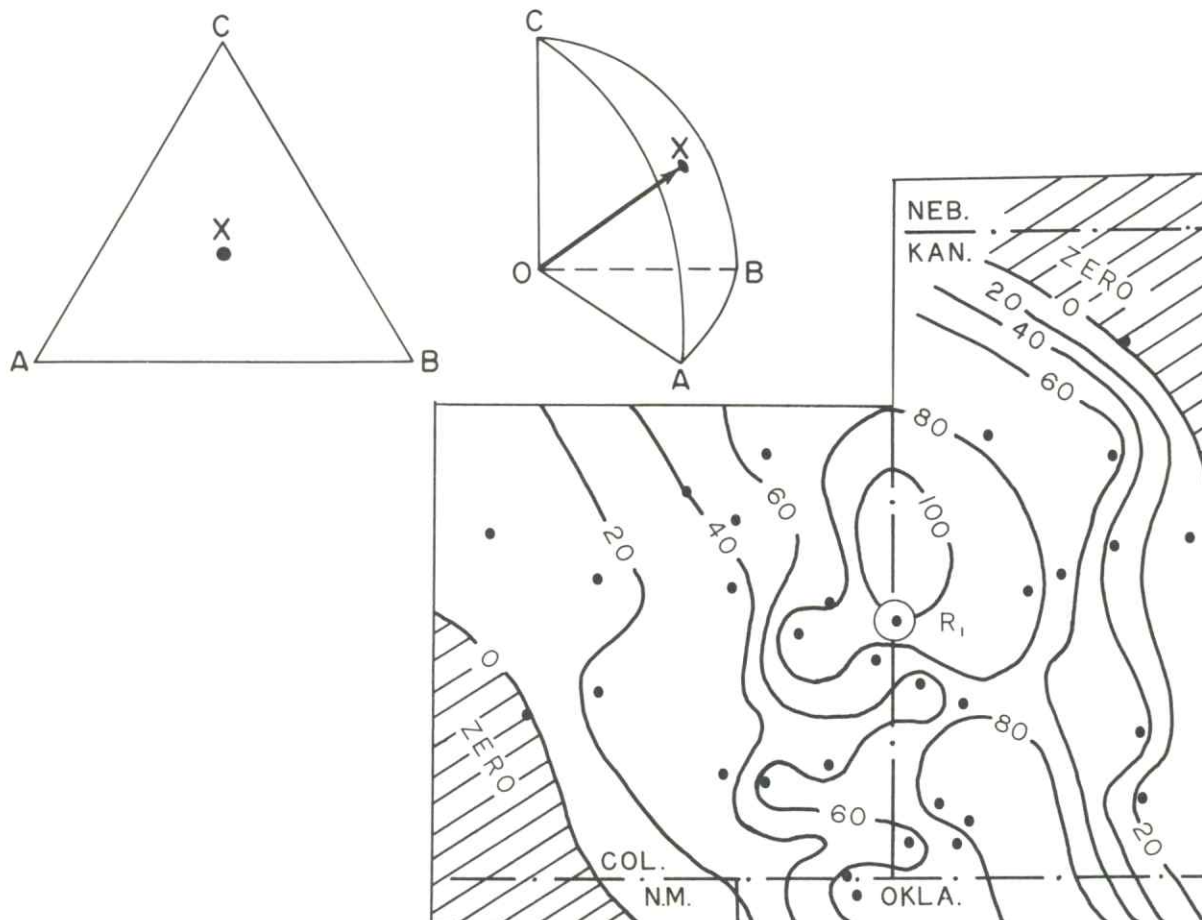


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Fortran Program For Factor and Vector Analysis of Geologic Data Using an IBM 7090 or 7094/1401 Computer System



SPECIAL DISTRIBUTION PUBLICATION 13



State Geological Survey
The University of Kansas, Lawrence, Kansas
1964

By
Vincent Manson
Columbia University
and
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Columbia University

KANSAS GEOLOGICAL SURVEY COMPUTER CONTRIBUTIONS

"Under the stimulus of increasing amounts of numerical data and the wide availability of high-speed computers, geologists have begun to look into problems of automatic data processing."

W. C. Krumbein

There is no doubt that the computer age is here -- to stay. We can see around us the many changes taking place as a result of this revolution, emphasizing that the computer is not a gimmick or just another new tool, but a new and fresh approach. These facts are so obvious that it seems trivial to mention them, but as J. N. Weber has noted in an article, "Impact of the digital computer on the geological sciences" (Jour. Geol. Education, v. 12, no. 2, 1964): "It is quite clear from the nature of currently published research that the potential of the digital computer has not yet been realized, and that the enormous impact of this revolutionary device on the nature of geological investigation is still to come."

Weber also notes that geoscience workers have encountered two difficulties in use of computers (1) the difficulty of programming or lack of available programs, and (2) cost of computer operation. The second difficulty now has been largely overcome. With the many commercial and academic installations available, cost of computer time is unbelievably economical. The first difficulty, far from being solved, however, has been recognized by many including W. C. Krumbein who pointed out in a paper, "The computer in geology" (Science, v. 136, no. 3522, 1962): "The problem of assembling a library of computer programs especially adapted to geological data is an important facet of data analysis." In the past two years, several steps have been taken by several organizations to remedy this lack of available programs.

A central clearinghouse (GEOCOMP) has been proposed (see, J. W. Harbaugh, "Computer pool may help geologists": Geotimes, April, 1964) for gathering and disseminating computer programs and information about computer programs applicable to the earth sciences. Anyone or any organization would be invited to voluntarily contribute programs to GEOCOMP, as many useful programs are already operative throughout the country and could be made available.

Prior to establishing a central clearinghouse such as GEOCOMP, however, computer programs, for the most part, are now being distributed on an individual basis between "workers in the field", and are not generally available to the public. The Kansas Geological Survey realized this problem and in 1963 began publishing computer programs of interest and value to earth scientists. Since inception of computer contributions, seven reports have been issued and four more are in various stages of preparation. Available contributions are listed in this publication on a special tearout page (page 47), which can be used as an order blank.

