DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

TRIAGG : Triangular Probability Distribution Aggregation for Petroleum Resource Assessment

By

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Open-File Report 89-483-A

A -- Documentation (paper copy)
B -- Executable program (5.25" diskette)

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1989

Original

NOTE FOR THE MONTHLY LIST

TRIAGG and AGG (version 89.02) are programs for IBM PC and compatible microcomputers to assess and aggregate estimates of a resource which is modelled by a triangular probability distribution; i.e., the resource input is estimated in terms of its minimum, modal (most likely) and maximum values. The resource could be a natural resource (oil or gas) or any other physical quantity with an uncertain value. TRIAGG produces output estimates in the form of the mean, standard deviation and a set of seven fractiles of the resource. AGG aggregates the estimates from prior runs of TRIAGG and produces output in the form of the mean, standard deviation and seven fractiles of the aggregate. Requirements: IBM PC or compatible; minimum 256K RAM; MS-DOS 3.1 or equivalent; printer able to print 132 columns. CGA compatible graphics adapter and graphics compatible printer are useful but optional. OF89-483-A, Documentation, 29 p., paper copy; OF89-483-B, Executable diskette (5.25").

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1. INTRODUCTION

TRIAGG is a general purpose methodology for appraising natural resources having an assumed triangular distribution. TRIAGG starts with three parameters of a resource in the form of estimated minimum, modal, and maximum values, and computes the estimates: mean value, standard deviation, and seven fractiles (*F100, F95, F75, F50, F25, F5, F0*). Each fractile *Fi* is a value of the resource, with an *i*/100 probability that the value of the resource exceeds *Fi.* In addition, TRIAGG is able to aggregate its computed estimates for up to 992 resource components.

The resource could be almost any physical quantity with an uncertain outcome, which can be assessed in terms of a minimum possible value, a maximum value, and a most likely value (the mode). Several components of a similar resource (that is, several sets of estimates of resources having the same units of measure) can be estimated, and then the estimates can be aggregated.

A package of computer programs for carrying out this assessment, named the TRIAGG system, was produced for use with microcomputers compatible with the IBM PC/XT/AT machines. This package contains a program called TRIAGG for computing the estimates and aggregation described above, and a program named AGG for carrying out further aggregations of groups of aggregated assessments. Thus the software system can estimate components, aggregate components to produce assessments, and aggregate assessments in any combination. If the host computer has graphics capability, TRIAGG also can display a graph of the triangular distributions while they are being entered into the data file, as an aid in generating and refining the original data.

An IBM-PC compatible 5.25" diskette containing the executable programs and documentation files for TRIAGG is distributed as a separate Open-File Report, number 89-483-B. The files on the diskette are:

TRIAGG.EXE	The component assessment and component aggregation program;
AGG.EXE	The assessment aggregation program;
-README	The title page and disclaimer for the software release;
TRIAGG.DOC	The documentation file for both the above programs;
INSTAL2D.BAT	The automatic installation batch file for a 2-diskette computer (5.25" diskette);
INSTALHD.BAT	The automatic installation batch file for a hard disk computer;
TRITEST.DAT	A file of hypothetical sample data for test-running the TRIAGG program;
AGGTEST.SCR	A script file of hypothetical data for test-running the AGG program;
TEST0.AGG TEST1.AGG TEST6.AGG	Three files of hypothetical aggregation data for test-running the AGG program.

The TRIAGG package consists of two modules, TRIAGG and AGG, performing respectively (1) the assessment and aggregation of a set of components, and (2) the aggregation of a set of TRIAGG aggregates:

Function	Module involved
Data entry and editing of component parameters	TRIAGG
Computation of estimates and aggregation of components	
Data entry and editing of prior aggregations	AGG
Aggregation of aggregates	

The first two functions are combined in the program TRIAGG. When TRIAGG runs, it requests a data file name and allows the user to pass this file into either the data entry and editing module, or into the assessment module for computation of estimates. In a similar way the second two functions are combined in the program AGG for combining the assessment output of several prior assessments and forming an aggregate assessment. TRIAGG and AGG are separate but cooperating programs, and they will be referred to collectively as the TRIAGG system.

The TRIAGG.DOC file contains most of the document you are now reading. It can be copied onto a printer using the DOS command

```
PRINT  disk:TRIAGG.DOC
```

where *disk* should be replaced by the drive letter of the disk drive containing the TRIAGG.DOC file; for example, if TRIAGG.DOC is in disk drive B, the command would be PRINT B:TRIAGG.DOC.

2. METHODOLOGY

A general risk analysis method was developed for petroleum resource assessment and other applications. The triangular probability distribution is used as a model with an analytic aggregation methodology based on probability theory rather than Monte Carlo simulation.

2.1 Triangular Probability Distribution

The input into the model consists of a set of components (e.g., geologic provinces) and, for each component, three potential resource estimates: minimum, most likely (mode), and maximum. Assuming a triangular probability distribution, the mean, standard deviation, and seven fractiles (*F100, F95, F75, F50, F25, F5,* and *F0*) are computed for each component, where for example, the probability of more than *F95* is equal to 0.95.

Given the parameters

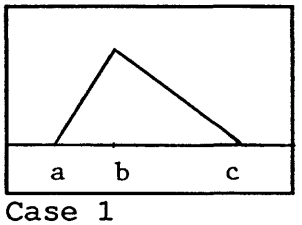
$$a = \text{minimum}, \quad b = \text{mode}, \quad c = \text{maximum}$$

the mean μ, variance σ^2 and standard deviation σ are computed by the formulas

$$\mu = \frac{a + b + c}{3}$$

$$\sigma^2 = \frac{a^2 + b^2 + c^2 - ab - ac - bc}{18}$$

$$\sigma = \sqrt{\sigma^2}$$



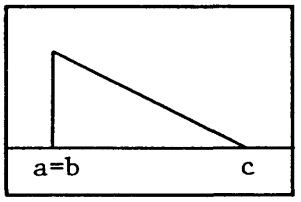
Case 1

The seven fractiles *F100p*, for p = 1.0, 0.95, 0.75, 0.5, 0.25, 0.05 and 0.0, are computed for three different cases as follows. Note: *F100* = *a* and *F0* = *c*.

