BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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CPLAY: A COMPUTER PROGRAM FOR ESTIMATING UNDISCOVERED PETROLEUM RESOURCES USING THE CANADIAN PLAY METHOD

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CONTENTS

SUMMARY

Computer program CPLAY is available on BMR's HP-1000 computer. It uses the Canadian play method to estimate the undiscovered recoverable petroleum resources of a petroleum play.

Input to the program consists of:

(1) alphanumeric data used to document the assessment;

(2) distributions for each of five reservoir parameters that determine the volume of hydrocarbons potentially contained in-place within the pools;

(3) success rates for oil and for gas;

(4) the proportion of oil to gas, the recovery factors, the gas expansion and oil contraction factors;

(5) existence risk, and

(6) a distribution for the number of prospects within the play.

The program output includes:

(1) the input data;

(2) cumulative probability distributions showing the conditional recoverable oil and gas pool sizes;

(3) tabulations of reservoir parameter values corresponding to classes of conditional recoverable oil and gas pool sizes;

(4) cumulative probability distributions showing the conditional recoverable play potentials for oil and gas;

(5) tabulations of the number of prospects corresponding to classes of conditional recoverable oil and gas play potential;

(6) the existence risks for oil and gas, and

(7) a summary report.

INTRODUCTION

The Canadian play method has been developed and used extensively by the Geological Survey of Canada (Energy, Mines and Resources, 1976; Procter & others, 1982). The necessary computer program for this method is unpublished, however, and computer program CPLAY has been written so that the method may be employed by the Bureau of Mineral Resources in Australia.

The Canadian play method

As described by the Geological Survey of Canada, the first step in carrying out this method is to identify all of the 'plays' that may be present in an area. Each play has one reservoir sequence in common.

The next step is to identify how many identified fields and potential structural and stratigraphic traps may contain the play. Next the conditional pool size distribution is determined (Fig. 1). This is the distribution of in-place pool sizes, assuming that all prospects contain hydrocarbons. It is determined by multiplying together random values selected from distributions for each of the reservoir parameters - area of prospect, reservoir thickness, fraction trap fill, porosity, and water saturation. Hence, the in-place pool size = area x thickness x fraction trap fill x porosity x (1 - water saturation).

