar, mature producing basins and we therefore need to have some basin classification scheme.

One basin classification scheme has been proposed by Klemme (1975). Klemme examined the oil recovery (or its gas equivalent) in terms of barrels per cubic mile of sediment and suggested a "yardstick", which, in conjunction with the rating of the main geological parameters, could assist in the determination of the R.F. for a general type of geological basin (Table 1).

The R.F. of an unexplored basin will lie within a range of values, which for similar types of basin can be defined, and the probability distribution of the R.F. can be constructed.

Thus the geological analysis of the area under consideration provides us with the critical data for input to the model, as shown in Figure 2. The area of country is divided into a number of potential petroleum basins, identified by K (K = 1,...N). Each basin is described by the distribution of the main parameters: the Area, the Thickness and the R.F., which are indexed by the appropriate K subscript. The type of distribution depends on one's knowledge about the behaviour of a parameter.

For example, the R.F. can be represented by the lognormal distribution for a given producing formation by a common reservoir mechanism. However, in the case of an unexplored basin the R.F. is a very difficult parameter to define and we can simplify the R.F. distribution as triangular with minimum, maximum and most likely values of the random variable R.F.

Table 1. "Yardstick" for basin evaluation

"Yardstick" for Basin Evaluation

| | Basin type | Richness factor<br>bbl per cubic<br>mile of sediments | Chance of<br>Commercial<br>production | <br>Presence<br>of giants | Field size*<br>largest field<br>(10th largest field) |
|---|---|---|---|---|---|
| Cratonic basins | 1. Cratonic interior | 35,000 High<br>18,000 Average<br>3,500 Low | 30% | 20% | |
| Cratonic basins | 2. Cratonic multicycle (Large) | 250,000<br>120,000<br>25,000 | 80% | 65% | 10% to 50%<br>(19% to 0.6%) |
| Cratonic basins | (Small) | 75,000<br>40,000<br>7,500 | 50% | 30% | 30% ±<br>(2% ±) |
| Cratonic basins | 3. Cratonic rift | 450,000<br>140,000<br>20,000 | 70% | 50% | 30%<br>(1.7%) |
| Intermediate basins | 4. Intermediate extracontinental<br>4A Closed | 600,000**<br>150,000<br>10,000 | 50% | 50% | 14%<br>(2%) |
| Intermediate basins | 4B Foredeep | 60,000<br>25,000<br>1,000 | 40% | 10% | 14%<br>(2%) |
| Intermediate basins | 4C Open | 300,000<br>160,000<br>3,000 | 50% | 65% | 30%<br>(0.6%) |
| Intermediate basins | 5. Pull-apart | ?<br>Presently<br>average 40,000 | 30% | 20% | ? |
| Intermediate basins | 6.–7. Intermontane | 4,000,000<br>180,000<br>5,000 | 20% | 40% | 35%<br>(1.3%) |
| Intermediate basins | 8. Delta | 220,000<br>190,000<br>? | 50% | Few giants | 6%<br>(1.5%) |
| Intermediate basins | Average all basins | 50,000 to 100,000 | 50% | 50% | 25%<br>(1.5%) |

*Based on ultimate recovery of total basin reserves.
**Middle East

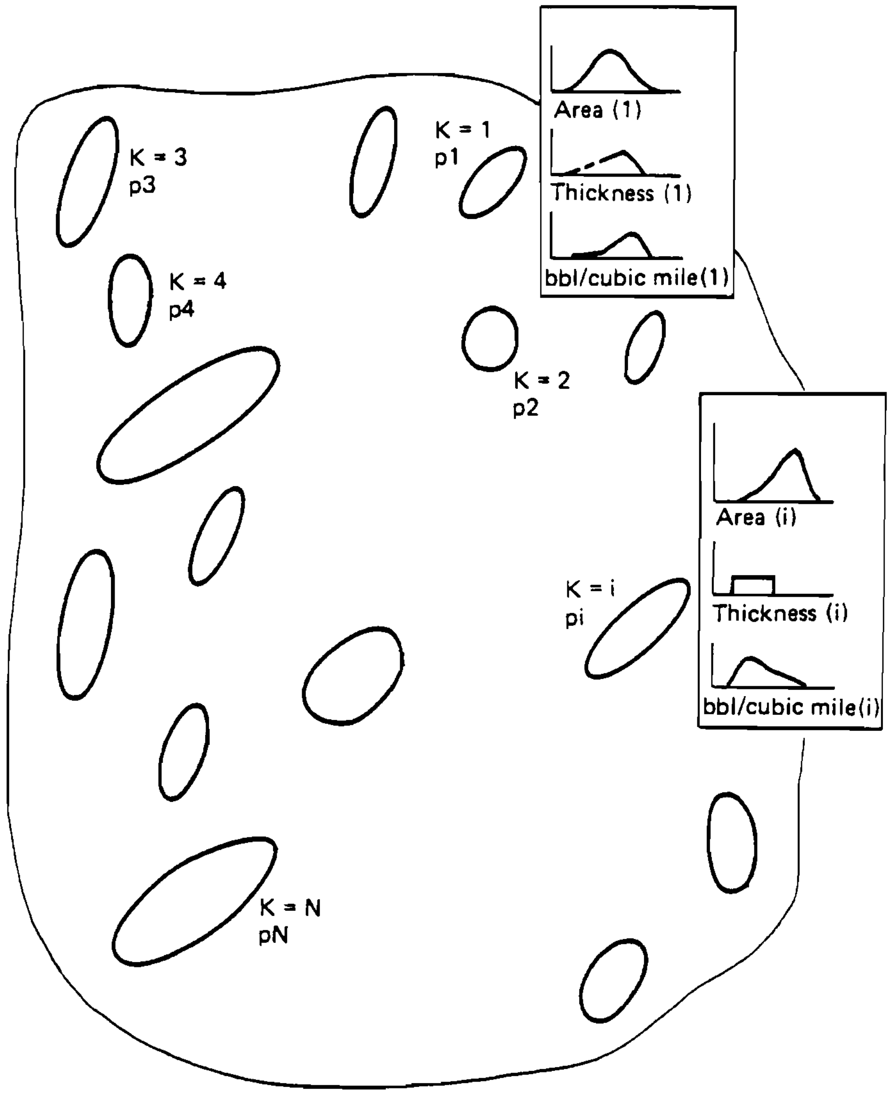


Figure 2. Hypothetical map of a country showing basins and distribution of main parameters.

The simulation model is presented in the flow chart Figure 3, where "A" is the set of distributions of the Area, Thickness and the R.F. The expected value of the undiscovered resources is calculated using Monte-Carlo techniques.

One simulation pass begins with the test to see whether oil exists in basin K and goes on to the next basin. Each test is performed by a comparison of the individual probability $P(B_k)$ of oil occurrence in the $K^{th}$ basin with the random number

$$W_k, 0 < W_k < 1,$$

and goes on to the next basin. If

$$0 < W_k < P(B_k),$$

then basin K has oil. If

$$P(B_k) < W_k < 1,$$

then basin K has no oil.

The individual probability $P(B_k)$ is assigned to each basin based on past experience of exploration or, if exploration has not yet been started, on past experience in areas with similar geology. One set of past experience is readily available in the form of national drilling statistics (national success ratio) which have been systematically recorded for many years. Unfortunately, most geologists feel that the national statistics are of little use in considering a particular venture and they are more willing to regard the local past experience in order to make a decision on a particular venture. Thus assigning probabilities is one of the critical parts of resource assessment.

Resources of the $K^{th}$ basin are assessed only after the test has been completed successfully by sampling the value of the Area, Thickness and R.F. and computing their product. Each iteration yields a value for total resources in the country. This simulation process is repeated i times, where i = 1,...I--the number of iterations. The mean, variance, etc. of total resources can then easily be calculated. Also, the frequency distribution and cumulative distribution graphs can be plotted to represent the result of the modelling.

## 5. THE EXPLORATION MODEL

The exploration submodel performs the calculations of resources at basin level by introducing oil structures or targets.