Case 1: $a < b < c$

If $p \geq \frac{c - b}{c - a}$, then

$$F100p = a + \sqrt{(1 - p)(c - a)(b - a)}$$



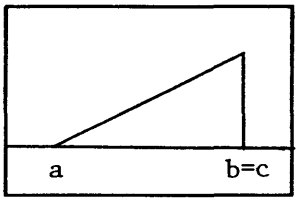
Case 2

Otherwise,

$$F100p = c - \sqrt{p(c - a)(c - b)}$$

Case 2: $a = b < c$

$$F100p = c - \sqrt{p}\,(c - a)$$



Case 3

Case 3: $a < b = c$

$$F100p = a + \sqrt{1 - p}\,(c - a)$$

2.2 Aggregation

The components are aggregated by combining the means, standard deviations, and respective fractiles under three possible cases: (1) complete independence, (2) perfect positive correlation, and (3) any degree of dependency between the two polar cases of (1) and (2).

Given n components with moments and fractiles

$$\mu_i,\ \sigma_i,\ F100_i,\ F95_i,\ F75_i,\ F50_i,\ F25_i,\ F5_i,\ F0_i \qquad \text{for } i = 1, \ldots, n,$$

the following three cases are used to compute the moments and fractiles for the aggregate,

$$\mu_a,\ \sigma_a,\ F100_a,\ F95_a,\ F75_a,\ F50_a,\ F25_a,\ F5_a,\ F0_a$$

In each summation Σ shown below, the index i is understood to run from 1 to n inclusive.

Case 1: Complete independence (dependency d = 0)

$$\mu_a = \Sigma\, \mu_i$$

$$\sigma^2_{a,0} = \Sigma\, \sigma_i^2$$

$$\sigma_{a,0} = \sqrt{\sigma^2_{a,0}}$$

The normal distribution fractiles $F95, \ldots, F5$ are based on the Central Limit Theorem:

$$F100_{a,0} = \Sigma\, F100_i$$

$$F95_{a,0} = \mu_a - 1.645\ \sigma_{a,0}$$

$$F75_{a,0} = \mu_a - 0.674\ \sigma_{a,0}$$

$$F50_{a,0} = \mu_a$$

$$F25_{a,0} = \mu_a + 0.674\ \sigma_{a,0}$$

$$F5_{a,0} = \mu_a + 1.645\ \sigma_{a,0}$$

$$F0_{a,0} = \Sigma\, F0_i$$

Case 2: Perfect positive correlation (dependency d = 1)

$$\mu_a = \Sigma\, \mu_i$$

$$\sigma_{a,1} = \Sigma\, \sigma_i$$

$$F100p_{a,1} = \Sigma\, F100p_i \qquad \text{for } p = 1.0,\ 0.95,\ 0.75,\ 0.5,\ 0.25,\ 0.05,\ 0.0$$

Case 3: Dependency *d* between 0 and 1 ($0 \leq d \leq 1$)

$$\mu_a = \Sigma \mu_i$$

$$\sigma_a = \sigma_{a,0} + d\,(\sigma_{a,1} - \sigma_{a,0})$$

$$F100p_a = F100p_{a,0} + d\,(F100p_{a,1} - F100p_{a,0})$$

for p = 1.0, 0.95, 0.75, 0.5, 0.25, 0.05, 0.0

The analytic probabilistic methodology was used to write a computer program called TRIAGG, for triangular distribution aggregation. A separate aggregation program called AGG was written for aggregating other aggregations.

2.3 Example

This methodology was applied to the Potential Gas Committee's 1989 national assessment of natural gas (Potential Gas Agency, 1989). This committee is part of the Potential Gas Agency at the Colorado School of Mines in Golden, Colorado. Data for the Committee's estimated resources of natural gas in billions of cubic feet for provinces of the Gulf Coast Area (Potential Gas Agency, 1989, p. 55) were analyzed by the TRIAGG and AGG programs.

TRIAGG was used to assess and aggregate natural gas deposits in each of the following seven provinces. Within each province are two components, corresponding to two depth ranges: (1) 0-15,000 feet and 15,000-30,000 feet for onshore provinces, and (2) 0-200 meters and 200-1,000 meters water depth for offshore provinces. The degree of dependency between components was taken to be 1.0.

1. Louisiana-Mississippi-Alabama Salt Basins - onshore
2. Louisiana Gulf Coast - onshore
3. East Texas Basin - onshore
4. Texas Gulf Coast Basin - onshore
5. Eastern Gulf - offshore
6. Louisiana - offshore
7. Texas - offshore

AGG was used to generate the following three aggregations of the above provinces.

1. Total onshore (degree of dependency = 0.5)
2. Total offshore (degree of dependency = 0.5)
3. Total onshore and offshore (degree of dependency = 0)

The results are shown in Tables 1-10 and in Figure 1.