A special editorial procedure was arranged to handle the computer programs rapidly and make them available as fast as possible. A board of editors reviews manuscripts and assists in setting policy in regard to computer applications for the Kansas Geological Survey.

COVAP, the vector-analysis program described by Manson and Imbrie in this Special Distribution Publication, source deck of punched cards will be made available for a limited time for the sum of \$15.00. Geologists should find many uses for this program especially in application to interpretations of map data.

Because the Survey is making every effort to make the computer programs and results as useful as possible, any comments or suggestions are welcomed and should be addressed to the Editor.

The Editor

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FORTRAN PROGRAM FOR FACTOR AND VECTOR
ANALYSIS OF GEOLOGIC DATA USING AN
IBM 7090 or 7094/1401
COMPUTER SYSTEM

by

Vincent Manson and John Imbrie

INTRODUCTION

The finest computer ever designed is the human brain. It takes in fantastically large quantities of information, stores some for future reference, and abstracts meaningful patterns all at a very reasonable cost. Whenever the basic data of a problem are essentially geometrical -- i.e., in the form of shapes or other visual patterns, the brain has no equal as a device for sorting out significant relationships from an initial confusion of complex detail. In many problems in science, however, basic data are large tables of numbers -- and here the human brain is not well designed to absorb the information by simple visual inspection. The primary function of the computer programs presented in this paper is to aid the human brain in abstracting simple, meaningful patterns from large tables of numerical data.

BACKGROUND OF PAPER

The origins of factor analysis go back to the early years of the present century when Charles Spearman (1904) and a school of investigators developed its essential concepts as a tool for psychometric research. Thurstone and a group of American workers added significantly to the theory and practice of factor analysis, notably by increasing its generality (1931), by exposition and improvement (Thurstone, 1947; Holzinger and Harman, 1941), and by developing practical computing techniques (Harman, 1960). Cattell (1952) provides a lucid, less technical account of the basic method, and the reader who desires more background should refer to the last two works cited.

In applying factor analysis to geological problems, Imbrie and Purdy (1962) found that certain modifications were needed to permit direct interpretations of map data. Factor analysis, which is the appropriate term to use in describing theoretical developments up to this point, has as its objective the resolution of observed samples (or variables) into a small number of significant component factors -- defined as theoretical samples (or variables). Imbrie (1963) introduced the term vector analysis to describe an augmented form of factor analysis in which final results are given in terms of actual samples (or variables) judged to be significant end members in the spectrum of diversity under study. The end-member samples (or variables) are termed reference vectors in the mathematical model.

Factor and vector analysis can only be accomplished with the aid of a modern high-speed digital computer. Various programs are available for performing these operations, including those given by Imbrie (1963). In that paper, a complete vector analysis is accomplished by using in sequence two separate programs called COLFAC and VOP. The program given here is known as COVAP (Columbia Vector Analysis Program). It will perform all necessary operations for factor and vector analysis on a single machine pass. Other advantages of COVAP are:

- (1) The limit on the number of variables or cases which can be factored is 100 instead of 70.
- (2) A graphic plot of the varimax factor matrix can be included in the output.
- (3) The output matrices are arranged in tabular form and clearly labeled.
- (4) A code name for each variable and each case is printed on all output tables for easy identification.
- (5) A data matrix transpose option permits R-mode, Q-mode, or R- and Q-mode analyses to be run with a single set of data cards.
- (6) If desired, each variable may be transformed to a percentage of its total range before Q-mode analysis.
- (7) Each column of the varimax matrix is scanned for the highest absolute value, and the set of vectors corresponding to these rows is used as the first estimate of the extreme vectors in the varimax matrix. This estimate is evaluated by computing the corresponding oblique matrix and scanning it for values in excess of unity. If values over one are found, a revised identification of the extreme vectors is made. This process is repeated until a satisfactory oblique solution is achieved.
- (8) The oblique matrix is re-ordered to facilitate inspection.
- (9) The table of eigenvalues includes only positive entries.

PROGRAM HISTORY

COVAP incorporates subroutines written by a number of individuals: 1. The University of California at Los Angeles BIMD 17 program for performing an R-mode factor analysis. This program in turn uses a SHARE routine for finding eigenvalues and eigenvectors, and employs Kaiser's varimax algorithm. 2. The University of Chicago 100 x 100 R-mode factor analysis and plot program by Clarence Bradford and Arthur Gasche. 3. Q-mode and oblique projection subroutines written by Imbrie at the Columbia University Computer Center. 4. System control, transpose, re-order, and transform subroutines written by Manson at the Columbia University Computer Center.

EXPLANATION OF VECTOR ANALYSIS

Data. Observational data are taken to be numerical measurements of n geological variables observed in N cases (localities, samples, specimens, etc). These data are arranged in tabular form with N horizontal rows and n vertical columns. In matrix notation, this is an $N \times n$ matrix (x_{ij}), in which x_{ij} represents the j 'th variable in the i 'th case ($j = 1, 2, 3, \dots, n$; $i = 1, 2, 3, \dots, N$).

Modes of analysis. Vector analysis may be carried out by two distinct but related procedures, called the R- and Q-modes. In the R-mode, attention is focused on n variables, and results follow from inspection of an n x n matrix of relationships (usually taken as product moment correlations) between all pairs of variables. In the Q-mode, attention is focused on N samples, and results follow from inspection of an N x N matrix of relationships between all pairs of samples.

R-mode studies are concerned with the dynamic interaction of variables in a given problem. An example would be an analysis of the relationships among dolomite, evaporite, and permeability as shown by samples taken from various places in a stratigraphic unit. Results would be expressed in the form of mathematical equations. Q-mode studies of the same data would examine lithologic samples, compare them, and plot facies patterns on maps or stratigraphic diagrams.

The program listed in this paper will perform either R-mode or Q-mode studies of any given data. Because Q-mode studies generally provide a more practical approach to the interpretation of geological problems, we have chosen here to outline the theory of vector analysis for the Q-mode only. R-mode studies involve very similar procedures and are fully explained elsewhere (Harman, 1960; Imbrie, 1963, 1964).