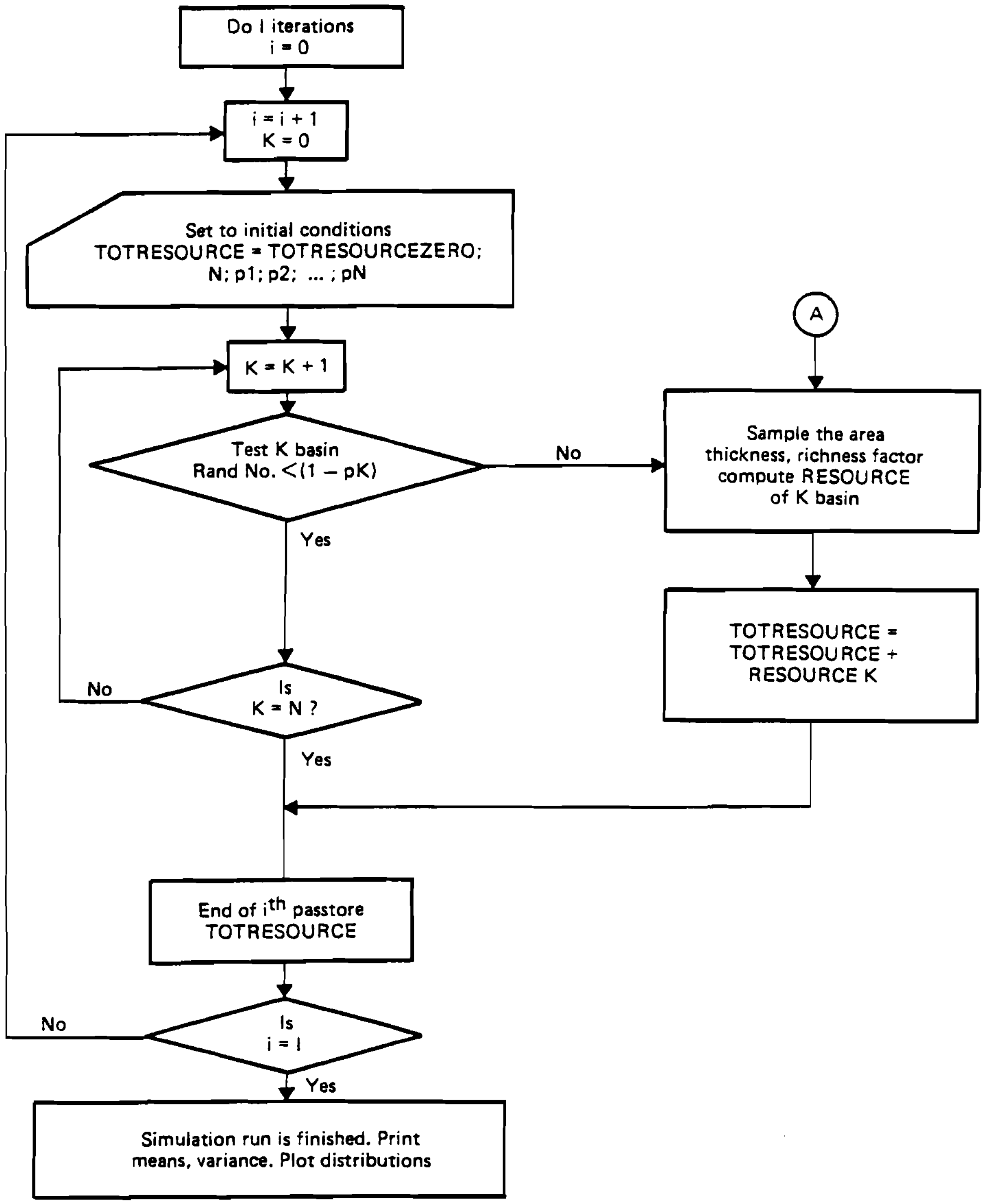


Figure 3. Flow chart of the resource submodel

An example of a similar simulation analysis is described by Newendorf (1975). The proposed model is an application of this example to resource assessment in the basin and the determination of the amount of exploratory drilling required to find the expected value of resources in the basin. This expected value is defined by the parameter CONT--the number of structures which are hypothesized to contain oil:

$$\text{CONT} = \text{NZERO} \times \text{pZERO},$$

where, NZERO is the number of structures which have to be tested and pZERO is the probability of success (assigned according to the exploratory success ratio in a given or similar basin). Index ZERO reflects the initial conditions of simulation.

When searching for oil, success and failure are considered as random trials, so the test for each k structure is made by the comparison of a random number with the probability of success p. In this model the occurrences of oil in each structure are the dependent event, and after each test the N, the p and the CONT parameters are revised. Each iteration is performed until all hypothesized oil-containing structures have been found.

The simulation model is presented in the flow chart Figure 4, where "B" is the set of input distributions of the Area, Thickness and the R.F. for each structure.

The result of modelling gives the amount of resources in the basin in the form of a cumulative probability graph with the means and standard deviation and the distribution of the random value k. This value represents the number of structures that had been drilled on each iteration pass before discovering all the CONT = NZERO x pZERO expected oil-containing structures. The minimum value of this distribution would be k = CONT--the case in which no dry structures were drilled. The maximum value of the distribution would be k = NZERO--the case in which the last oil-containing structure was not found until the very last structure had been drilled.

With the distribution of k values we could gain insight into the amount of exploratory drilling required to find all the resources in the basin.

## 6. MAKING DECISIONS CONCERNING THE FACILITIES OF A COUNTRY WITH REGARD TO RESOURCES, TECHNOLOGY, ETC.

This part of the model produces the forecast of future production, and depends on the results of the exploration model. In general, the submodel attempts to restore the balance between producing facilities and resource supply. The mean value of prospective resources is compared with the amount of required reserves obtained from the extrapolation of the initially accepted production rates. The impact of economic, technological and political factors must be taken into account. Without doubt

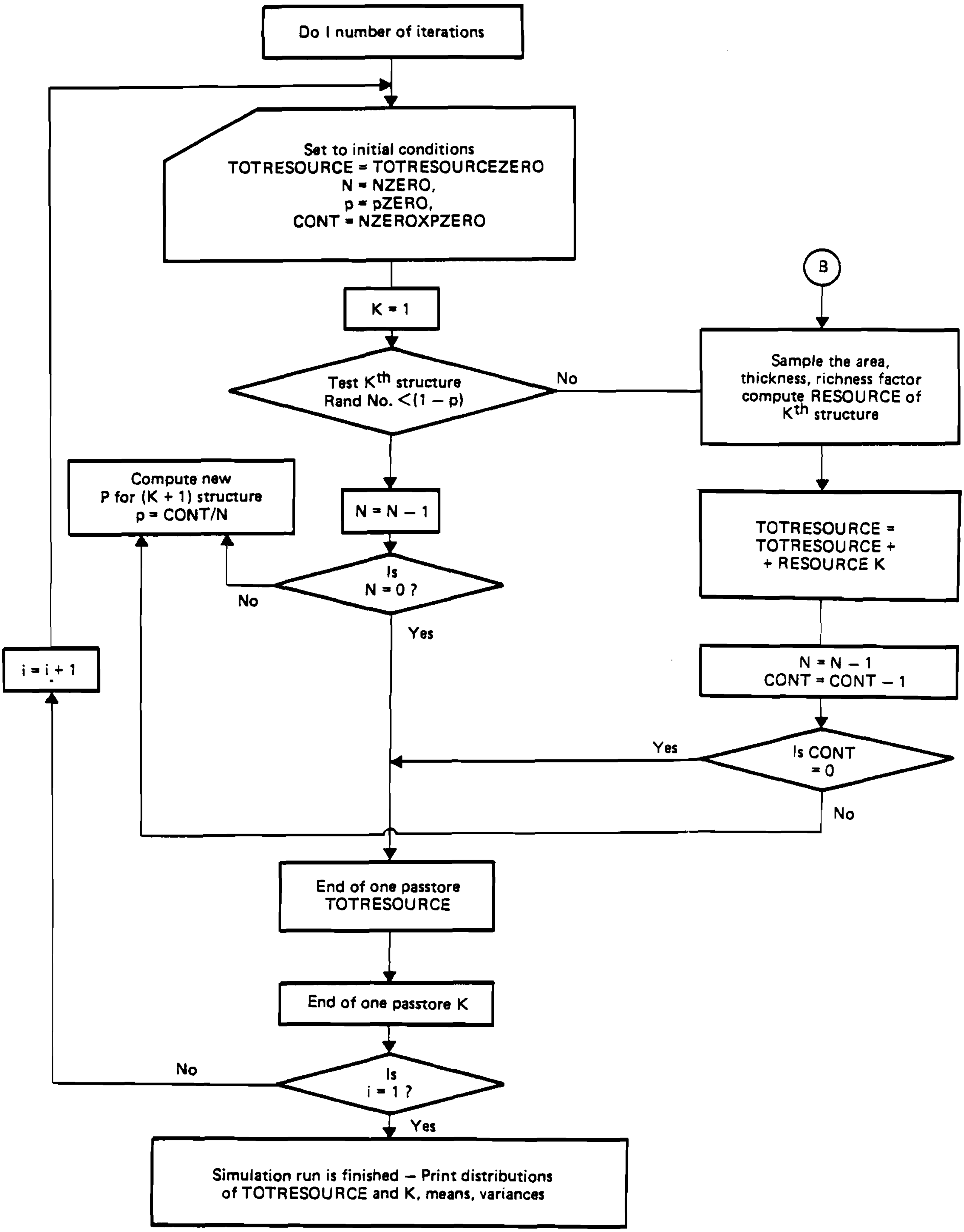


Figure 4. Flow chart of the exploration submodel

these factors are quite unpredictable--also the comparison of prospective resources with various probabilities may be made. All this leads to some correction of the production curve obtained through the selected criteria of experts in the first part of the model. Several revised alternative curves could be taken into account for the establishment of the production policy.

## 7. THE TEST CASE

The first run of the model was made for Mexico. The determination of the future production rate was based on information from the ENERTREE Data Base Retrieval System using data from the IIASA OilData Base. Our sources of information for the resource assessment submodel are published data, in particular "Development in Mexican Petroleum" by Meyerhoff and Morvis.

Geological analysis was accomplished for the determination of the richness factor by using Klemme's classification scheme (1975)--see Table 1. We considered 19 prospective basins in Mexico. For each basin the geological analysis was performed and the distribution of the main parameters was constructed. The individual probability is assigned using Meyer's description of geological features (1978).

The results of the determination of future production rates and of the required resources to supply these rates are presented in Appendix 1. Table A1.1 shows the input data and results for polynomial extrapolation. Figure A1.1 shows the production curve derived from this method. 25,549 billion barrels of resources are required to supply this form of oil production curve.

Table A1.2 shows the input data and results for cubic-spline interpolation. The production curve derived from the cubic-spline method is presented in Figure A1.2. 49,9229 billion barrels of resources are required for these rates of production.