Table 1 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Onshore Louisiana-Mississippi-Alabama salt basins

TRIAGG 89.02 P300.TRL 16:07:11 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Assessment name : LA-MS-AL Salt Basins - Onshore
Units : Billion cubic feet
Degree of dependency : 1.000

INPUT: PARAMETERS

COMPONENT NAME	MIN.	MODE	MAX.
LA-MS-AL Salt Basins 0-15,000'	3200.00	4550.00	6650.00
LA-MS-AL Salt Basins 15,000-30,000'	450.000	1150.00	1600.00

OUTPUT: ESTIMATES

COMPONENT NAME	MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
LA-MS-AL Salt Basins 0-15,000'	4800.00	709.753	3200.00	3682.57	4279.06	4746.71	5304.17	6048.12	6650.00
LA-MS-AL Salt Basins 15,000-30,000'	1066.66	236.584	450.000	650.624	898.608	1084.42	1240.31	1439.14	1600.00
AGGREGATION	5866.66	946.337	3650.00	4333.19	5177.67	5831.14	6544.48	7487.27	8250.00

Table 2 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Onshore Louisiana Gulf Coast

TRIAGG 89.02 P310.TRL 16:06:30 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Assessment name : LA Gulf Coast - Onshore
Units : Billion cubic feet
Degree of dependency : 1.000

INPUT:

COMPONENT NAME	PARAMETERS MIN.	MODE	MAX.
LA Gulf Coast 0-15,000'	2000.00	2900.00	3400.00
LA Gulf Coast 15,000-30,000'	2800.00	3950.00	4750.00

OUTPUT:

COMPONENT NAME	ESTIMATES MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
LA Gulf Coast 0-15,000'	2766.66	289.635	2000.00	2250.99	2561.24	2793.72	2981.66	3212.91	3400.00
LA Gulf Coast 15,000-30,000'	3833.33	400.173	2800.00	3134.85	3548.74	3858.89	4125.50	4470.71	4750.00
AGGREGATION	6600.00	689.809	4800.00	5385.84	6109.99	6652.61	7107.17	7683.63	8150.00

Table 3 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Onshore East Texas basin

TRIAGG 89.02 P320.TRL 16:09:08 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Assessment name : East TX Basin - Onshore
Units : Billion cubic feet
Degree of dependency : 1.000

INPUT:		PARAMETERS		
COMPONENT NAME		MIN.	MODE	MAX.
East TX Basin	0-15,000'	750.000	1400.00	2050.00
East TX Basin	15,000-30,000'	50.0000	100.000	150.000

OUTPUT:		ESTIMATES								
COMPONENT NAME		MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
East TX Basin	0-15,000'	1400.00	265.361	750.000	955.548	1209.61	1400.00	1590.38	1844.45	2050.00
East TX Basin	15,000-30,000'	100.000	20.4124	50.0000	65.8113	85.3553	100.000	114.644	134.188	150.000
AGGREGATION		1500.00	285.773	800.000	1021.35	1294.97	1500.00	1705.02	1978.64	2200.00

Table 4 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Onshore Texas Gulf Coast basin

TRIAGG 89.02 P330.TRL 16:11:10 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Assessment name : TX Gulf Coast Basin - Onshore
Units : Billion cubic feet
Degree of dependency : 1.000

INPUT:

COMPONENT NAME	PARAMETERS MIN.	MODE	MAX.
TX Gulf Coast 0-15,000'	600.000	3200.00	4700.00
TX Gulf Coast 15,000-30,000'	4100.00	5500.00	7050.00

OUTPUT:

COMPONENT NAME	ESTIMATES MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
TX Gulf Coast 0-15,000'	2833.33	846.889	600.000	1330.06	2232.48	2908.67	3460.04	4145.47	4700.00
TX Gulf Coast 15,000-30,000'	5550.00	602.425	4100.00	4554.42	5116.12	5537.96	5980.82	6571.85	7050.00
AGGREGATION	8383.33	1449.31	4700.00	5884.49	7348.60	8446.64	9440.87	10717.3	11750.0

Table 5 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Offshore Eastern Gulf

TRIAGG 89.02 P930.TRL 16:14:48 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Assessment name : Eastern Gulf - Offshore
Units : Billion cubic feet
Degree of dependency : 1.000

INPUT:

COMPONENT NAME		PARAMETERS MIN.	MODE	MAX.
Eastern Gulf Shelf	0-200 m	2900.00	4100.00	5400.00
Eastern Gulf Slope	200-1,000 m	0.00000	0.00000	0.00000

OUTPUT:

COMPONENT NAME		ESTIMATES MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
Eastern Gulf Shelf	0-200 m	4133.33	510.446	2900.00	3287.29	3766.02	4125.24	4498.61	4996.88	5400.00
Eastern Gulf Slope	200-1,000 m	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
AGGREGATION		4133.33	510.446	2900.00	3287.29	3766.02	4125.24	4498.61	4996.88	5400.00

Table 6 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Offshore Louisiana

TRIAGG 89.02 P935.TRL 16:16:26 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Assessment name : LA - Offshore
Units : Billion cubic feet
Degree of dependency : 1.000

INPUT:

COMPONENT NAME		PARAMETERS MIN.	MODE	MAX.
LA Shelf	0-200 m	9700.00	16300.0	18500.0
LA Slope	200-1,000 m	400.000	1400.00	2500.00

OUTPUT:

COMPONENT NAME		ESTIMATES MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
LA Shelf	0-200 m	14833.3	1869.64	9700.00	11404.1	13510.5	15088.8	16300.0	17516.1	18500.0
LA Slope	200-1,000 m	1433.33	428.822	400.000	724.037	1124.56	1425.29	1740.06	2160.14	2500.00
AGGREGATION		16266.6	2298.46	10100.0	12128.1	14635.0	16514.1	18040.0	19676.2	21000.0

Table 7 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Offshore Texas

TRIAGG 89.02 P940.TRL 16:18:03 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Assessment name : TX - Offshore
Units : Billion cubic feet
Degree of dependency : 1.000

INPUT:

COMPONENT NAME	PARAMETERS MIN.	MODE	MAX.
TX Shelf 0-200 m	2300.00	4600.00	6600.00
TX Slope 200-1,000 m	50.0000	100.000	150.000

OUTPUT:

COMPONENT NAME	ESTIMATES MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
TX Shelf 0-200 m	4500.00	878.445	2300.00	3003.20	3872.41	4523.73	5133.71	5944.25	6600.00
TX Slope 200-1,000 m	100.000	20.4124	50.0000	65.8113	85.3553	100.000	114.644	134.188	150.000
AGGREGATION	4600.00	898.858	2350.00	3069.01	3957.77	4623.73	5248.35	6078.44	6750.00