The vector model. In applying vector analysis to geological problems, the basic data are first arranged in a table in which rows represent cases (field samples) and columns represent variables (minerals, oxides, elements, etc.). The array of numbers in any row expresses the composition of that sample. Many useful graphic techniques for analyzing and displaying compositional data of this kind have been developed. Given a table of chemical analyses (Na, Ca, Al, Si, and O) of 20 plagioclase feldspars, for example, we can easily derive a more compact and meaningful representation by considering each specimen a mixture of two end-member minerals, albite and anorthite. The geometric model commonly used to display these facts is a set of 20 points spaced proportionally along a line whose ends represent samples of pure albite and anorthite. This establishes a useful classification. In addition, the fact that each sample can be accurately resolved into contributions of exactly two end members is, in itself, a key discovery that points to the existence of important and interesting underlying physico-chemical relationships.

More complex systems can be plotted on a triangular diagram or in a tetrahedron. Note that before we can apply these graphic techniques, however, three questions must be answered: (1) How many end members are needed to account for the compositional variation observed in the system? (2) What is the composition of the end members? and (3) What proportion of each specimen should be attributed to each end member?

As shown in Figure 1, a simple geometric vector model may be substituted for a triangular diagram with no loss of information. Here, each of three mutually orthogonal reference vectors or coordinates (OA, OB, OC) represents a sample having 100 percent of end members A, B, and C. A sample (X) having equal contributions of each end member (X_A , X_B , and X_C) is also shown. In vector terms, X is resolved into components X_A , X_B , and X_C . The right spherical triangle ABC

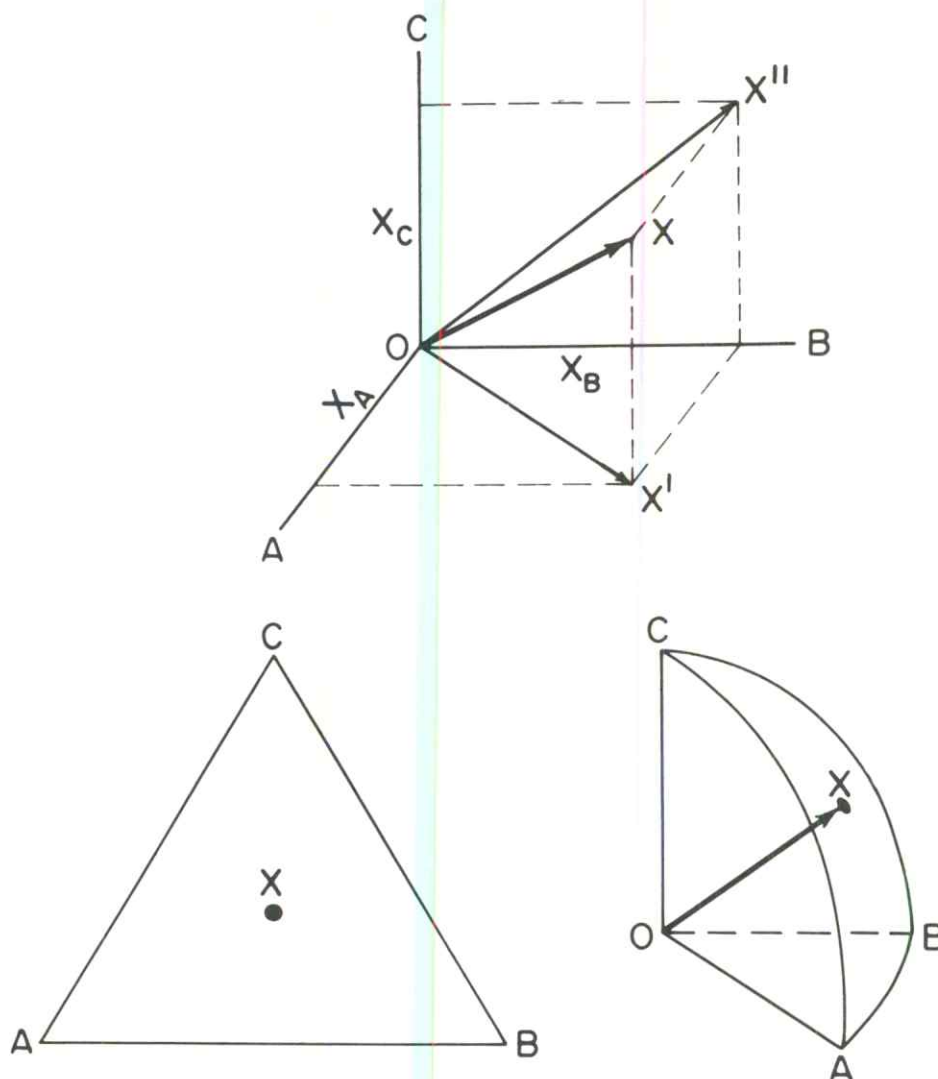


Figure 1.-Relations between triangular diagram and vector model for the analysis of a system with three end members. Vectors A, B, and C constitute a coordinate system within which vector X is fixed.

is the vector analog of the equilateral plane triangle ABC. Note that in the geometric vector model the position of the vector reflects the composition of the sample. Two samples with nearly identical compositions will be represented as two adjacent points or as two vectors with a small angular distance between them. As long as we are dealing with three-component systems, there is, of course, little to be gained by using the vector model. However, to this geometric vector model there corresponds an algebraic vector model that can be extended to any number of end members. The plagioclase diagram (two components), the triangular diagram (three components), and the tetrahedron (four components) are therefore to be considered as special cases of a more

general analytical system. Moreover, by adopting an algebraic vector model we can employ the powerful techniques of vector and matrix algebra. Given a set of raw data from a poorly understood system, these techniques can be used: (1) to treat any number of end members; (2) to employ as end members samples having any desired composition, and (3) to determine by direct calculation the number of end members (m) needed to account for the compositional variation observed, to identify the end members, and to calculate the proportion of each sample attributable to each end member.