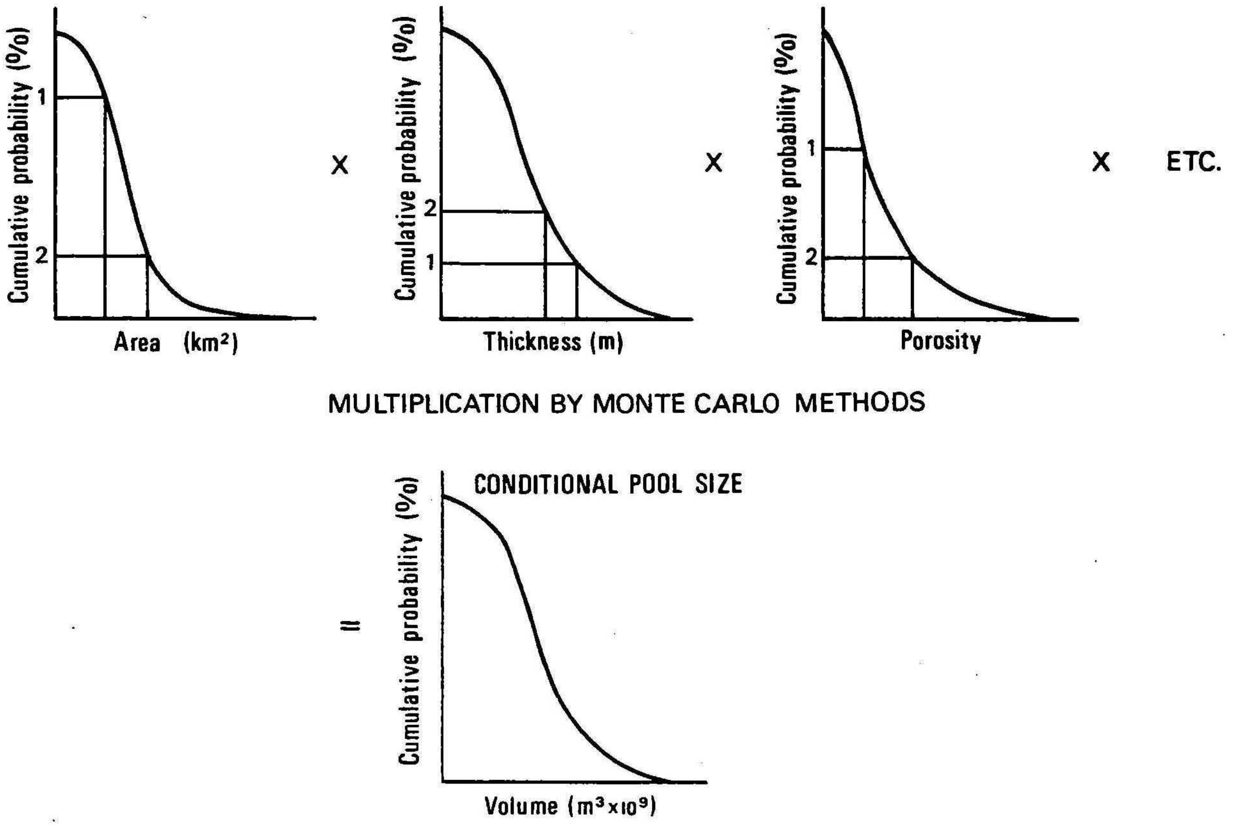

Figure 1

FIGURE 1*

The computer program estimates the conditional in-place play potential using the conditional pool size distribution, the number of prospects distribution, and the success rate (Fig. 2). During each iteration, a number of prospects is selected at random from the number of prospects distribution. The potential presence or absence of hydrocarbons in each prospect is simulated by comparison of the success rate with a random number. The size of each pool is determined by a random

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* Modified after Energy, Mines and Resources, 1976

selection from the conditional pool size distribution and these pool sizes are added to obtain the total in-place resource volume of the play. Many iterations are carried out to determine a distribution of values for conditional in-place play potential. Average values for the proportions of in-place oil and gas, the oil and gas recovery factors, and gas expansion and oil contraction factors are used to produce cumulative probability distributions of recoverable oil and gas.