Table 8 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Total onshore

AGG 89.02 ONSHORE.AGL 16:20:36 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Aggregation name : Total Onshore
Units : Billion cubic feet
Degree of dependency : 0.500

			ESTIMATES						
ASSESSMENT NAME	MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
LA-MS-AL Salt Basins - Onshore	5866.66	946.337	3650.00	4333.19	5177.67	5831.14	6544.48	7487.27	8250.00
LA Gulf Coast - Onshore	6600.00	689.809	4800.00	5385.84	6109.99	6652.61	7107.17	7683.63	8150.00
East TX Basin - Onshore	1500.00	285.773	800.000	1021.35	1294.97	1500.00	1705.02	1978.64	2200.00
TX Gulf Coast Basin - Onshore	8383.33	1449.31	4700.00	5884.49	7348.60	8446.64	9440.87	10717.3	11750.0
AGGREGATION	22350.0	2628.16	13950.0	17936.9	20505.3	22390.2	24209.0	26658.9	30350.0

Table 9 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Total offshore

AGG 89.02 OFFSHORE.AGL 16:22:14 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Aggregation name : Total Offshore
Units : Billion cubic feet
Degree of dependency : 0.500

	ESTIMATES								
ASSESSMENT NAME	MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
Eastern Gulf - Offshore	4133.33	510.446	2900.00	3287.29	3766.02	4125.24	4498.61	4996.88	5400.00
LA - Offshore	16266.6	2298.46	10100.0	12128.1	14635.0	16514.1	18040.0	19676.2	21000.0
TX - Offshore	4600.00	898.858	2350.00	3069.01	3957.77	4623.73	5248.35	6078.44	6750.00
AGGREGATION	25000.0	3113.98	15350.0	19669.3	22830.1	25131.5	27242.8	29948.6	33150.0

Table 10 -- Estimated resources of natural gas for provinces of the Gulf Coast Area - Total onshore and offshore

AGG 89.02 GULFAGG.AGL 16:24:17 6-Jun-1989

Project name : Natural Gas - Gulf Coast Area - Probable
Aggregation name : Total Onshore and Offshore
Units : Billion cubic feet
Degree of dependency : 0.000

			ESTIMATES						
ASSESSMENT NAME	MEAN	S. D.	F100	F95	F75	F50	F25	F5	F0
Total Onshore	22350.0	2628.16	13950.0	17936.9	20505.3	22390.2	24209.0	26658.9	30350.0
Total Offshore	25000.0	3113.98	15350.0	19669.3	22830.1	25131.5	27242.8	29948.6	33150.0
AGGREGATION	47350.0	4074.82	29300.0	40646.9	44603.5	47350.0	50096.4	54053.0	63500.0