In order to accomplish these ends, we need only define the set of ordered numbers in each row of the data table as an algebraic vector. Using appropriate equations, all angular and distance relationships among the vectors can then be defined and calculated. If only three end members are needed, these angles and distances also may be represented geometrically. If more than three end members are required, we can maintain the same algebraic definitions although our geometrical intuition fails.

The characteristic feature of the technique described in this paper is thus the representation of a table of compositional data (N samples, n variables) as a set of N algebraic vectors in an m coordinate system (hopefully, m will be less than n). In the sense that it manipulates empirical data with a view to further understanding, it is a statistical method. An important distinction, however, is that in the present treatment, no formal consideration is given to problems of statistical inference. For additional explanation, see Imbrie and van Andel (1964).

STRATIGRAPHIC EXAMPLE OF VECTOR ANALYSIS

Krumbein (1962) published numerical stratigraphic data compiled by W. T. Fox on 31 wells from southeastern Colorado and western Kansas. The unit selected for analysis is that part of the Permian above the top of the Stone Corral Dolomite. The basic data for the study (Krumbein, 1962, Table VI) are the thickness in feet of each of four lithic components: sand, shale, carbonate, evaporite. Control points for the problems and isoliths of each component are given in Figure 2.

Krumbein and Imbrie (1963) and Imbrie (1963) used these data ("Fox data") to illustrate factor and vector techniques and test various computer programs. The results of Q-mode analysis are shown in Tables 9-20.

(1) 100.0 percent of the information contained in the data can be expressed by a three end-member vector system as shown in Table 11. Total information is here defined as the sum of the squares of all numbers in the data table.

(2) Three wells (2002, 1012, 2034) having the most divergent lithologic composition are identified and used as reference vectors (i.e., end members) on Tables 19 and 20. Their location is indicated by a capital R in Figure 3.

(3) By definition, the reference wells contain 100 percent of the end member corresponding to them. All other wells are analyzed into contributions of these end members in Tables 19 and

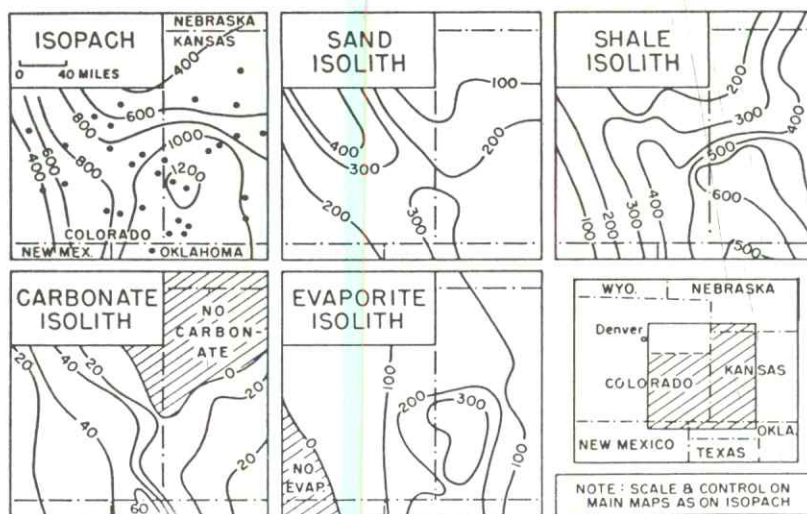


Figure 2.-Isopach and net thickness maps for Permian strata younger than the Stone Corral Dolomite. Scale and control points are the same for all maps. From Krumbein (1962).

20. Contours on the three maps in Figure 3 show areal variation in the composition of the wells in terms of these end members. The well represented by row 2 of the oblique matrix (Table 19), for example, is resolved into contributions of the three reference wells in the proportion .272 : .525 : .257.

Geologic implications of the oblique matrix can be clarified in two ways. First, the actual composition at reference wells can be examined in the data Table and environmental interpretations made. Reference well 1 has the maximum evaporite thickness and the minimum carbonate thickness of any well; total thickness is near the maximum. Conditions probably represented by this well are rapid subsidence in an evaporite basin. Reference well 2 has the minimum thickness, shale content, and evaporite content of any well; it therefore may represent slow deposition of carbonate and silica sands under shelf conditions. Reference well 3 has the minimum sandstone and carbonate thicknesses observed, and is characterized by moderate total thickness, considerable shale, and some evaporite. It represents offshore deposition of fine detritals in an evaporitic basin.

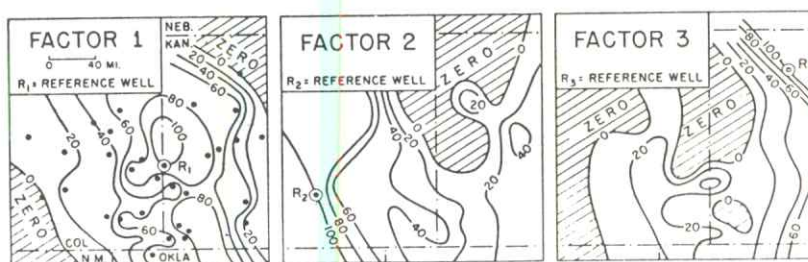


Figure 3.-Factor-vector maps of same unit described in Figure 2. Each map shows lithologic variations in terms of compositions at the reference-well indicated by R. From Krumbein and Imbrie (1963)

After examining the raw data, a map of each variable was contoured, showing geographic variations in the quantitative importance of conditions represented by each reference well (Fig. 3). Each map represents one column of Table 19. Note that reference wells 2 and 3 lie at the southwestern and northeastern extremities of the map, and that reference well 1 lies in the center. The map patterns specify essential characteristics of every locality.