The input data, some intermediate statistics and the output of the resource assessment submodel are presented in Appendix 2. The results show the resources in Mexico in the form of the probability distributions. Frequency distribution is shown in Figure A2.1 and cumulative distribution in Figure A2.2. The minimum value is 8,0934 billion barrels and the maximum value is 140,34 billion barrels. The mean value of resources in Mexico is 58,3726 billion barrels. On the cumulative graph the value 11,574 billion barrels with a probability of 1 may be interpreted as proven reserves.

The comparison of results of the resource assessment submodel with the amount of resources derived from the extrapolation of the production curve (25,5490 or 42,9229) shows that with the probability 0.98 or 0.7 this amount of requirable resources can be supplied from future discoveries.

It is necessary to mention here that some of the data used in the test case are not verified and are sometimes "speculative." Detailed work on input data could greatly improve the result of modelling.

APPENDIX 1

** Table A1.1 Input parameters and results using polynomial extrapolation

** running program LSTINT for mexico

list of INPUT parameters :

| AVILABLE | | | INFORMATION | |
|---|---|---|---|---|
| | TIME | PRODUCTION | WEIGHT | FITTED VALUE |
| 1 | 1952.0 | 0.772800e 08 | 1.0000 | 0.989935d 08 |
| 2 | 1953.0 | 0.724300e 08 | 1.0000 | 0.937919d 08 |
| 3 | 1954.0 | 0.836400e 08 | 1.0000 | 0.896720d 08 |
| 4 | 1955.0 | 0.881300e 08 | 1.0000 | 0.866339d 08 |
| 5 | 1956.0 | 0.941000e 08 | 1.0000 | 0.846774d 08 |
| 6 | 1957.0 | 0.922000e 08 | 1.0000 | 0.838027d 08 |
| 7 | 1958.0 | 0.100600e 09 | 1.0000 | 0.840097d 08 |
| 8 | 1959.0 | 0.963900e 08 | 1.0000 | 0.852985d 08 |
| 9 | 1960.0 | 0.990300e 08 | 1.0000 | 0.876690d 08 |
| 10 | 1961.0 | 0.106800e 09 | 1.0000 | 0.911212d 08 |
| 11 | 1962.0 | 0.111800e 09 | 1.0000 | 0.956551d 08 |
| 12 | 1963.0 | 0.114900e 09 | 1.0000 | 0.101271d 09 |
| 13 | 1964.0 | 0.115600e 09 | 1.0000 | 0.107968d 09 |
| 14 | 1965.0 | 0.117900e 09 | 1.0000 | 0.115747d 09 |
| 15 | 1966.0 | 0.121000e 09 | 1.0000 | 0.124608d 09 |
| 16 | 1967.0 | 0.132900e 09 | 1.0000 | 0.134551d 09 |
| 17 | 1968.0 | 0.142300e 09 | 1.0000 | 0.145575d 09 |
| 18 | 1969.0 | 0.167800e 09 | 1.0000 | 0.157681d 09 |
| 19 | 1970.0 | 0.156500e 09 | 1.0000 | 0.170869d 09 |
| 20 | 1971.0 | 0.155900e 09 | 1.0000 | 0.185138d 09 |
| 21 | 1972.0 | 0.161300e 09 | 1.0000 | 0.200490d 09 |
| 22 | 1973.0 | 0.164900e 09 | 1.0000 | 0.216923d 09 |
| 23 | 1974.0 | 0.209800e 09 | 1.0000 | 0.234437d 09 |
| 24 | 1975.0 | 0.261500e 09 | 1.0000 | 0.253034d 09 |
| 25 | 1976.0 | 0.293100e 09 | 1.0000 | 0.272712d 09 |
| 26 | 1977.0 | 0.358000e 09 | 1.0000 | 0.293472d 09 |

EXTRAPOLATED FROM 1952.0 UNTIL 1985.0
USING A POLYNOMIAL OF THE 2 DEGREE.
WITH AN OVERALL DEGREE OF FIT OF 0.352277e 08

| TABLE | FUNCTION | |
|---|---|---|
| | TIME | PRODUCTION |
| 1 | 1985.0 | 0.498500e 09 |
| 2 | 1990.0 | 0.525000e 09 |
| 3 | 1995.0 | 0.540000e 09 |
| 4 | 2000.0 | 0.550000e 09 |

RESERVE TO PRODUCTION RATIO USED : 20.00
TIME PERIOD USED IN SIMULATION RANGES FROM : 1952.00 UNTIL 2000.00

** END OF INFORMATION -- BEGINING OF SIMULATION **

Table A1.1 contd.

| METHOD | T I M E | | CURRENT PRODUCTION | TOTAL PRODUCTION |
|---|---|---|---|---|
| poly 2 | 1 | 1952.0 | 0.9899355e 08 | 0.0000000 |
| poly 2 | 11 | 1953.0 | 0.9379194e 08 | 0.7485501e 08 |
| poly 2 | 21 | 1954.0 | 0.8967204e 08 | 0.1528900e 09 |
| poly 2 | 31 | 1955.0 | 0.8663387e 08 | 0.2387750e 09 |
| poly 2 | 41 | 1956.0 | 0.8467744e 08 | 0.3298901e 09 |
| poly 2 | 51 | 1957.0 | 0.8380273e 08 | 0.4230401e 09 |
| poly 2 | 61 | 1958.0 | 0.8400974e 08 | 0.5194401e 09 |
| poly 2 | 71 | 1959.0 | 0.8529850e 08 | 0.6179352e 09 |
| poly 2 | 81 | 1960.0 | 0.8766898e 08 | 0.7156450e 09 |
| poly 2 | 91 | 1961.0 | 0.9112119e 08 | 0.8185600e 09 |
| poly 2 | 101 | 1962.0 | 0.9565513e 08 | 0.9278601e 09 |
| poly 2 | 111 | 1963.0 | 0.1012708e 09 | 0.1041210e 10 |
| poly 2 | 121 | 1964.0 | 0.1079682e 09 | 0.1156460e 10 |
| poly 2 | 131 | 1965.0 | 0.1157473e 09 | 0.1273210e 10 |
| poly 2 | 141 | 1966.0 | 0.1246082e 09 | 0.1392660e 10 |
| poly 2 | 151 | 1967.0 | 0.1345508e 09 | 0.1519610e 10 |
| poly 2 | 161 | 1968.0 | 0.1455751e 09 | 0.1657210e 10 |
| poly 2 | 171 | 1969.0 | 0.1576811e 09 | 0.1812260e 10 |
| poly 2 | 181 | 1970.0 | 0.1708689e 09 | 0.1974410e 10 |
| poly 2 | 191 | 1971.0 | 0.1851384e 09 | 0.2130610e 10 |
| poly 2 | 201 | 1972.0 | 0.2004896e 09 | 0.2289209e 10 |
| poly 2 | 211 | 1973.0 | 0.2169226e 09 | 0.2452308e 10 |
| poly 2 | 221 | 1974.0 | 0.2344372e 09 | 0.2639659e 10 |
| poly 2 | 231 | 1975.0 | 0.2530337e 09 | 0.2875310e 10 |
| poly 2 | 241 | 1976.0 | 0.2727118e 09 | 0.3152610e 10 |
| poly 2 | 251 | 1977.0 | 0.2934717e 09 | 0.3478160e 10 |
| poly 2 | 261 | 1978.0 | 0.3153133e 09 | 0.3785690e 10 |
| poly 2 | 271 | 1979.0 | 0.3382366e 09 | 0.4112375e 10 |
| poly 2 | 281 | 1980.0 | 0.3622417e 09 | 0.4462525e 10 |
| poly 2 | 291 | 1981.0 | 0.3873285e 09 | 0.4837221e 10 |
| poly 2 | 301 | 1982.0 | 0.4134970e 09 | 0.5237543e 10 |
| poly 2 | 311 | 1983.0 | 0.4407472e 09 | 0.5664577e 10 |
| poly 2 | 321 | 1984.0 | 0.4690793e 09 | 0.6119400e 10 |
| poly 2 | 331 | 1985.0 | 0.4984930e 09 | 0.6603098e 10 |
| table | 341 | 1986.0 | 0.5038000e 09 | 0.7104248e 10 |
| table | 351 | 1987.0 | 0.5091000e 09 | 0.7610699e 10 |
| table | 361 | 1988.0 | 0.5144000e 09 | 0.8122451e 10 |
| table | 371 | 1989.0 | 0.5197000e 09 | 0.8639502e 10 |
| table | 381 | 1990.0 | 0.5250000e 09 | 0.9161853e 10 |
| table | 391 | 1991.0 | 0.5280000e 09 | 0.9688357e 10 |
| table | 401 | 1992.0 | 0.5310000e 09 | 0.1021786e 11 |
| table | 411 | 1993.0 | 0.5340000e 09 | 0.1075036e 11 |
| table | 421 | 1994.0 | 0.5370000e 09 | 0.1128587e 11 |
| table | 431 | 1995.0 | 0.5400000e 09 | 0.1182437e 11 |
| table | 441 | 1996.0 | 0.5420000e 09 | 0.1236537e 11 |
| table | 451 | 1997.0 | 0.5440000e 09 | 0.1290838e 11 |
| table | 461 | 1998.0 | 0.5460000e 09 | 0.1345338e 11 |
| table | 471 | 1999.0 | 0.5480000e 09 | 0.1400038e 11 |
| table | 481 | 2000.0 | 0.5500000e 09 | 0.1454938e 11 |

total production during this period will be : 0.145494e 11 bbls
reserve to production ratio is : 20.0000 bbls
total reserves needed will equal to : 0.255494e 11 bbls