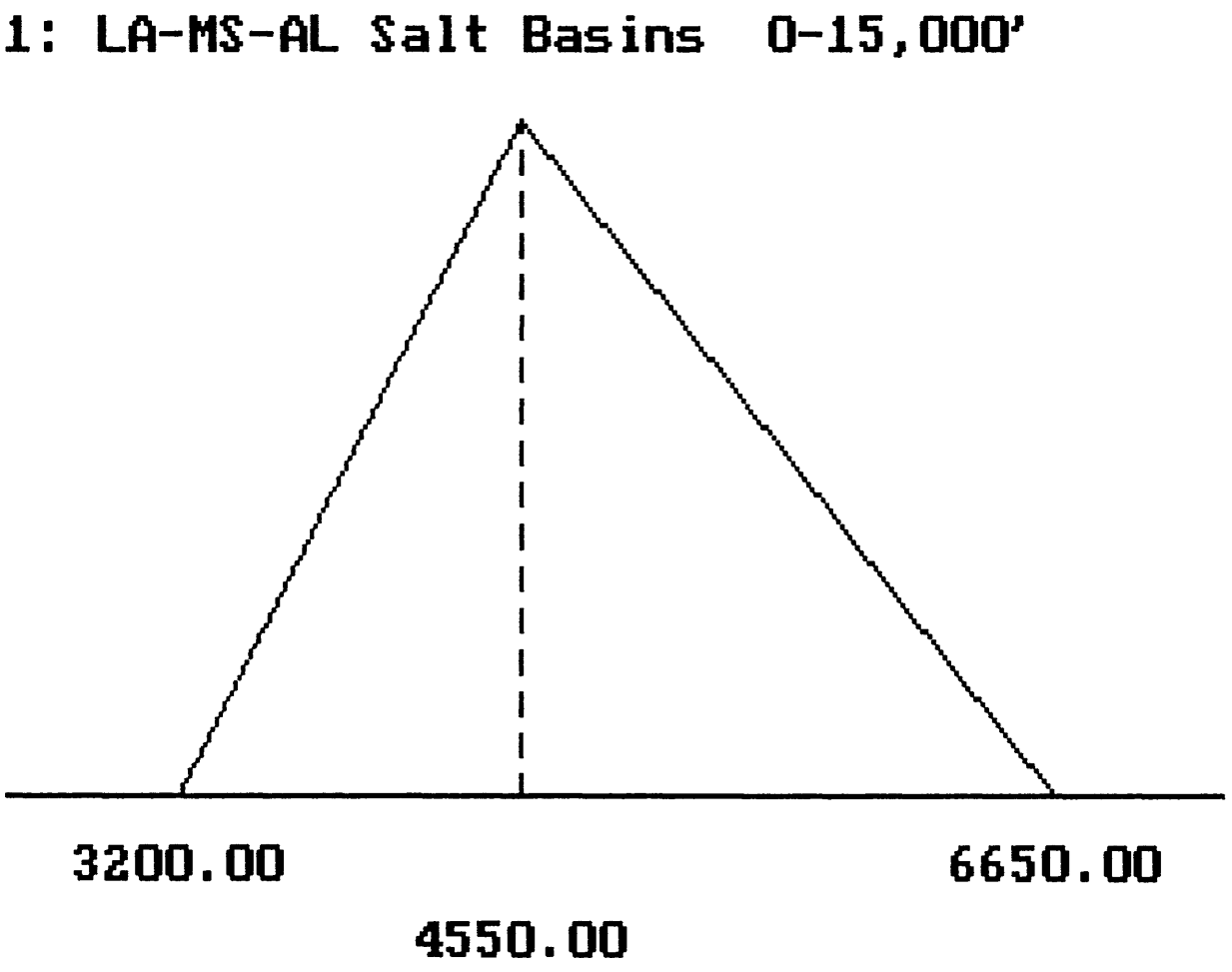


Figure 1 -- Triangular probability distribution of estimated resources of natural gas for Louisiana-Mississippi-Alabama salt basins, 0-15,000 foot depth

3. COMPUTER REQUIREMENTS

The computer hardware needed for running TRIAGG is the following:

IBM PC/XT/AT or compatible machine of other manufacture;
Monochrome or color monitor;
2 diskette drives (5.25"), or 1 diskette and a hard disk;
256K memory;
Printer able to print 132 characters on a line.

A graphics adapter in the computer is not required, but it is useful. The user may give a command to display a plot of the triangular distribution of any component, like the sample shown in Figure 1. If the computer used to run TRIAGG lacks a graphics adapter, the program will show an error message if the plot command is given. The graphics standard used is CGA. A dot matrix or other graphics compatible printer is needed for printing TRIAGG graphics.

Minor compatibility problems may occur in running TRIAGG on some display hardware, or with some older versions of the DOS operating system. The development system was MS-DOS 3.1.

4. SOFTWARE INSTALLATION

This section covers the installation of the necessary executable files to generate a TRIAGG working system on either a dual 5.25" diskette computer or on a computer with a diskette and a hard disk. Information on running the TRIAGG system after it is installed appears in the next section.

In all the instructions that follow, italics are used to indicate a part of a command which must be replaced with a phrase that fits your application.

4.1 Installation for a Diskette System

To install a TRIAGG system on a PC with two 5.25" diskette drives:

Format a new diskette. Use the standard form of the FORMAT command which includes the DOS operating system on the new diskette. For help in doing this, refer to the MS-DOS or PC-DOS manual for your machine. Label this diskette "TRIAGG SYSTEM DISK."

Install TRIAGG. Insert the new TRIAGG system disk into drive A. Insert the master diskette on which TRIAGG was delivered into drive B. Now run the installation program for two diskettes by typing

```
B:INSTAL2D
```

This command takes care of copying the necessary files onto the new TRIAGG system disk.

Make a backup copy of the system diskette, and keep it in a secure place for recovery of the system in case the working disk is damaged. Refer to the MS-DOS or PC-DOS manual for your machine for help in copying a diskette.

Format another diskette to use as a TRIAGG data disk. As TRIAGG runs, it will generate additional files which will be placed on the same disk with the data. It is not advisable to put the data files on the same disk with the system, as the system disk has limited free space.

Enable graphics. If the computer has graphics capability, arrange to have the system load the DOS-supplied GRAPHICS program so copies of TRIAGG plots can be produced on a dot matrix printer. Use an ASCII text editor (such as EDLIN, Sidekick, or a word processor) to create an AUTOEXEC.BAT file on the TRIAGG system disk, and add the following line to the file:

```
GRAPHICS
```

Or add this line to AUTOEXEC.BAT if such a file already exists.

4.2 Installation for a Hard Disk System

To install a TRIAGG system on a PC with a hard disk and a diskette drive, use the following procedures.

The TRIAGG installation program will create a new directory on the hard disk, named \TRIAGG. In the unlikely case there is already such a directory on the hard disk, the installation may fail. The existing \TRIAGG directory should be eliminated (refer to an MS-DOS or PC-DOS manual) before running the installation procedure.

Insert the master diskette on which TRIAGG was delivered into diskette drive A.

Install TRIAGG. Run the installation program for hard disk systems by typing

```
A:INSTALHD  disk:
```

In place of *disk* substitute the drive letter of the hard disk where TRIAGG is to be installed (one of C, D, E, F), and be sure to include the colon after the drive letter. An example of the install command is

```
A:INSTALHD  C:
```

Modify AUTOEXEC.BAT. Use an ASCII text editor (such as EDLIN, Sidekick, or a word processor) to modify the PATH command in the AUTOEXEC.BAT file in the root directory of the startup disk. At the end of the PATH command, add the text

```
;disk:\TRIAGG
```

where *disk* is the same as in the preceding paragraph. For example, if you are installing to disk C, append to the PATH command the phrase

```
;C:\TRIAGG
```

If the AUTOEXEC.BAT file doesn't have a PATH command in it, add a line at the end of the file which says

```
PATH disk:\TRIAGG
```

An example of this is `PATH C:\TRIAGG`.

If the startup disk doesn't have an AUTOEXEC.BAT file, use an ASCII text editor to create one, and put the above PATH command in it.

If the computer has graphics capability, arrange to have the system load the DOS-supplied GRAPHICS program so copies of TRIAGG plots can be produced on a dot matrix printer. To do this, include the line

```
GRAPHICS
```

in the AUTOEXEC.BAT file.

Execute AUTOEXEC.BAT. To make the changes in AUTOEXEC.BAT take effect before running the TRIAGG system for the first time, enter the command

```
\AUTOEXEC
```

This makes it possible to use TRIAGG immediately. This command only has to be done once. From now on, the modifications in AUTOEXEC.BAT will take effect automatically every time the computer is turned on.