It is interesting to compare these maps with isopach and net thickness maps of the same data (Fig. 2). Although in general the two sets of maps are different, relationships between them can be discerned. For example, the factor-vector map of reference well 1 is clearly a mixture of patterns contained in the isopach and evaporite maps. Factor maps have the merit of recording the maximum information with the minimum number of maps. They may also be valuable because they express features of the data that are not discovered in plotting components individually. They should be viewed as useful supplements to other kinds of maps which display specific and important information on one or two components.

MACHINE OUTPUT FOR STRATIGRAPHIC EXAMPLE

Appendix II is a print-out of the actual card input used in the analysis of the Fox data. The program was set in this case to perform both an R- and Q-mode analysis of the data (see the instructions for program operation given below). Tables 1-20 are the resultant output.

Tables 1-8 are the R-mode output of the problem. For discussion of these results, see Imbrie (1963).

Tables 9-20 are the output of the Q-mode.

Table 9 gives the code number, code name, and various common statistics calculated from the data given for each of the 31 wells.

Table 10 reproduces part of the $\cos \theta$ matrix showing for each pair of wells the cosine of the angle between the vectors. This number is the coefficient of proportional similarity and ranges from zero for two samples having nothing in common to unity for two samples with identical proportional composition.

Table 11 shows how much of the total information on the 31 wells can be retained if successively more end members are postulated. Three end members retain 100.0 percent of the compositional information contained in the data.

Table 12 is the principal components factor matrix. For details, see Harman (1960).

Table 13 is the varimax matrix, i.e., a table showing for each sample its proportional composition in terms of three theoretical end members each having nothing in common with the others (mutually orthogonal vectors). The theoretical reference vectors in this orthogonal scheme are selected to fit the data best in a least-squares sense.

Tables 17-18 are intermediate output recording the programmed search and identification of the three most extreme vectors in the varimax configuration.

Table 19 is the oblique projection matrix in which each row records the proportional composition at a well in terms of three reference vectors (actual wells). The code number and name

TABLE 1
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

VARIABLE NO. NAME	MEAN	ST DEV	SKEW	KURTOSIS
1 TOTAL	860.581	254.192	-0.352	-1.163
2 SAND	247.323	85.566	-0.250	0.855
3 SHALE	428.839	164.121	-0.218	-0.479
4 NONCLA	184.419	104.124	0.295	-1.114
5 CARB	21.645	16.572	1.077*	1.208
6 EVAP	162.774	104.469	0.394	-0.895

SE - SKEW = 0.421
SE - KURTOSIS = 0.821

* SIGNIFICANT AT .05 LEVEL
** SIGNIFICANT AT .01 LEVEL

TABLE 2
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM
MATRIX TO BE FACTORED

VARIABLE NO. NAME	1	2	3	4	5	6
1 TOTAL	1.000					
2 SAND	0.243	1.000				
3 SHALE	0.887	-0.123	1.000			
4 NONCLA	0.844	-0.035	0.690	1.000		
5 CARB	0.145	0.461	-0.053	0.059	1.000	
6 EVAP	0.818	-0.108	0.696	0.987	-0.100	1.000

TABLE 3
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM
TABLE OF POSITIVE EIGENVALUES

NO.	EIGENVALUE	PERCENT OF COMMUNALITY OVER			
		ALL (6) FACTORS		4 ROTATED FACTORS	
1	3.465	57.8	57.8	57.8	57.8
2	1.540	25.7	83.4	25.7	83.4
3	0.560	9.3	92.7	9.3	92.7
4	0.435	7.3	100.0	7.3	100.0
5	0.000	0.0			

TRACE OF ORIGINAL MATRIX 6.000
COMMUNALITY OVER 6 FACTORS = 6.000
4 FACTORS = 6.000

TABLE 4
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

UNROTATED FACTOR MATRIX				
FACTOR NUMBER	1	2	3	4
SUM SQUARES DOWN COLUMNS	3.465	1.540	0.560	0.435

(continued page 9)

VARIABLE COMMUNALITY
NO. NAME 4 FACTORS

1	TOTAL	1.000	0.954	0.222	-0.127	0.159
2	SAND	1.000	-0.000	0.870	-0.488	-0.075
3	SHALE	1.000	0.875	-0.105	-0.008	0.473
4	NONCLA	1.000	0.949	-0.007	0.104	-0.296
5	CARB	1.000	0.022	0.839	0.542	0.043
6	EVAP	1.000	0.943	-0.140	0.018	-0.302

TABLE 5

R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

ROTATED FACTOR MATRIX

		FACTOR NUMBER	1	2	3	4
SUM SQUARES DOWN COLUMNS			2.343	1.074	1.023	1.560

VARIABLE COMMUNALITY
NO. NAME 4 FACTORS

1	TOTAL	1.000	0.642	0.248	0.086	0.720
2	SAND	1.000	-0.027	0.970	0.240	-0.003
3	SHALE	1.000	0.412	-0.105	-0.033	0.905
4	NONCLA	1.000	0.940	-0.025	0.066	0.335
5	CARB	1.000	-0.001	0.235	0.972	0.005
6	EVAP	1.000	0.937	-0.062	-0.089	0.333

TABLE 6

R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

V MATRIX

NAME	INDEX	4	2	5	3
NONCLA	4	0.9397	-0.0252	0.0655	0.3348
SAND	2	-0.0265	0.9703	0.2403	-0.0027
CARB	5	-0.0007	0.2348	0.9720	0.0047
SHALE	3	0.4119	-0.1051	-0.0333	0.9046

INVERSE OF V MATRIX

1.2701	0.0072	-0.1035	-0.4696
0.0343	1.0969	-0.2738	-0.0080
-0.0046	-0.2655	1.0946	-0.0047
-0.5745	0.1144	0.0556	1.3182

TABLE 7

R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

OBLIQUE PROJECTION PROGRAM

OBLIQUE AXES

NAME	INDEX	4	2	5	3
TOTAL	1	0.410	0.337	0.000	0.646

(continued page 10)

SAND	2	0.000	1.000	0.000	0.000
SHALE	3	0.000	0.000	0.000	1.000
NONCLA	4	1.000	0.000	0.000	0.000
CARB	5	0.000	0.000	1.000	0.000
EVAP	6	0.997	0.000	-0.158	0.000