** END OF EXPERIMENT **

try again

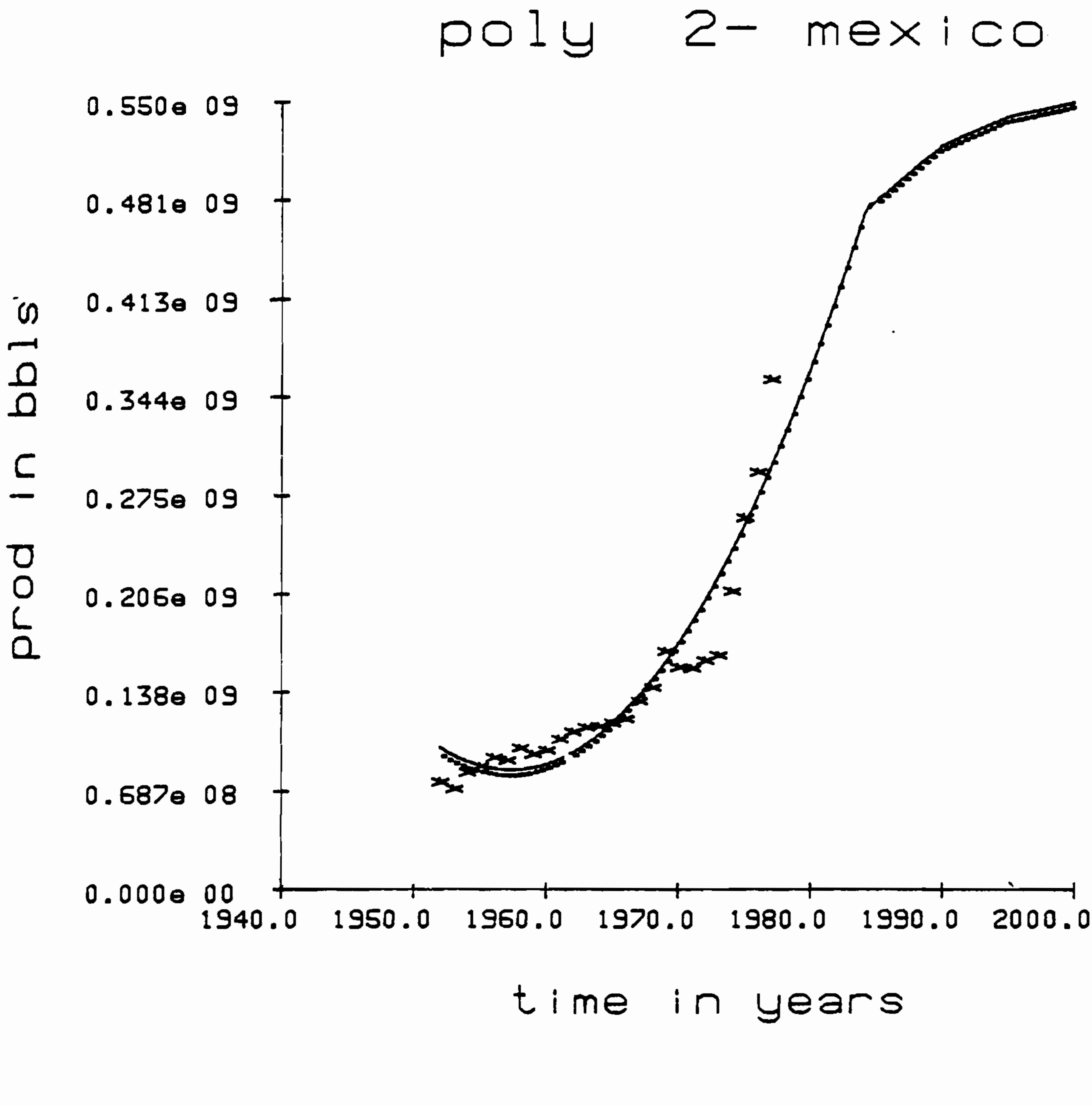


Figure A1.1 Production curve obtained using polynomial extrapolation

Table A1.2 Input data and results using cubic-spline interpolation

** running program SPLINT for mexico

list of INPUT parameters :

| AVAILABLE | | INFORMATION |
|---|---|---|
| | TIME | PRODUCTION |
| 1 | 1952.0 | 0.772800e 08 |
| 2 | 1953.0 | 0.724300e 08 |
| 3 | 1954.0 | 0.836400e 08 |
| 4 | 1955.0 | 0.881300e 08 |
| 5 | 1956.0 | 0.941000e 08 |
| 6 | 1957.0 | 0.922000e 08 |
| 7 | 1958.0 | 0.100600e 09 |
| 8 | 1959.0 | 0.963900e 08 |
| 9 | 1960.0 | 0.990300e 08 |
| 10 | 1961.0 | 0.106800e 09 |
| 11 | 1962.0 | 0.111800e 09 |
| 12 | 1963.0 | 0.114900e 09 |
| 13 | 1964.0 | 0.115600e 09 |
| 14 | 1965.0 | 0.117900e 09 |
| 15 | 1966.0 | 0.121000e 09 |
| 16 | 1967.0 | 0.132900e 09 |
| 17 | 1968.0 | 0.142300e 09 |
| 18 | 1969.0 | 0.167800e 09 |
| 19 | 1970.0 | 0.156500e 09 |
| 20 | 1971.0 | 0.155900e 09 |
| 21 | 1972.0 | 0.161300e 09 |
| 22 | 1973.0 | 0.164900e 09 |
| 23 | 1974.0 | 0.209800e 09 |
| 24 | 1975.0 | 0.261500e 09 |
| 25 | 1976.0 | 0.293100e 09 |
| 26 | 1977.0 | 0.358000e 09 |

EXTRAPOLATED FROM 1952.0 UNTIL 1985.0
USING A SPLINE.

| T A B L E | | F U N C T I O N |
|---|---|---|
| | TIME | PRODUCTION |
| 1 | 1985.0 | 0.960000e 09 |
| 2 | 1990.0 | 0.970000e 09 |
| 3 | 1995.0 | 0.975000e 09 |
| 4 | 2000.0 | 0.980000e 09 |

RESERVE TO PRODUCTION RATIO USED : 20.00
TIME PERIOD USED IN SIMULATION RANGES FROM : 1952.00 UNTIL 2000.00

** END OF INFORMATION -- BEGINING OF SIMULATION **

Table A1.2 contd.

| METHOD | T I M E | | CURRENT PRODUCTION | TOTAL PRODUCTION |
|---|---|---|---|---|
| spline | 1 | 1952.0 | 0.7728000e 08 | 0.0000000 |
| spline | 11 | 1953.0 | 0.7243000e 08 | 0.7485501e 08 |
| spline | 21 | 1954.0 | 0.8364000e 08 | 0.1528900e 09 |
| spline | 31 | 1955.0 | 0.8813000e 08 | 0.2387750e 09 |
| spline | 41 | 1956.0 | 0.9410000e 08 | 0.3298901e 09 |
| spline | 51 | 1957.0 | 0.9220000e 08 | 0.4230401e 09 |
| spline | 61 | 1958.0 | 0.1006000e 09 | 0.5194401e 09 |
| spline | 71 | 1959.0 | 0.9639000e 08 | 0.6179352e 09 |
| spline | 81 | 1960.0 | 0.9903000e 08 | 0.7156450e 09 |
| spline | 91 | 1961.0 | 0.1068000e 09 | 0.8185600e 09 |
| spline | 101 | 1962.0 | 0.1118000e 09 | 0.9278601e 09 |
| spline | 111 | 1963.0 | 0.1149000e 09 | 0.1041210e 10 |
| spline | 121 | 1964.0 | 0.1156000e 09 | 0.1156460e 10 |
| spline | 131 | 1965.0 | 0.1179000e 09 | 0.1273210e 10 |
| spline | 141 | 1966.0 | 0.1210000e 09 | 0.1392660e 10 |
| spline | 151 | 1967.0 | 0.1329000e 09 | 0.1519610e 10 |
| spline | 161 | 1968.0 | 0.1423000e 09 | 0.1657210e 10 |
| spline | 171 | 1969.0 | 0.1678000e 09 | 0.1812260e 10 |
| spline | 181 | 1970.0 | 0.1565000e 09 | 0.1974410e 10 |
| spline | 191 | 1971.0 | 0.1559000e 09 | 0.2130610e 10 |
| spline | 201 | 1972.0 | 0.1613000e 09 | 0.2289209e 10 |
| spline | 211 | 1973.0 | 0.1649000e 09 | 0.2452308e 10 |
| spline | 221 | 1974.0 | 0.2098000e 09 | 0.2639659e 10 |
| spline | 231 | 1975.0 | 0.2615000e 09 | 0.2875310e 10 |
| spline | 241 | 1976.0 | 0.2931000e 09 | 0.3152610e 10 |
| spline | 251 | 1977.0 | 0.3580000e 09 | 0.3478160e 10 |
| spline | 261 | 1978.0 | 0.4331812e 09 | 0.3873751e 10 |
| spline | 271 | 1979.0 | 0.5083624e 09 | 0.4344522e 10 |
| spline | 281 | 1980.0 | 0.5835436e 09 | 0.4890475e 10 |
| spline | 291 | 1981.0 | 0.6587249e 09 | 0.5511608e 10 |
| spline | 301 | 1982.0 | 0.7339060e 09 | 0.6207923e 10 |
| spline | 311 | 1983.0 | 0.8090873e 09 | 0.6979420e 10 |
| spline | 321 | 1984.0 | 0.8842685e 09 | 0.7826099e 10 |
| spline | 331 | 1985.0 | 0.9594497e 09 | 0.8747959e 10 |
| table | 341 | 1986.0 | 0.9620000e 09 | 0.9708935e 10 |
| table | 351 | 1987.0 | 0.9640000e 09 | 0.1067194e 11 |
| table | 361 | 1988.0 | 0.9660000e 09 | 0.1163694e 11 |
| table | 371 | 1989.0 | 0.9680000e 09 | 0.1260394e 11 |
| table | 381 | 1990.0 | 0.9700000e 09 | 0.1357294e 11 |
| table | 391 | 1991.0 | 0.9710000e 09 | 0.1454344e 11 |
| table | 401 | 1992.0 | 0.9720000e 09 | 0.1551495e 11 |
| table | 411 | 1993.0 | 0.9730000e 09 | 0.1648745e 11 |
| table | 421 | 1994.0 | 0.9740000e 09 | 0.1746095e 11 |
| table | 431 | 1995.0 | 0.9750000e 09 | 0.1843544e 11 |
| table | 441 | 1996.0 | 0.9760000e 09 | 0.1941093e 11 |
| table | 451 | 1997.0 | 0.9770000e 09 | 0.2038742e 11 |
| table | 461 | 1998.0 | 0.9780000e 09 | 0.2136491e 11 |
| table | 471 | 1999.0 | 0.9790000e 09 | 0.2234340e 11 |
| table | 481 | 2000.0 | 0.9800000e 09 | 0.2332289e 11 |