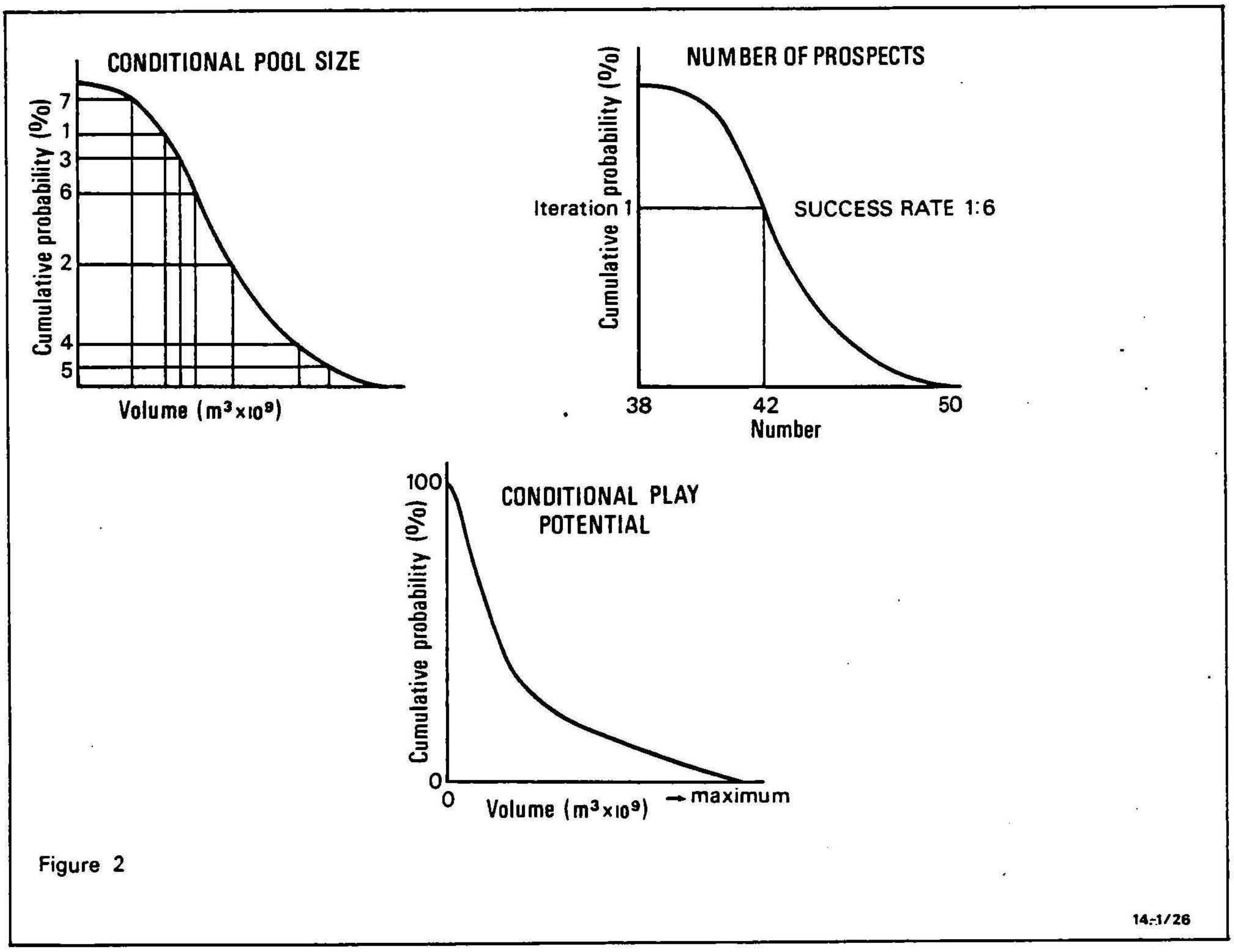

FIGURE 2 *

* Modified after Energy, Mines and Resources, 1976.

DESCRIPTION OF THE PROGRAM

Input of data for documentation

The following data are read from a file and printed out by program CPLAY.

- basin name
- subdivision
- name of the play
- who compiled the data
- date the data were compiled
- hydrocarbons assessed
- number of iterations to be carried out in the simulations
- an optional 5-digit seed for the random number generator

Input and printing of distributions for the reservoir parameters

The estimated distributions for area of prospect, thickness of reservoir, fraction trap fill, porosity, and water saturation are read from the input file by the main program. Subroutine DISWR is responsible for printing the distributions out. Subroutine CPD calculates the means and standard deviations of these distributions and converts them into cumulative probability distributions. The main program is responsible for printing out the means and standard deviations.

Calculation of the conditional in-place pool size distribution

One potential in-place pool size is calculated by random sampling of the five reservoir parameters, using subroutine MONTE, and their multiplication in the equation: pool size = area x thickness x fraction trap fill x porosity x (1 - water saturation). Sampling and multiplication are repeated many times and the results are summarised as a histogram and a cumulative probability distribution of pool sizes; up to 21 values from this distribution are stored in the computer.

The results of each iteration are retained for analysis. The pools are arranged into classes by equal division of the range of sizes. For each class, the values of the five reservoir parameters and their squares are accumulated allowing calculation of the average value and standard deviation.

Input of success rates

Oil and gas success rates are read from the input file.

Input and printing of data used to calculate recoverable potential

The following data are read from the input file for oil and are printed out together with the success rate:

. oil existence risk;

. formation volume factor, B_o;

- oil recovery factor, R_o, and
- proportion of oil to gas, P_o.

A conversion factor, C_o, is calculated using the equation: $C_o = R_oP_o/B_o$. In-place oil pool sizes are multiplied by the conversion factor to estimate the unrisked recoverable gas pool sizes.

The following data are read from the input file for gas and are printed out together with the success rate:

- gas existence risk;
- gas expansion factor, B_g;
- gas recovery factor, R_g, and
- proportion of gas to oil, P_g.

A conversion factor, C_g, is calculated from these values, using the equation: $C_g = R_gP_g/B_g$. In-place gas pool sizes are multiplied by the conversion factor to estimate the unrisked recoverable gas pool sizes.

Input and printing of the number of prospects

The number of prospects distribution is read from the input file, printed out by subroutine DISWR, and converted into a cumulative probability distribution by subroutine CPD.

of the distribution. These are then printed out by the main program.

<u>Printing of conditional recoverable pool size distribution and analysis</u>

Subroutine PHIST uses the conversion factor, C_o, to convert the in-place oil pool size classes into corresponding recoverable oil pool size classes. The subroutine is also responsible for printing the cumulative conditional pool size distribution for recoverable oil. Subroutine MOMNT calculates and prints the mean, standard deviation, skewness, and kurtosis for this distribution and also for the distribution of log pool sizes.

The means and standard deviations of each of the five reservoir parameters for each recoverable oil pool size class are printed out. The number of values within each class is also printed. No information is printed if the number is zero.

The procedure described in this section will be ignored if the proportion of oil to gas is 0 to 1 or the success rate for oil is zero. The procedure is repeated for gas, unless the proportion of gas to oil is 0 to 1 or the success rate for gas is zero.

Calculation of the conditional recoverable play potential (subroutine TOTP)

A histogram of conditional recoverable play potential is estimated by simulating repeated drilling of the prospects in the play. For each iteration, subroutine MONTE is used for random sampling of the cumulative distribution of number of prospects. The likely presence or absence of petroleum in each prospect is simulated by comparing a random number with the specified success rate. The size of each potential discovery is determined, using subroutine MONTE, by selecting a random value of pool size from the conditional pool size distribution. At the end of each iteration, pool sizes are summed to obtain the total unrisked in-place play potential.