Make a data directory. It is possible to put the data files in the same directory with the system, but it may be preferable to package the data files in a different directory. The data may be kept on a diskette instead of the hard disk, but this is not as convenient.

To make a new directory for storage of TRIAGG and AGG files, enter the DOS command

```
MKDIR  \dirname
```

where *dirname* is replaced by any name chosen for the new directory, 8 or fewer characters in length.

5. TRIAGG OPERATION GUIDE

Before running TRIAGG, it must be correctly installed on the computer. If this has not been done, complete the installation procedure described in section 4. After installation is complete, proceed with the operation of the system, described below.

When TRIAGG generates its output file, the current time and date are included at the top of the output page. Time and date are taken from the computer's internal clock calendar. If the computer does not have a continuous clock with a battery backup feature, you will have to type the time and date every time the system is started up. If this entry is bypassed, the time and date printed by TRIAGG will be meaningless.

In most respects, operation of TRIAGG is the same whether a dual diskette system or a hard disk computer is used. There are a few differences in the ways these two installations are started; both cases are covered separately below.

5.1 Starting TRIAGG - Diskette Computers

Insert disks. Put the TRIAGG system disk in drive A and a formatted data disk in drive B.

Start the program. After the DOS prompt A>, type

```
TRIAGG
```

Enter data file name. When TRIAGG asks for a data file name, type a name of the form

```
B:datafile.DAT
```

where B: is the data disk drive designator, and *datafile* is replaced by the name chosen for your own file. An example of a file name is B:FILE5.DAT. The data file name must be 8 or fewer letters or digits, not counting the .DAT suffix. The .DAT is not required as part of the name, but it is recommended. Other suffixes are possible, but you must avoid the suffixes .TRL, .AGG, and .AGL as TRIAGG uses these for its own output files.

5.2 Starting TRIAGG - Hard Disk Computers

Log into the directory on the hard disk where data files are to be kept, or stay in the root directory if you prefer.

Start the program. After the DOS prompt, type

```
TRIAGG
```

Enter data file name. When TRIAGG asks for a data file name, type a name of the form

datafile.DAT

where *datafile* is replaced by the name of your own file. An example of a data file name is SOUTH.DAT. The data file name must be 8 or fewer letters or digits. The suffix .DAT is not required, but it is recommended. Other suffixes are possible, but you must avoid the suffixes .TRL, .AGG, and .AGL as TRIAGG uses these for its own output files.

The file name may include a directory path prefix if needed, for example \MYDATA\TESTRUN.DAT.

The data file will be used by the TRIAGG editor to store the parameters entered for the components to be assessed. Then the TRIAGG assessor will read the file to make the assessment. The data file will be left in the file directory for later editing and rerun.

5.3 Operation of TRIAGG - Both Diskette and Hard Disk Computers

After TRIAGG is loaded and it has attached a data file, both diskette and hard disk systems work the same. A diskette system will work a bit slower.

If the named file does not already exist, TRIAGG will ask if you want to create a new file with that name. Press key Y or N; no carriage return is needed for this entry. The N response is provided as an escape in case you really wanted an existing file but typed its name incorrectly. TRIAGG will load the data entry module so you can proceed to enter new data.

The first data entry screen will appear. It includes a bar at the top of the screen with the name of the file being edited, and a bar at the bottom showing a menu of the control keys: the arrow keys, the RETURN and TAB keys, PgUp and PgDn. The details of working with the data input editor are described below.

If the named file is an old one, then TRIAGG gives the options of editing the file or sending the file directly to the TRIAGG assessment module. The details of this are given later.

5.4 Operation of the TRIAGG Data entry Editor - New Files

TRIAGG has a random access data entry module. The program accepts keyboard entry of input data parameters through a series of several display screens. Each screen contains cells for entry of a group of parameters.

Screen control keys. By using the cursor keypad and other control keys you can browse randomly through the cells on the visible screen, and through the adjacent screens, until you come to the cell where you want to enter or edit data. These are the control keys:

Up arrow key	This key jumps the cursor to the next line above the current line. But if the cursor is already on the first line of the screen, there is no effect. The up arrow key will not move off the first component screen; use the PgUp key in that case.
Down arrow key	This key jumps the cursor to the next line below the current line. But if the cursor is already on the last line of the screen, there is no effect. The down arrow key will not move off screen 1; use the PgDn key in that case.
Right arrow key	This key jumps the cursor to the next cell to the right of the current cell, if there is one. If the cursor is already on the last cell on the current line, the cursor jumps to the first cell on the next line below. If the cursor is already on the last cell of the screen, there is no effect.
Left arrow key	This key jumps the cursor to the next cell to the left of the current cell, if there is one. If the cursor is already on the leftmost cell of the current line, there is no effect.
RETURN key TAB key	These two have the same effect as the right arrow key.
PgUp key	This key jumps to the previous screen. If the cursor is already on screen 1, TRIAGG will advise "No previous screen."
PgDn key	This key jumps to the next screen. If the cursor is already on the last data screen (the one containing component number 992), TRIAGG will advise "No following screen."
ESC key	This key can be pressed at any time to escape from the data entry function. TRIAGG then gives the options of sending the data to the assessment module, to return for more editing on the data, or to quit.

You can step sequentially through the cells on a screen by striking the RETURN key after entering each value. The right arrow key and the TAB key have the same function as RETURN.

For a new file, TRIAGG will display empty cells, except for the dependency parameter (on screen 1) which is tentatively preset to 0.0. You can step through the cells and substitute actual values for your application.

The size of each cell limits the amount of space available for that entry. If a cell is completely filled with characters, the editor will jump to the next cell.

Correcting errors. TRIAGG checks for errors as values are entered. If a cell has an error in it, TRIAGG displays an error message on the screen and waits for the operator to retype correctly.