TABLE 8

R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

REORDERED OBLIQUE PROJECTION MATRIX

NAME		NONCLA	SAND	CARB	SHALE
INDEX		4	2	5	3
NONCLA	4	1.000	0.000	0.000	0.000
EVAP	6	0.997	0.000	-0.158	0.000
SAND	2	0.000	1.000	0.000	0.000
CARB	5	0.000	0.000	1.000	0.000
SHALE	3	0.000	0.000	0.000	1.000
TOTAL	1	0.410	0.337	0.000	0.646

TABLE 9

R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

CASE NO.	NAME	MEAN	SUM SQ	SQ RT	SUM SQ	SKEW	KURTOSIS
1	1001	319.833	1002323.000	1001.161		1.614	3.484*
2	1004	324.833	1149327.000	1072.067		1.421	1.903
3	1006	295.000	1022546.000	1011.210		1.202	0.866
4	1007	155.333	301378.000	548.979		1.117	-0.192
5	1009	367.500	1401699.000	1183.934		1.485	2.658
6	1010	348.167	1219873.000	1104.479		1.599	2.909
7	1012	128.667	210728.000	459.051		1.057	-0.199
8	1014	218.500	539843.000	734.740		1.294	0.758
9	1015	232.000	574536.000	757.982		1.430	2.189
10	1017	219.167	527839.000	726.525		1.382	1.860
11	1019	349.167	1171633.000	1082.420		1.719*	3.833*
12	1020	432.500	1931909.000	1389.931		1.250	1.352
13	1021	254.667	689376.000	830.287		1.488	2.172
14	1023	174.333	308924.000	555.809		1.479	2.187
15	2002	434.333	1878748.000	1370.674		1.159	1.862
16	2003	451.167	2244295.000	1498.097		1.216	0.602
17	2004	454.167	2093283.000	1446.818		1.383	2.293
18	2005	433.667	1865180.000	1365.716		1.475	3.002
19	2006	378.667	1547464.000	1243.971		1.382	2.011
20	2008	449.500	2070323.000	1438.862		1.072	1.035
21	2009	373.833	1453215.000	1205.494		1.392	1.830
22	2011	255.667	747290.000	864.459		1.260	1.039
23	2012	270.833	886501.000	941.542		1.167	0.238
24	2015	378.833	1480089.000	1216.589		1.468	2.463
25	2016	428.000	1791784.000	1338.575		1.474	2.778
26	2017	349.333	1296734.000	1138.742		1.422	1.893
27	2019	200.167	401855.000	633.920		1.447	2.993
28	2021	208.333	461852.000	679.597		1.285	1.434
29	2031	351.167	1506629.000	1227.448		1.137	0.068
30	2034	183.167	497363.000	705.240		0.988	-1.664
31	8001	425.000	1798468.000	1341.070		1.599	2.668

SE - SKEW = 0.845
SE - KURTOSIS = 1.741

* SIGNIFICANT AT .05 LEVEL
** SIGNIFICANT AT .01 LEVEL

TABLE 10

R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

MATRIX TO BE FACTORED

CASE NO. NAME	1	2	3	4	5	6	7	8	9	10	11	12
1 1001	1.000											
2 1004	0.983	1.000										
3 1006	0.958	0.985	1.000									
4 1007	0.929	0.954	0.991	1.000								
5 1009	0.996	0.994	0.974	0.945	1.000							
6 1010	0.998	0.991	0.962	0.927	0.998	1.000						
7 1012	0.924	0.959	0.993	0.998	0.943	0.925	1.000					
8 1014	0.952	0.962	0.990	0.996	0.961	0.946	0.990	1.000				
9 1015	0.992	0.997	0.978	0.947	0.999	0.997	0.947	0.959	1.000			
10 1017	0.982	0.999	0.992	0.968	0.994	0.988	0.970	0.974	0.996	1.000		
11 1019	0.999	0.980	0.958	0.931	0.994	0.996	0.925	0.955	0.989	0.980	1.000	
12 1020	0.984	0.965	0.911	0.860	0.979	0.988	0.858	0.887	0.977	0.956	0.980	1.000

CASE NO. NAME	1	2	3	4	5	6	7	8	9	10	11	12
13 1021	0.989	0.999	0.977	0.944	0.997	0.996	0.947	0.955	0.999	0.996	0.987	0.976
14 1023	0.993	0.982	0.940	0.896	0.991	0.997	0.895	0.918	0.990	0.975	0.990	0.997
15 2002	0.985	0.951	0.899	0.853	0.974	0.984	0.847	0.886	0.968	0.945	0.983	0.996
16 2003	0.977	0.972	0.920	0.866	0.979	0.986	0.869	0.886	0.981	0.963	0.971	0.996
17 2004	0.994	0.977	0.936	0.894	0.991	0.996	0.891	0.919	0.988	0.972	0.991	0.997
18 2005	0.998	0.978	0.945	0.910	0.994	0.997	0.905	0.935	0.990	0.976	0.997	0.992
19 2006	0.991	0.997	0.976	0.944	0.999	0.996	0.945	0.956	1.000	0.996	0.988	0.978
20 2008	0.976	0.947	0.886	0.833	0.967	0.979	0.829	0.865	0.963	0.937	0.973	0.998
21 2009	0.991	0.982	0.939	0.894	0.991	0.996	0.894	0.916	0.990	0.975	0.987	0.997
22 2011	0.980	0.996	0.969	0.930	0.992	0.990	0.935	0.939	0.996	0.992	0.975	0.976
23 2012	0.964	0.990	0.958	0.912	0.980	0.979	0.922	0.917	0.987	0.983	0.957	0.969
24 2015	0.996	0.990	0.959	0.922	0.998	0.999	0.921	0.941	0.997	0.987	0.993	0.990