total production during this period will be : 0.233229e 11 bbls
reserve to production ratio is : 20.0000 bbls
total reserves needed will equal to : 0.429229e 11 bbls

** END OF EXPERIMENT **

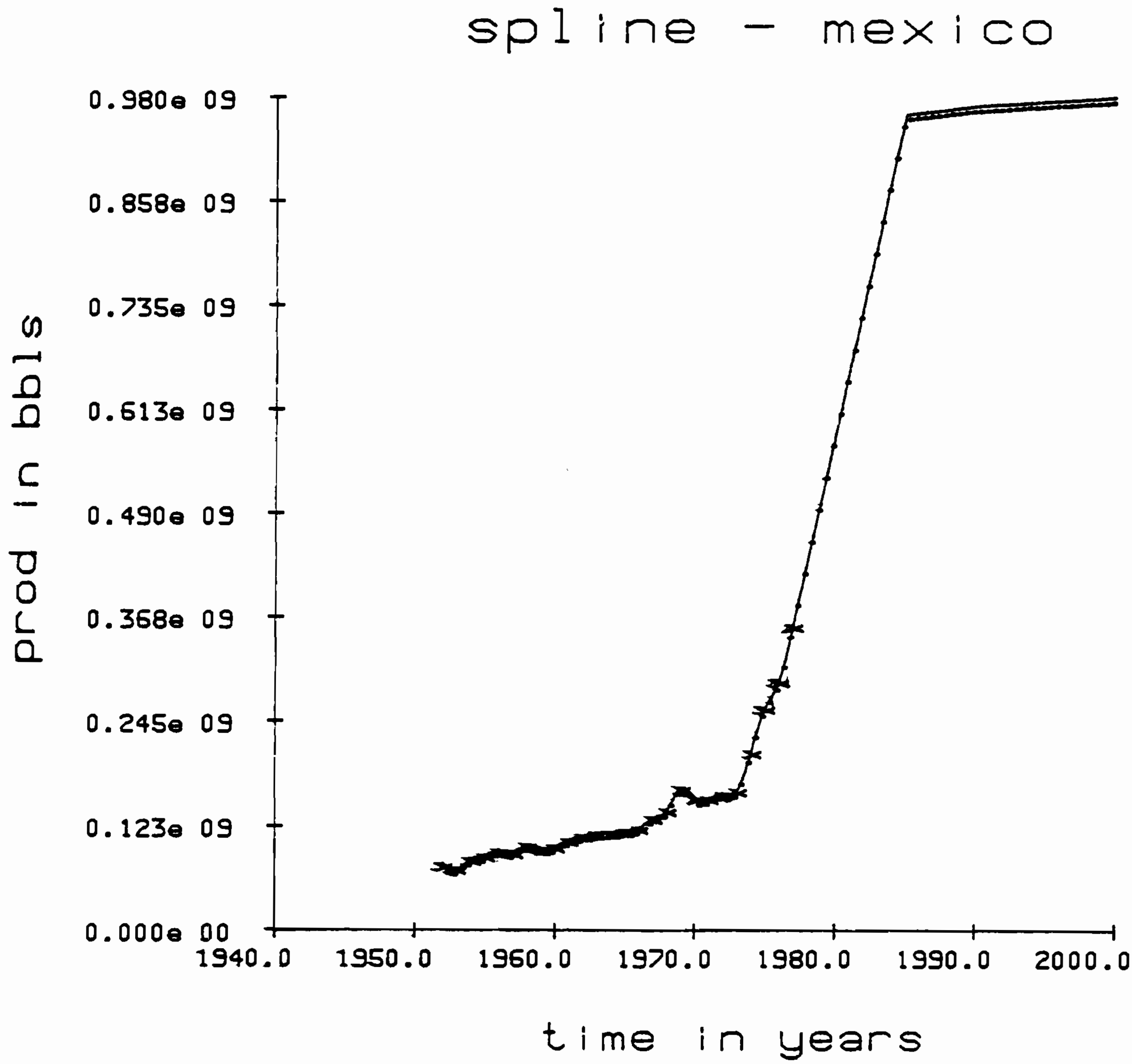


Figure A1.2 Production curve obtained using cubic-spline interpolation

APPENDIX 2

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                    PBASIN3 DATA1

THE INITIAL INPUT DATA

UTPUT OF INTERMEDIATE CYCLE CALCULATIONS: NO
      OUTPUT OF FINAL CYCLE CALCULATIONS: NO
              OUTPUT OF PLOTS AND CHARTS: YES
THE MAXIMUM NUMBER OF BUCKETS FOR GRAPHS:  20

             TOTAL NUMBER OF ITERATIONS:  2000
  RANDOM NUMBER SEEDS THAT ARE USED ARE:  4724   909
  RANDOM NUMBER SEEDS THAT ARE USED ARE:  5586 -1159
TOTAL NUMBER OF STRUCTURES IN THE BASIN:  19

[  1]  Offshore Reforma Trend  STRUCTURE   1 USES (PROB IS 0.6000) DISTS:   1.   2.   3.
[  2]  Onshore Reforma         STRUCTURE   2 USES (PROB IS 1.0000) DISTS:   4.   5.   6.
[  3]  Tampico                 STRUCTURE   3 USES (PROB IS 1.0000) DISTS:   7.   8.   9.
[  4]  Isthmus Tabasco         STRUCTURE   4 USES (PROB IS 0.6000) DISTS:  10.  11.  12.
[  5]  Burgos                  STRUCTURE   5 USES (PROB IS 0.5000) DISTS:  13.  14.  15.
[  6]  Veracruz                STRUCTURE   6 USES (PROB IS 1.0000) DISTS:  16.  17.  18.
[  7]  Valle-San Luis Patosi   STRUCTURE   7 USES (PROB IS 0.1000) DISTS:  19.  20.  21.
[  8]  Parros                  STRUCTURE   8 USES (PROB IS 0.3000) DISTS:  22.  23.  24.
[  9]  Sabinas                 STRUCTURE   9 USES (PROB IS 0.2000) DISTS:  25.  26.  27.
[ 10]  Gulf of California      STRUCTURE  10 USES (PROB IS 0.1000) DISTS:  28.  29.  30.
[ 11]  Sebastian Vizcaino      STRUCTURE  11 USES (PROB IS 0.1000) DISTS:  31.  32.  33.
[ 12]  Santo-Domingo           STRUCTURE  12 USES (PROB IS 0.1000) DISTS:  34.  35.  36.
[ 13]  Mazathan                STRUCTURE  13 USES (PROB IS 0.2000) DISTS:  37.  38.  39.
[ 14]  Guaymas                 STRUCTURE  14 USES (PROB IS 0.2000) DISTS:  40.  41.  42.
[ 15]  Yucatan Platform        STRUCTURE  15 USES (PROB IS 0.1000) DISTS:  43.  44.  45.
[ 16]  Sabine - Cruz           STRUCTURE  16 USES (PROB IS 0.1000) DISTS:  46.  47.  48.
[ 17]  Pedregasa-Ville Ahumede STRUCTURE  17 USES (PROB IS 0.2000) DISTS:  49.  50.  51.
[ 18]  Tlaxiaco                STRUCTURE  18 USES (PROB IS 0.1000) DISTS:  52.  53.  54.
[ 19]  Baja California         STRUCTURE  19 USES (PROB IS 0.1000) DISTS:  55.  56.  57.