If there is a typing error in the current cell, you can backspace over the incorrect characters and then retype. Once the cursor is moved off a cell, you can return to it and make a correction, but then the entire cell must be retyped.

Numeric entries. If the parameter is a number, it can be entered either in fixed point notation (as in 3.1416) or in floating point scientific notation (as in 2.386E+3, which means 2.386×10^3). A number in scientific notation must have at least one digit ahead of the E, otherwise TRIAGG will assume it is zero. Numbers may have an algebraic sign prefix (+ or -). Integers or whole numbers are acceptable for any numeric cell. Numbers are never written with commas or any other punctuation except for a sign prefix or a decimal point.

5.4.1 Screen 1.

This has cells for 4 parameters:

Project name	This allows documenting program output by including a main title for the entire project (60 characters).
Assessment name	This is a subtitle for giving a name to this individual assessment within the project (35 characters).
Units	This defines the units in which the parameters of each component are expressed (20 characters).
Dependency	This defines the degree of dependency between the components: a decimal fraction between 0 (independent) and 1 (perfect positive correlation), inclusive (10 characters). A dependency which is out of range will cause an error message.

5.4.2 Other screens.

These contain cells for recording parameters of as many as 992 components. Each component has 4 cells: the name of the component (35 characters), and numeric entries for minimum, mode, and maximum values of the component (10 characters each).

Component lines. The lines of data for entry of components on screens 2 and following consist of a component name (cell 1) and the parameters for that component (cells 2, 3, 4). The editor does not allow an incomplete line: if a component name is entered in an empty cell, the system will supply tentative values (all zeros) for the parameters. You can then advance to the parameter cells and substitute other values. And if the component name cell is empty, the editor prevents an attempt to enter numbers in the parameter cells.

If any components are entered with blank lines between them, the program will move the nonblank lines into consecutive locations when the editing is done and the file is written out into the directory.

Parameter entries. The Min/Mode/Max parameters in the component lines on screens 2 and following must be in nondecreasing order. If they are not, an error message is given. Due to the computer's magnitude limits on real numbers, no parameter may exceed 1.0E18 (10 to the power 18) in absolute value.

Graphic display. While the cursor is positioned on any component, keying CTRL-G will bring up a graphic display showing the shape of the triangular distribution of that component. The CTRL-G command is given by holding down on the CTRL key while striking the G key. See Figure 1 for an example of a plot. The labels on the x-axis correspond to the minimum value, mode value, and maximum value of the resource respectively, with the mode value displayed on a line below the other two to avoid collision in case the mode is close to one of the end points.

If the computer has no CGA compatible graphics adapter, TRIAGG will give an error message at the CTRL-G command.

While the plot is on the screen, you can print out a copy of it by keying SHIFT-PrtScr on the keyboard; hold down on the SHIFT key while striking the PrtScrn (or PrintScrn) key. Only a graphics-compatible dot matrix printer is able to copy the graphic image. Press any key to escape from the graph and return to data entry mode. If the GRAPHICS program has not been loaded prior to running TRIAGG, this SHIFT-PrtScrn command will not work correctly. See sections 4.1 and 4.2 above.

When you have entered all the data on the input screens, press the ESC key. TRIAGG will show the DO WHAT menu:

Do what with this file?

E Return to editing
S Send the file to the assessment program
X Exit and save file
Q Quit without saving.

Press the letter key corresponding to the action wanted. Either upper or lower case letters are accepted, and no carriage return is needed.

The **E** command causes TRIAGG to go back to the data entry module for further review and editing. This is the same as editing an old file, and this process is described in the next section.

The **S** command causes TRIAGG to save the file in the directory, then send the data directly to the assessment module. TRIAGG then terminates. Only the new version of the file is kept, and it replaces the old version, if any.

The **X** command causes TRIAGG to save the data file in the directory and then quit. Assessment of the data is not done. Only the new version of the file is kept, and it replaces the old version, if any.

The **Q** command causes the system to terminate without saving the newly created (or edited) file; this option is used if you realize the current edits are useless and you don't want to save this version of the data.

5.5 Operation of the TRIAGG Data entry Editor - Old Files

If the name of an already existing TRIAGG data file is entered when TRIAGG asks for it, the system will show a DO WHAT menu similar to the one in the paragraph above. If the file needs to be edited before sending it on to the TRIAGG assessment program, press the E key.

Editing existing cells. TRIAGG will display the data entry screens as before, but now showing the cells already filled with the parameters in the existing file. If the existing values for any screen are correct, press PgUp or PgDn to review the other screens. If the content of a cell needs to be changed, move the cursor to that cell and type the new entry to replace the old.

Deleting a component. To erase an existing component, move to the screen displaying the component, move the cursor to the component name to be deleted, and press the space bar. The component name will be erased, and when the cursor moves away from that line or ESC is used to escape from the editor, all the other entries for the line will vanish.

There is no way to move a component to a different line of the screen, other than by deleting it as shown above and retyping it elsewhere.

When the edited file is correct, press the ESC key to return to the DO WHAT menu.

5.6 Computing the TRIAGG Assessment

The DO WHAT menu gives the option of sending the current data file to the TRIAGG assessment module. To do this, press the S key. The TRIAGG assessor will read the input data file, perform the assessment and aggregation of components, and produce two output files: (1) a listing which summarizes the input data and displays output estimates in terms of mean, standard deviation, and fractiles of components and their aggregate; and (2) a file of parameters which can be fed into the assessment aggregator program AGG to combine estimates of several assessments after they are processed by TRIAGG.

The summary listing file is named by TRIAGG to agree with the data file name, with the file name suffix replaced by .TRL. The .TRL suffix is intended to suggest "TRIAGG List". The summary file will show the current time and date, obtained from the computer system either through its clock calendar adapter (if it has one) or through manual entry when the computer was first turned on.