TABLE 11
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

TABLE OF POSITIVE EIGENVALUES

NO.	EIGENVALUE	PERCENT OF COMMUNALITY OVER			
		ALL (31) FACTORS		3 ROTATED FACTORS	
1	30.069	97.0	97.0	97.0	97.0
2	0.682	2.2	99.2	2.2	99.2
3	0.240	0.8	100.0	0.8	100.0
4	0.009	0.0	100.0		
5	0.000	0.0			
6	0.000	0.0			
7	0.000	0.0			
8	0.000	0.0			
9	0.000	0.0			
10	0.000	0.0			
11	0.000	0.0			
12	0.000	0.0			

TRACE OF ORIGINAL MATRIX 31.000
COMMUNALITY OVER 31 FACTORS = 31.000
 3 FACTORS = 30.991

TABLE 12
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

UNROTATED FACTOR MATRIX

		FACTOR NUMBER		
SUM SQUARES DOWN COLUMNS		1	2	3
		30.069	0.682	0.240
CASE NO.	NAME	COMMUNALITY 3 FACTORS		
1	1001	1.000	0.995	0.005
2	1004	0.999	0.994	0.083
3	1006	1.000	0.967	0.251
4	1007	0.999	0.931	0.363
5	1009	1.000	0.999	0.040
6	1010	1.000	0.999	-0.010
7	1012	1.000	0.931	0.361
8	1014	1.000	0.947	0.310
9	1015	1.000	0.999	0.045
10	1017	1.000	0.991	0.123
11	1019	1.000	0.992	0.018
12	1020	1.000	0.986	-0.162
13	1021	0.999	0.998	0.042
14	1023	1.000	0.996	-0.087
15	2002	1.000	0.979	-0.164
16	2003	1.000	0.988	-0.148
17	2004	1.000	0.994	-0.090
18	2005	1.000	0.995	-0.047
19	2006	1.000	0.999	0.037
20	2008	1.000	0.975	-0.209
21	2009	1.000	0.996	-0.092
22	2011	1.000	0.995	0.011
23	2012	1.000	0.986	-0.013
24	2015	1.000	0.999	-0.024
25	2016	1.000	0.990	-0.095
26	2017	1.000	0.999	-0.030
27	2019	0.999	0.996	-0.024
28	2021	1.000	0.994	-0.107
29	2031	1.000	0.986	-0.040
30	2034	1.000	0.932	-0.240
31	8001	0.998	0.996	-0.065

TABLE 13

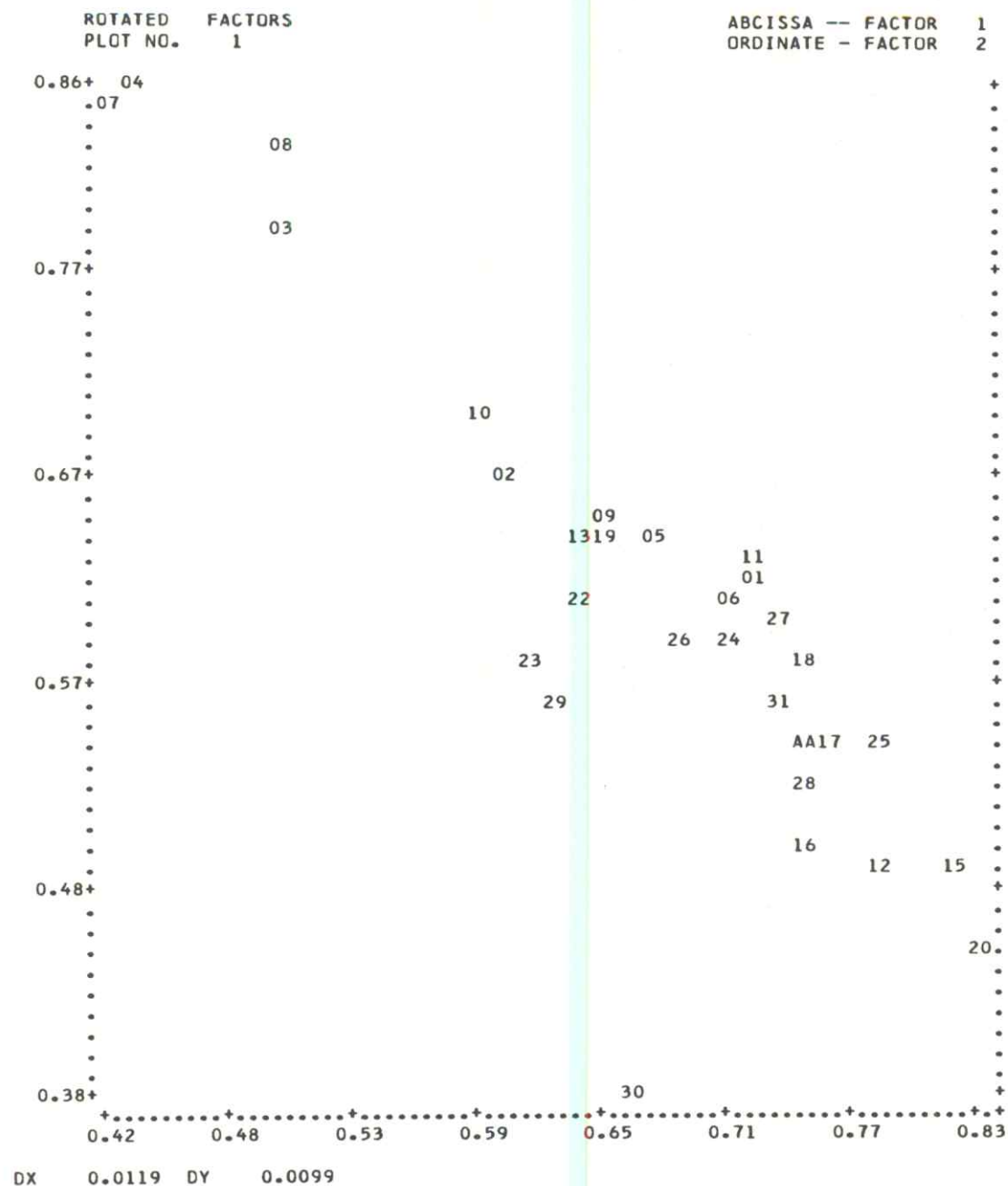
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