NUMBER OF DISTRIBUTIONS REFERENCED BY THE ABOVE STRUCTURES:     57

[  1] TRIANGLE DISTRIBUTION USES ARGUMENTS:  45000.       50000.       48263.
[  2] TRIANGLE DISTRIBUTION USES ARGUMENTS:  2.0000       3.0000       2.4800
[  3] TRIANGLE DISTRIBUTION USES ARGUMENTS:  3000.0     0.30000e 06 0.16000e 06
[  4] TRIANGLE DISTRIBUTION USES ARGUMENTS:  20000.       30000.       25097.
[  5] TRIANGLE DISTRIBUTION USES ARGUMENTS:  3.0000       6.5482       4.2092
[  6] TRIANGLE DISTRIBUTION USES ARGUMENTS:  10000.     0.60000e 06 0.15000e 06
[  7] TRIANGLE DISTRIBUTION USES ARGUMENTS:  25000.       30000.       28958.
[  8] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1.5000       2.0000       1.8645
[  9] TRIANGLE DISTRIBUTION USES ARGUMENTS:  3000.0     0.30000e 06 0.16000e 06
[ 10] TRIANGLE DISTRIBUTION USES ARGUMENTS:  14000.       16000.       15444.
[ 11] TRIANGLE DISTRIBUTION USES ARGUMENTS:  2.0000       2.5000       2.4860
[ 12] TRIANGLE DISTRIBUTION USES ARGUMENTS:  3000.0     0.30000e 06 0.16000e 06
[ 13] TRIANGLE DISTRIBUTION USES ARGUMENTS:  25000.       30000.       27027.
[ 14] TRIANGLE DISTRIBUTION USES ARGUMENTS:  4.0000       6.2150       5.0000
[ 15] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1000.0       60000.       25000.
[ 16] TRIANGLE DISTRIBUTION USES ARGUMENTS:  9000.0       10000.       9266.4
[ 17] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1.2430       4.9720       3.5000
[ 18] TRIANGLE DISTRIBUTION USES ARGUMENTS: 0.30000e-01   3.0000       1.6000
[ 19] TRIANGLE DISTRIBUTION USES ARGUMENTS:  15000.       20000.       18532.
[ 20] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1.5000       2.5000       1.8645
[ 21] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1000.0       60000.       25000.
[ 22] TRIANGLE DISTRIBUTION USES ARGUMENTS:  10000.       12000.       11583.
[ 23] TRIANGLE DISTRIBUTION USES ARGUMENTS:  2.0000       3.0000       2.1753
[ 24] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1000.0       60000.       25000.
[ 25] TRIANGLE DISTRIBUTION USES ARGUMENTS:  29000.       31000.       30888.
[ 26] TRIANGLE DISTRIBUTION USES ARGUMENTS:  2.1000       3.0000       2.4860
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[ 28] TRIANGLE DISTRIBUTION USES ARGUMENTS:  6000.0      6200.0      6177.6
[ 29] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1.2430      3.7290      3.0000
[ 30] TRIANGLE DISTRIBUTION USES ARGUMENTS:  3000.0     0.30000e 06 0.16000e 06
[ 31] TRIANGLE DISTRIBUTION USES ARGUMENTS:  4630.0      4635.0      4633.2
[ 32] UNIFORM  DISTRIBUTION USES ARGUMENTS: 0.62150      3.1075
[ 33] CONSTANT  VALUE      IS  ASSIGNED  TO:  40000.
[ 34] TRIANGLE DISTRIBUTION USES ARGUMENTS:  6500.0      6600.0      6563.4
[ 35] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1.8645      3.1075      2.5000
[ 36] CONSTANT  VALUE      IS  ASSIGNED  TO:  40000.
[ 37] TRIANGLE DISTRIBUTION USES ARGUMENTS:  5000.0      6000.0      5405.4
[ 38] TRIANGLE DISTRIBUTION USES ARGUMENTS: 0.62150      1.5000      1.2000
[ 39] CONSTANT  VALUE      IS  ASSIGNED  TO:  40000.
[ 40] TRIANGLE DISTRIBUTION USES ARGUMENTS:  3200.0      3500.0      3474.9
[ 41] TRIANGLE DISTRIBUTION USES ARGUMENTS: 0.62150      1.5000      1.2000
[ 42] CONSTANT  VALUE      IS  ASSIGNED  TO:  40000.
[ 43] TRIANGLE DISTRIBUTION USES ARGUMENTS:  96000.      98000.      96525.
[ 44] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1.2000      2.0000      1.4295
[ 45] CONSTANT  VALUE      IS  ASSIGNED  TO:  40000.
[ 46] TRIANGLE DISTRIBUTION USES ARGUMENTS:  9000.0      10000.      9652.5
[ 47] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1.8645      3.1075      2.5000
[ 48] CONSTANT  VALUE      IS  ASSIGNED  TO:  40000.
[ 49] TRIANGLE DISTRIBUTION USES ARGUMENTS:  22000.      24000.      23166.
[ 50] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1.4910      3.1070      2.5000
[ 51] TRIANGLE DISTRIBUTION USES ARGUMENTS:  10000.      60000.      25000.
[ 52] TRIANGLE DISTRIBUTION USES ARGUMENTS:  1000.0      1200.0      1152.0
[ 53] TRIANGLE DISTRIBUTION USES ARGUMENTS: 0.62000      1.2000     0.93230
[ 54] TRIANGLE DISTRIBUTION USES ARGUMENTS:  10000.      60000.      25000.
[ 55] TRIANGLE DISTRIBUTION USES ARGUMENTS:  2600.0      2800.0      2700.0
[ 56] TRIANGLE DISTRIBUTION USES ARGUMENTS: 0.62000      2.0000      1.1187
[ 57] CONSTANT  VALUE      IS  ASSIGNED  TO:  40000.

   E N D    O F    I N P U T

+------+------+---------------------+----+------------+------------+------------+------------+------------+------------+

                              2000 PASSES COMPLETED.

MAX KHIT   13.000     MAX KMISS   16.000     MAX K   19.000     MAX TOTAL RESERVE  0.14034e 12
MIN KHIT   3.0000     MIN KMISS   6.0000     MIN K   19.000     MIN TOTAL RESERVE  0.80934e 10
AVG KHIT   6.6420     AVG KMISS   12.358     AVG K   19.000     AVG TOTAL RESERVE  0.55871e 11