The aggregation data file is named by TRIAGG to agree with the data file name, with the suffix replaced by .AGG. For example, if the original data file name is TEST.DAT, then TRIAGG generates new files with names TEST.TRL and TEST.AGG.

Now TRIAGG will run its assessment. The running time varies with the speed of the host computer and the number of components in the data file; most runs will finish within a few seconds. The program displays a histogram bar showing the progress of the

calculation. When TRIAGG is finished, it will return to DOS. The .TRL and .AGG output files, as well as the source data file, are kept in the file directory.

5.7 Printing the TRIAGG Output

If the printer normally prints less than 132 columns across the page, it must be reset manually, or by a mode-setting utility program, to print 132 columns. Scroll the paper in the printer until the print head is positioned about 3 lines below the tear-off perforations.

Now enter the standard DOS command:

```
PRINT  testdata.TRL
```

where *testdata* is replaced by whatever name was given to the data file when it was originally created through the TRIAGG editor. Examples of this command are

```
PRINT TEST3.TRL    and    PRINT B:WESTERN.TRL
```

The output file is printed on one or more pages.

The other file output by TRIAGG, the one with the .AGG suffix, is also printable; but it is formatted to be read by the AGG program, not for human readability.

6. AGG OPERATION GUIDE

AGG is a program which combines the assessments from two or more previous runs of TRIAGG. AGG will aggregate the assessments and produce two new output files: (1) a summary listing file showing input values and output estimates; and (2) another .AGG file which can later participate in a higher level aggregation. Thus the inputs to AGG are the output files (those having the suffix .AGG) created during prior runs of either TRIAGG or AGG.

To run AGG, type the command

```
AGG
```

6.1 Operation of the AGG Data Entry Editor - New Files

AGG has the same data entry module as TRIAGG except for a few details. Each screen contains cells for entry of a group of inputs, including the names of assessment aggregation files for up to 992 prior runs of TRIAGG or AGG.

The data file created through the AGG data entry module does not contain raw resource data; it is just a list of other files containing assessment component data to be aggregated. It is called a "script" file. When AGG requests a script file name, enter a chosen name for the file to contain the data to drive this aggregation. The prefix name of this script file should be chosen not to conflict with any other files in the same directory. The file type suffix .SCR is recommended, to distinguish an AGG script file from a TRIAGG input file (which may have a .DAT file type suffix).

Component lines. The lines of data for entry of assessment components on screens 2 and following consist of the names of aggregation files produced during prior runs of TRIAGG (or of AGG). As these are entered, AGG checks them to be sure they are valid aggregation data files. If they are not, an error is generated.

6.2 Operation of the AGG Data entry Editor - Old Files

This is nearly identical to the operation of the TRIAGG editor. The following operation is slightly different, since each line has only one cell:

Deleting a component. To erase an existing assessment component file name in screens 2 and following, move to the screen displaying the component, move the cursor to the component file name to be deleted, and press the space bar.

When the edited script file is correct, press the ESC key to return to the DO WHAT menu.

6.3 Computing the AGG Assessment

The DO WHAT menu gives the option of sending the current script file to the AGG aggregation module. To do this, press the S key. The aggregator will read the script file, open all the assessment aggregation files listed in the script, perform the aggregation of assessments, and produce two output files: (1) a listing which summarizes the content of the input files and displays output estimates in terms of mean, standard deviation, and fractiles of their aggregate; and (2) another file of parameters which can participate in further aggregations.

The summary listing file is named by AGG to agree with the script file name, but having the file name suffix .AGL. The .AGL suffix is intended to suggest "AGG List". The aggregation data file is named by AGG to agree with the script file name, but with the suffix .AGG. Thus if the script file name is TOTAL.SCR, then AGG will produce two new files named TOTAL.AGL and TOTAL.AGG.

Now AGG will compute the aggregation. The program displays a histogram bar showing the progress of the calculation. When AGG is finished, it will return to DOS. The .AGL and new .AGG output files, as well as the script file, are kept in the file directory. All the aggregation input files which participated in the aggregation are left intact.

6.4 Printing the AGG Output

As with TRIAGG, if the printer normally prints less than 132 columns across the page, you will have to set it manually, or use a mode-setting utility program, to print 132 columns. Scroll the paper in the printer until the print head is positioned about 3 lines below the tear-off perforations.

Enter the DOS command:

```
PRINT  script.AGL
```

where *script* is replaced by whatever prefix name was given to the script file when it was originally created through the AGG editor.

7. SELECTED REFERENCES

Crovelli, R. A., 1987, Probability theory versus simulation of petroleum potential in play analysis, *in* Albin, S. L., and Harris, C. M., eds., Statistical and computational issues in probability modeling, Part 1: Annals of Operations Research, v. 8, p. 363-381.

Crovelli, R. A., and Balay, R. H., 1986, FASP, an analytic resource appraisal program for petroleum play analysis: Computers and Geosciences, v. 12, no. 4B, p. 423-475.

Crovelli, R.A., and Balay, R.H., 1987, FASPUM Metric Version--Analytic petroleum resource appraisal microcomputer programs for play analysis using a reservoir-engineering model: U.S. Geological Survey Open-File Report 87-414A, 14 p. [U.S. Geological Survey Open-File Report 87-414B, 5.25" diskette.]

Crovelli, R.A., and Balay, R.H., 1988, A microcomputer program for oil and gas resource assessment: COGS Computer Contributions, v. 4, no. 3, p. 108-122.

Crovelli, R.A., and Balay, R.H., 1989, FASPUE English Version--Analytic petroleum resource appraisal microcomputer programs for play analysis using a reservoir-engineering model: U.S. Geological Survey Open-File Report 89-1-A, 17 p. [U.S. Geological Survey Open-File Report 89-1-B, 5.25" diskette.]

Potential Gas Agency, Colorado School of Mines, 1989, Potential Supply of Natural Gas in the United States (December 31, 1988) -- Report of the Potential Gas Committee: 160 p.