After many iterations, the total in-place play potential is calculated in histogram form. Subroutine PHIST uses the conversion factor to convert in-place potential to recoverable potential and prints the results as a cumulative probability distribution. Subroutine MOMNT prints the mean, standard deviation, skewness, and kurtosis of this distribution. The main program prints the existence risk with this data. Subroutine PERC calculates some percentiles of the distribution.

The number of prospects and the total in-place play potential for each iteration are stored for further analysis. For each class, the mean, standard deviation, maximum, and minimum number of successful prospects are printed. The number of values within each class is also printed. No information is printed if the number is zero.

Printing of summary report

The input data for documentation and some percentiles of the distributions for the conditional recoverable oil and gas play potentials are printed out. The means of these distributions and their percentiles are also printed.

INPUT DATA

The input for program CPLAY should be typed into a file with the following format.

Line	Cols	Variable	Description	Format for entire line
1	1-80	ITITL1	Basin name	(40A2)
2	1-80	ITITL2	Subdivision	(40A2)
3	1-80	ITITL3	Play	(40A2)
4	1-80	ITITL4	Data compiled by	(40A2)
5	1-80	ITITL5	Date of assessment	(40A2)
6	1-80	ITITL6	Hydrocarbons assessed: OIL and/or GAS	(40A2)
7	1-5	NRUNS	Number of iterations to be carried out in each simulation (suggested values: 2000 or 5000).	(2I5)

	6-10	ISEED	Seed for random number generator. If omitted, 12345 is used.	

The next five lines specify the distributions for the five reservoir parameters: area (sq km) (line 8); thickness (m) (line 9); fraction trap fill (line 10); porosity (line 11); water saturation (line 12).

8-12	1	TYPE(I)	Type of distribution (K-constant, U-uniform, blank-frequency histogram, C-cumulative, T-triangular)	(A1,I5, 5(6F10. 3/))
	2-6	NUM(I)	Number of x,y pairs specifying the distribution	
	7-16	VAL(I,1)	Parameter value of the first pair	
	17-26	FREQ(I,1)	Corresponding probability or relative frequency	
	27-36	VAL(I,2)	Parameter value of the second pair	
	37-46	FREQ(I,2)	Corresponding probability or relative frequency	
	47-56	VAL(I,3)	Parameter value of the third pair	
	57-66	FREQ(I,3)	Corresponding probability or relative frequency	

If more than 3 pairs are required to specify the distribution for any of the parameters, 1 to 4 continuation lines may be added. Up to 3 pairs can be entered per continuation line, 20 columns per pair, starting in column 1 (ie each number has F10.0 format).

13	1-10	SROIL	Success rate for oil	(2F10.3)
	11-20	SRGAS	Success rate for gas	
14	1-10	ORISK	Oil existence risk	(4F10.3)
	11-20	FVF	Formation volume factor (oil contraction factor)	
	21-30	RO	Oil recovery factor	
	31-40	POIL	Proportion of oil	
15	1-10	GRISK	Gas existence risk	(4F10.3)
	11-20	BG	Gas expansion factor	

	21-30	RG	Gas recovery factor	
	31-40	PGAS	Proportion of gas	
16	1	TYPE(7)	Type of distribution for the number of prospects	(A1,I5, (6F10.3))
	2-6	NUM(7)	Number of x,y pairs specifying the distribution	
	7-66		Values and probabilities (or relative frequencies) specifying the distribution (as for lines 8-12; continuation lines added as necessary)	

RUNNING THE PROGRAM

Program CPLAY resides in BMR's Hewlett-Packard 1000 computer. To run it, use the commands:

```
RP,CPLAY     (to restore program CPLAY)
RU,CPLAY     (to run program CPLAY)
```

The program will ask for the name of the data file. The output will be sent back to the terminal. To send the output to the printer instead, use:

```
RU,CPLAY,6   (to run program CPLAY; output to LU6)
LP,-N        (to print the output file)
```

or

```
RU,CPLAY,16  (to run program CPLAY; output
             directly to the printer)
```

REFERENCES

ENERGY, MINES AND RESOURCES CANADA, 1976 - Oil and natural gas resources of Canada, 1976. Energy, Mines and Resources Canada, Report EP77-1, 76p.

PROCTER, R.M., LEE, P.J., & TAYLOR, G.,C., 1982 - Methodology of petroleum resource evaluation. Geological Survey of Canada, Petroleum Resources Appraisal Secretariat.