     E N D    O F    R U N
```

SOME STATISTICS ON THE STRUCTURES AS CALCULATED BY THE 2000 RUNS.

| NO | STRUCTURE NAME | TOTAL NO OF K | OIL STRUCK | OIL STRK/TOTL K | PROBABILITY | MU RESERVES | MU TOTL RESERV |
|---|---|---|---|---|---|---|---|
| 1 | Offshore Reforma Trend | 2000.00 | 1190.00 | 0.59500 | 0.60000 | 0.110685e 11 | 0.110685e 11 |
| 2 | Onshore Reforma | 2000.00 | 2000.00 | 1.00000 | 1.00000 | 0.294264e 11 | 0.404950e 11 |
| 3 | Tampico | 2000.00 | 2000.00 | 1.00000 | 1.00000 | 0.781144e 10 | 0.483064e 11 |
| 4 | Isthmus Tabasco | 2000.00 | 1189.00 | 0.59450 | 0.60000 | 0.320271e 10 | 0.515091e 11 |
| 5 | Burgos | 2000.00 | 1029.00 | 0.51450 | 0.50000 | 0.203805e 10 | 0.535472e 11 |
| 6 | Veracruz | 2000.00 | 2000.00 | 1.00000 | 1.00000 | 46743.3 | 0.535472e 11 |
| 7 | Valle-San Luis Patosi | 2000.00 | 186.000 | 0.09300 | 0.10000 | 0.955891e 08 | 0.536428e 11 |
| 8 | Parros | 2000.00 | 611.000 | 0.30550 | 0.30000 | 0.239423e 09 | 0.538822e 11 |
| 9 | Sabinas | 2000.00 | 439.000 | 0.21950 | 0.20000 | 0.482913e 09 | 0.543651e 11 |
| 10 | Gulf of California | 2000.00 | 199.000 | 0.09950 | 0.10000 | 0.257904e 09 | 0.546230e 11 |
| 11 | Sebastian Vizcaino | 2000.00 | 182.000 | 0.09100 | 0.10000 | 0.327833e 08 | 0.546558e 11 |
| 12 | Santo-Domingo | 2000.00 | 190.000 | 0.09500 | 0.10000 | 0.626131e 08 | 0.547184e 11 |
| 13 | Mazathan | 2000.00 | 419.000 | 0.20950 | 0.20000 | 0.499720e 08 | 0.547684e 11 |
| 14 | Guaymas | 2000.00 | 399.000 | 0.19950 | 0.20000 | 0.302283e 08 | 0.547986e 11 |
| 15 | Yucatan Platform | 2000.00 | 196.000 | 0.09800 | 0.10000 | 0.590504e 09 | 0.553891e 11 |
| 16 | Sabine - Cruz | 2000.00 | 204.000 | 0.10200 | 0.10000 | 0.983032e 08 | 0.554874e 11 |
| 17 | Pedregasa-Ville Ahumede | 2000.00 | 440.000 | 0.22000 | 0.20000 | 0.366576e 09 | 0.558540e 11 |
| 18 | Tlaxiaco | 2000.00 | 213.000 | 0.10650 | 0.10000 | 0.353814e 07 | 0.558576e 11 |
| 19 | Baja California | 2000.00 | 198.000 | 0.09900 | 0.10000 | 0.132426e 08 | 0.558708e 11 |

CYCLE 20 IS PRESENTED IN DETAIL BELOW BECAUSE IT IS A (RES MIN ) CYCLE.

| PASS | NUMB | BASIN NAME | OIL? | PROBABILITY | A R E A | • THICKNESS | • RICHNESS | = RESERVES | TOTL RESERVE |
|---|---|---|---|---|---|---|---|---|---|
| 20 | 1 | Offshore Reforma Tr | | 0.60000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 20 | 2 | Onshore Reforma | OIL | 1.00000 | 0.2004e 05 | 3.028 | 0.1825e 05 | 0.1107e 10 | 0.1107e 10 |
| 20 | 3 | Tampioo | OIL | 1.00000 | 0.2526e 05 | 1.547 | 0.4855e 05 | 0.1897e 10 | 0.3005e 10 |
| 20 | 4 | Isthmus Tabasco | | 0.60000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 5 | Burgos | | 0.50000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 6 | Veracruz | OIL | 1.00000 | 9204. | 3.363 | 2.093 | 0.6477e 05 | 0.3005e 10 |
| 20 | 7 | Valle-San Luis Pato | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 8 | Parros | | 0.30000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 9 | Sabinas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 10 | Gulf of California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 11 | Sebastian Vizcaino | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 12 | Santo-Domingo | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 13 | Mazathan | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 14 | Guaymas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 15 | Yucatan Platform | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 16 | Sabine - Cruz | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 17 | Pedregasa-Ville Ahu | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3005e 10 |
| 20 | 18 | Tlaxiaco | OIL | 0.10000 | 1014. | 1.034 | 0.4512e 05 | 0.4732e 08 | 0.3052e 10 |
| 20 | 19 | Baja California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3052e 10 |

CYCLE 1793 IS PRESENTED IN DETAIL BELOW BECAUSE IT IS A (RES AVG ) CYCLE.

| PASS | NUMB | BASIN NAME | OIL? | PROBABILITY | A R E A | * THICKNESS | * RICHNESS | = RESERVES | TOTL RESERVE |
|---|---|---|---|---|---|---|---|---|---|
| 1793 | 1 | Offshore Reforma Tr | OIL | 0.60000 | 0.4502e 05 | 2.009 | 9199. | 0.8322e 09 | 0.8322e 09 |
| 1793 | 2 | Onshore Reforma | OIL | 1.00000 | 0.2041e 05 | 3.230 | 0.7062e 05 | 0.4656e 10 | 0.5488e 10 |
| 1793 | 3 | Tampico | OIL | 1.00000 | 0.2676e 05 | 1.812 | 0.2093e 06 | 0.1015e 11 | 0.1563e 11 |
| 1793 | 4 | Isthmus Tabasco | | 0.60000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1563e 11 |
| 1793 | 5 | Burgos | OIL | 0.50000 | 0.2526e 05 | 5.524 | 0.4383e 05 | 0.6117e 10 | 0.2175e 11 |
| 1793 | 6 | Veracruz | OIL | 1.00000 | 9656. | 2.441 | 1.520 | 0.3583e 05 | 0.2175e 11 |
| 1793 | 7 | Valle-San Luis Pato | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2175e 11 |
| 1793 | 8 | Parros | | 0.30000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2175e 11 |
| 1793 | 9 | Sabinas | OIL | 0.20000 | 0.3010e 05 | 2.597 | 0.5561e 05 | 0.4347e 10 | 0.2610e 11 |
| 1793 | 10 | Gulf of California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |
| 1793 | 11 | Sebastian Vizcaino | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |
| 1793 | 12 | Santo-Domingo | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |
| 1793 | 13 | Mazathan | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |
| 1793 | 14 | Guaymas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |
| 1793 | 15 | Yucatan Platform | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |
| 1793 | 16 | Sabine - Cruz | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |
| 1793 | 17 | Pedregasa-Ville Ahu | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |
| 1793 | 18 | Tlaxiaco | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |
| 1793 | 19 | Baja California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2610e 11 |

CYCLE 671 IS PRESENTED IN DETAIL BELOW BECAUSE IT IS A (RES MAX ) CYCLE.

| PASS | NUMB | BASIN NAME | OIL? | PROBABILITY | A R E A • | THICKNESS • | RICHNESS = | RESERVES | TOTL RESERVE |
|---|---|---|---|---|---|---|---|---|---|
| 671 | 1 | Offshore Reforma Tr | OIL | 0.60000 | 0.4502e 05 | 2.009 | 9199. | 0.8322e 09 | 0.8322e 09 |
| 671 | 2 | Onshore Reforma | OIL | 1.00000 | 0.2041e 05 | 3.230 | 0.7062e 05 | 0.4656e 10 | 0.5488e 10 |
| 671 | 3 | Tampico | OIL | 1.00000 | 0.2676e 05 | 1.812 | 0.2093e 06 | 0.1015e 11 | 0.1563e 11 |
| 671 | 4 | Isthmus Tabasco | OIL | 0.60000 | 0.1414e 05 | 2.447 | 0.2275e 06 | 0.7870e 10 | 0.2350e 11 |
| 671 | 5 | Burgos | OIL | 0.50000 | 0.2845e 05 | 4.615 | 0.2711e 05 | 0.3559e 10 | 0.2706e 11 |
| 671 | 6 | Veracruz | OIL | 1.00000 | 9295. | 3.583 | 2.803 | 0.9335e 05 | 0.2706e 11 |
| 671 | 7 | Valle-San Luis Pato | OIL | 0.10000 | 0.1637e 05 | 2.083 | 0.2461e 05 | 0.8392e 09 | 0.2790e 11 |
| 671 | 8 | Parros | | 0.30000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 9 | Sabinas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 10 | Gulf of California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 11 | Sebastian Vizcaino | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 12 | Santo-Domingo | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 13 | Mazathan | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 14 | Guaymas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 15 | Yucatan Platform | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 16 | Sabine - Cruz | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 17 | Pedregasa-Ville Ahu | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 18 | Tlaxiaco | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |
| 671 | 19 | Baja California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2790e 11 |

CYCLE 1 IS PRESENTED IN DETAIL BELOW BECAUSE IT IS A (SPECIFD ) CYCLE.

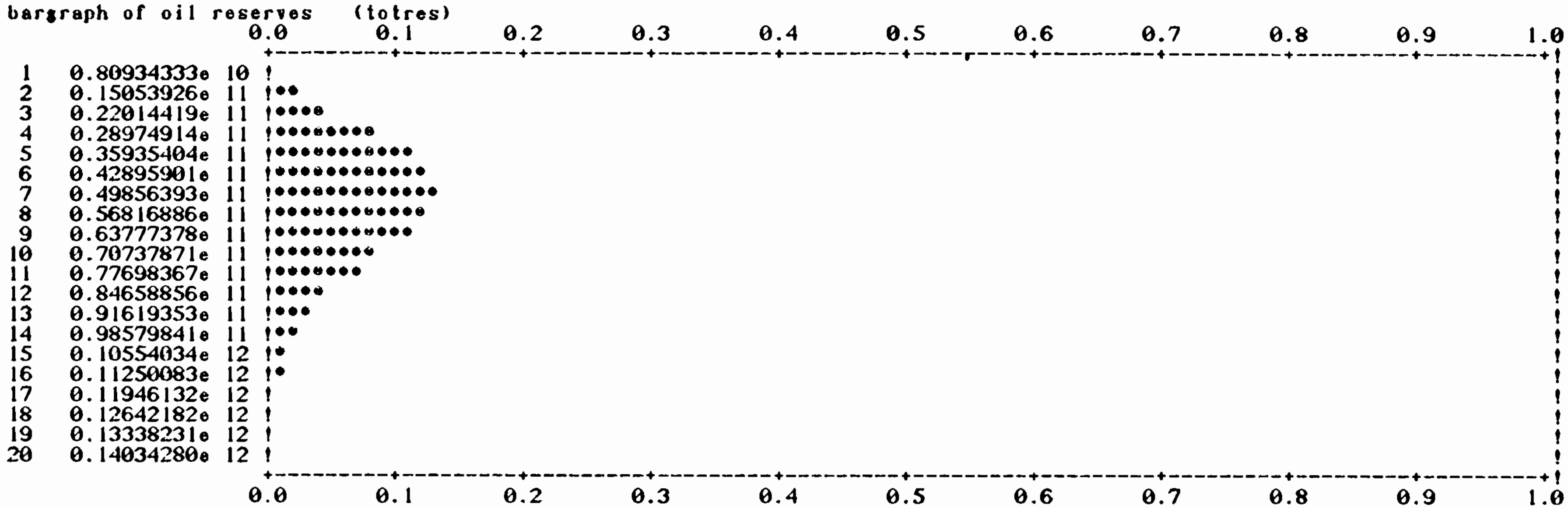
| PASS | NUMB | BASIN NAME | OIL? | PROBABILITY | A R E A | • THICKNESS | • RICHNESS | = RESERVES | TOTL RESERVE |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Offshore Reforma Tr | OIL | 0.60000 | 0.4502e 05 | 2.009 | 9199. | 0.8322e 09 | 0.8322e 09 |
| 1 | 2 | Onshore Reforma | OIL | 1.00000 | 0.2041e 05 | 3.230 | 0.7062e 05 | 0.4656e 10 | 0.5488e 10 |
| 1 | 3 | Tampico | OIL | 1.00000 | 0.2676e 05 | 1.812 | 0.2093e 06 | 0.1015e 11 | 0.1563e 11 |
| 1 | 4 | Isthmus Tabasco | OIL | 0.60000 | 0.1414e 05 | 2.447 | 0.2275e 06 | 0.7870e 10 | 0.2350e 11 |
| 1 | 5 | Burgos | | 0.50000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2350e 11 |
| 1 | 6 | Veracruz | OIL | 1.00000 | 9656. | 2.441 | 1.520 | 0.3583e 05 | 0.2350e 11 |
| 1 | 7 | Valle-San Luis Pato | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2350e 11 |
| 1 | 8 | Parros | | 0.30000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2350e 11 |
| 1 | 9 | Sabinas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2350e 11 |
| 1 | 10 | Gulf of California | OIL | 0.10000 | 6107. | 2.926 | 0.2803e 06 | 0.5009e 10 | 0.2851e 11 |
| 1 | 11 | Sebastian Vizcaino | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2851e 11 |
| 1 | 12 | Santo-Domingo | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2851e 11 |
| 1 | 13 | Mazathan | OIL | 0.20000 | 5208. | 1.231 | 0.4000e 05 | 0.2565e 09 | 0.2877e 11 |
| 1 | 14 | Guaymas | OIL | 0.20000 | 3380. | 1.286 | 0.4000e 05 | 0.1739e 09 | 0.2894e 11 |
| 1 | 15 | Yucatan Platform | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2894e 11 |
| 1 | 16 | Sabine - Cruz | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2894e 11 |
| 1 | 17 | Pedregasa-Ville Ahu | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2894e 11 |
| 1 | 18 | Tlaxiaco | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2894e 11 |
| 1 | 19 | Baja California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2894e 11 |

CYCLE 1000 IS PRESENTED IN DETAIL BELOW BECAUSE IT IS A (SPECIFD ) CYCLE.

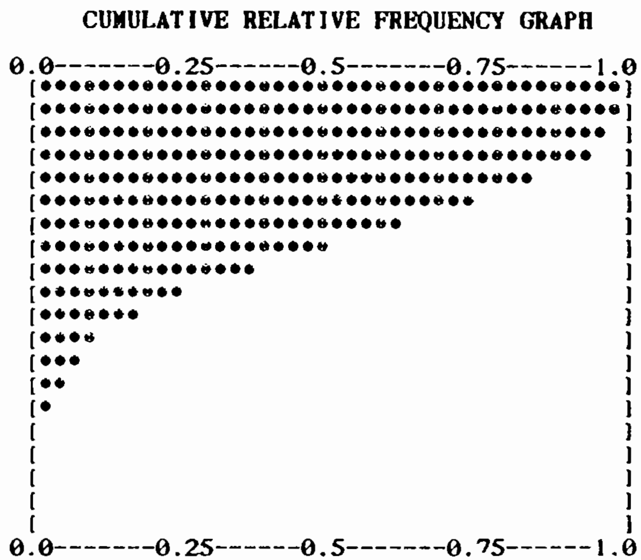
| PASS | NUMB | BASIN NAME | OIL? | PROBABILITY | A R E A | • THICKNESS | • RICHNESS | = RESERVES | TOTL RESERVE |
|---|---|---|---|---|---|---|---|---|---|
| 1000 | 1 | Offshore Reforma Tr | OIL! | 0.60000 | 0.4502e 05 | 2.009 | 9199. | 0.8322e 09 | 0.8322e 09 |
| 1000 | 2 | Onshore Reforma | OIL! | 1.00000 | 0.2041e 05 | 3.230 | 0.7062e 05 | 0.4656e 10 | 0.5488e 10 |
| 1000 | 3 | Tampico | OIL! | 1.00000 | 0.2676e 05 | 1.812 | 0.2093e 06 | 0.1015e 11 | 0.1563e 11 |
| 1000 | 4 | Isthmus Tabasco | OIL! | 0.60000 | 0.1414e 05 | 2.447 | 0.2275e 06 | 0.7870e 10 | 0.2350e 11 |
| 1000 | 5 | Burgos | OIL! | 0.50000 | 0.2845e 05 | 4.615 | 0.2711e 05 | 0.3559e 10 | 0.2706e 11 |
| 1000 | 6 | Veracruz | OIL! | 1.00000 | 9295. | 3.583 | 2.803 | 0.9335e 05 | 0.2706e 11 |
| 1000 | 7 | Valle-San Luis Pato | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2706e 11 |
| 1000 | 8 | Parros | OIL! | 0.30000 | 0.1058e 05 | 2.525 | 0.2461e 05 | 0.6574e 09 | 0.2772e 11 |
| 1000 | 9 | Sabinas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2772e 11 |
| 1000 | 10 | Gulf of California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2772e 11 |
| 1000 | 11 | Sebastian Vizoaino | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2772e 11 |
| 1000 | 12 | Santo-Domingo | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2772e 11 |
| 1000 | 13 | Mazathan | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2772e 11 |
| 1000 | 14 | Guaymas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2772e 11 |
| 1000 | 15 | Yucatan Platform | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2772e 11 |
| 1000 | 16 | Sabine - Cruz | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2772e 11 |
| 1000 | 17 | Pedregasa-Ville Ahu | OIL! | 0.20000 | 0.2346e 05 | 2.317 | 0.1732e 05 | 0.9417e 09 | 0.2866e 11 |
| 1000 | 18 | Tlaxiaco | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2866e 11 |
| 1000 | 19 | Baja California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2866e 11 |

CYCLE 2000 IS PRESENTED IN DETAIL BELOW BECAUSE IT IS A (SPECIFD ) CYCLE.

| PASS | NUMB | BASIN NAME | OIL? | PROBABILITY | A R E A | • THICKNESS | • RICHNESS | = RESERVES | TOTL RESERVE |
|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1 | Offshore Reforma Tr | OIL | 0.60000 | 0.4502e 05 | 2.009 | 9199. | 0.8322e 09 | 0.8322e 09 |
| 2000 | 2 | Onshore Reforma | OIL | 1.00000 | 0.2041e 05 | 3.230 | 0.7062e 05 | 0.4656e 10 | 0.5488e 10 |
| 2000 | 3 | Tampico | OIL | 1.00000 | 0.2676e 05 | 1.812 | 0.2093e 06 | 0.1015e 11 | 0.1563e 11 |
| 2000 | 4 | Isthmus Tabasco | | 0.60000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1563e 11 |
| 2000 | 5 | Burgos | | 0.50000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1563e 11 |
| 2000 | 6 | Veracruz | OIL | 1.00000 | 9043. | 3.985 | 2.275 | 0.8196e 05 | 0.1563e 11 |
| 2000 | 7 | Valle-San Luis Pato | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1563e 11 |
| 2000 | 8 | Parros | OIL | 0.30000 | 0.1163e 05 | 2.173 | 0.2711e 05 | 0.6853e 09 | 0.1632e 11 |
| 2000 | 9 | Sabinas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1632e 11 |
| 2000 | 10 | Gulf of California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1632e 11 |
| 2000 | 11 | Sebastian Vizcaino | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1632e 11 |
| 2000 | 12 | Santo-Domingo | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1632e 11 |
| 2000 | 13 | Mazathan | OIL | 0.20000 | 5361. | 1.196 | 0.4000e 05 | 0.2564e 09 | 0.1658e 11 |
| 2000 | 14 | Guaymas | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1658e 11 |
| 2000 | 15 | Yucatan Platform | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1658e 11 |
| 2000 | 16 | Sabine - Cruz | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1658e 11 |
| 2000 | 17 | Pedregasa-Ville Ahu | | 0.20000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1658e 11 |
| 2000 | 18 | Tlaxiaco | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1658e 11 |
| 2000 | 19 | Baja California | | 0.10000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1658e 11 |




| I | LOWER BOUND - UPPER BOUND | MIDPOINT | FREQ | REL FREQ | CUM REL FREQ |
|---|---|---|---|---|---|
| 1 | 0.80934e 10 - 0.15054e 11 | 0.11574e 11 | 5. | 0.002 | 1.000 |
| 2 | 0.15054e 11 - 0.22014e 11 | 0.18534e 11 | 35. | 0.018 | 0.998 |
| 3 | 0.22014e 11 - 0.28975e 11 | 0.25495e 11 | 84. | 0.042 | 0.980 |
| 4 | 0.28975e 11 - 0.35935e 11 | 0.32455e 11 | 164. | 0.082 | 0.938 |
| 5 | 0.35935e 11 - 0.42896e 11 | 0.39416e 11 | 214. | 0.107 | 0.856 |
| 6 | 0.42896e 11 - 0.49856e 11 | 0.46376e 11 | 245. | 0.123 | 0.749 |
| 7 | 0.49856e 11 - 0.56817e 11 | 0.53337e 11 | 263. | 0.132 | 0.627 |
| 8 | 0.56817e 11 - 0.63777e 11 | 0.60297e 11 | 240. | 0.120 | 0.495 |
| 9 | 0.63777e 11 - 0.70738e 11 | 0.67258e 11 | 226. | 0.113 | 0.375 |
| 10 | 0.70738e 11 - 0.77698e 11 | 0.74218e 11 | 159. | 0.079 | 0.262 |
| 11 | 0.77698e 11 - 0.84659e 11 | 0.81179e 11 | 146. | 0.073 | 0.183 |
| 12 | 0.84659e 11 - 0.91619e 11 | 0.88139e 11 | 85. | 0.043 | 0.110 |
| 13 | 0.91619e 11 - 0.98580e 11 | 0.95100e 11 | 51. | 0.025 | 0.067 |
| 14 | 0.98580e 11 - 0.10554e 12 | 0.10206e 12 | 37. | 0.019 | 0.042 |
| 15 | 0.10554e 12 - 0.11250e 12 | 0.10902e 12 | 23. | 0.012 | 0.023 |
| 16 | 0.11250e 12 - 0.11946e 12 | 0.11598e 12 | 13. | 0.007 | 0.012 |
| 17 | 0.11946e 12 - 0.12642e 12 | 0.12294e 12 | 6. | 0.003 | 0.005 |
| 18 | 0.12642e 12 - 0.13338e 12 | 0.12990e 12 | 1. | 0.001 | 0.002 |
| 19 | 0.13338e 12 - 0.14034e 12 | 0.13686e 12 | 1. | 0.001 | 0.002 |
| 20 | 0.14034e 12 - 0.14730e 12 | 0.14382e 12 | 2. | 0.001 | 0.001 |




MEAN IS 0.583726e 11 STANDARD DEVIATION IS 5402.43

Figures A2.1 and A2.2. Frequency distribution and cumulative distribution

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