ROTATED FACTOR MATRIX

		FACTOR NUMBER	1	2	3
SUM SQUARES DOWN COLUMNS			14.768	12.040	4.183
CASE NO.	NAME	COMMUNALITY 3 FACTORS			
1	1001	1.000	0.731	0.628	0.267
2	1004	0.999	0.616	0.679	0.398
3	1006	1.000	0.504	0.794	0.339
4	1007	0.999	0.437	0.863	0.252
5	1009	1.000	0.681	0.654	0.331
6	1010	1.000	0.715	0.615	0.330
7	1012	1.000	0.416	0.858	0.301
8	1014	1.000	0.509	0.836	0.205
9	1015	1.000	0.660	0.655	0.367
10	1017	1.000	0.598	0.710	0.371
11	1019	1.000	0.730	0.638	0.243
12	1020	1.000	0.794	0.489	0.361
13	1021	0.999	0.653	0.651	0.386
14	1023	1.000	0.753	0.553	0.357
15	2002	1.000	0.826	0.487	0.282
16	2003	1.000	0.752	0.495	0.435
17	2004	1.000	0.766	0.552	0.329
18	2005	1.000	0.757	0.587	0.287
19	2006	1.000	0.662	0.649	0.376
20	2008	1.000	0.831	0.447	0.331
21	2009	1.000	0.748	0.548	0.374
22	2011	1.000	0.643	0.621	0.448
23	2012	1.000	0.623	0.593	0.510
24	2015	1.000	0.717	0.604	0.348
25	2016	1.000	0.786	0.547	0.288
26	2017	1.000	0.700	0.597	0.392
27	2019	0.999	0.741	0.606	0.289
28	2021	1.000	0.751	0.534	0.388
29	2031	1.000	0.640	0.572	0.512
30	2034	1.000	0.673	0.376	0.637
31	8001	0.998	0.746	0.571	0.341

R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

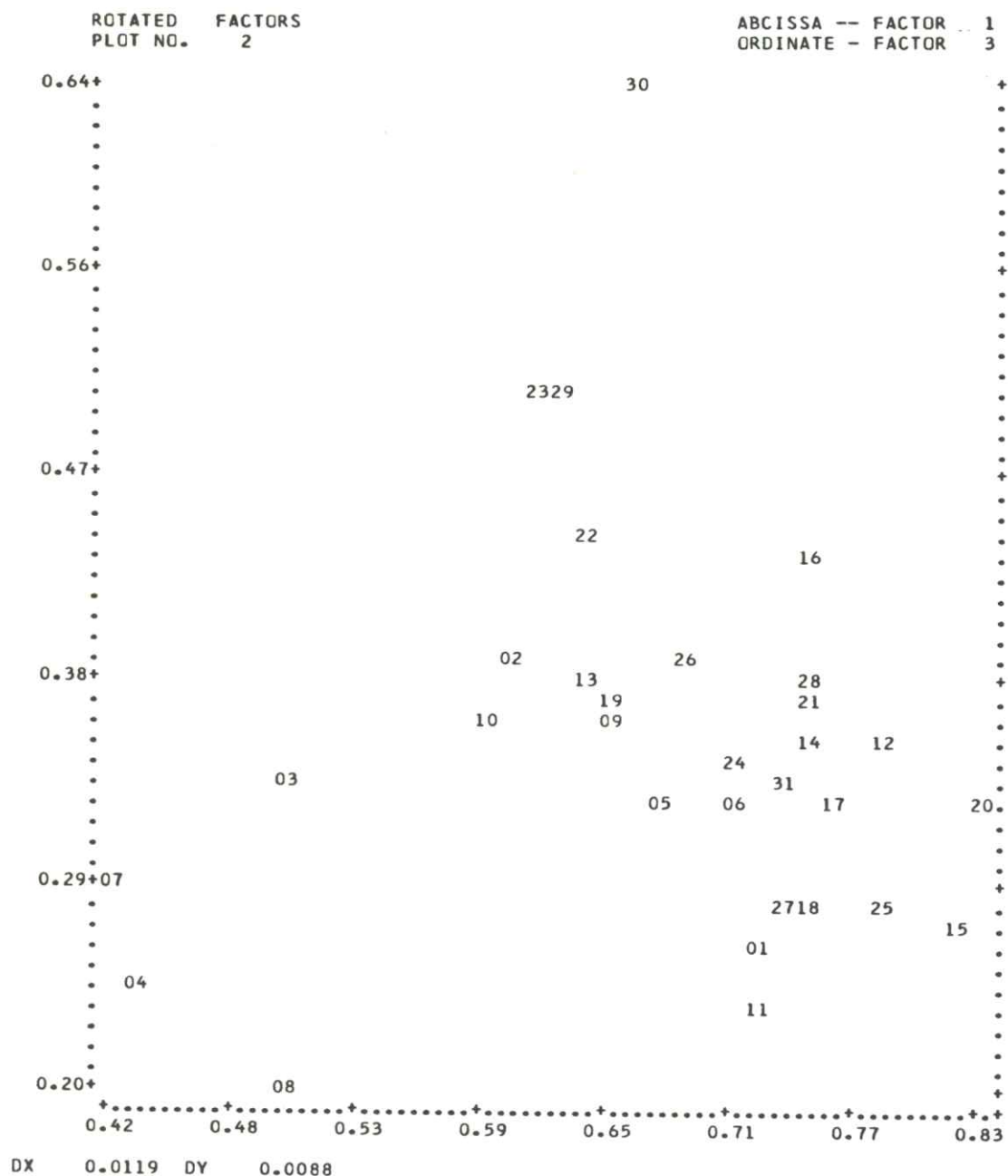
TABLE 14



ALPHA IDENTIFICATION
AA 14 21

R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

TABLE 15



ALPHA IDENTIFICATION

TABLE 16

R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

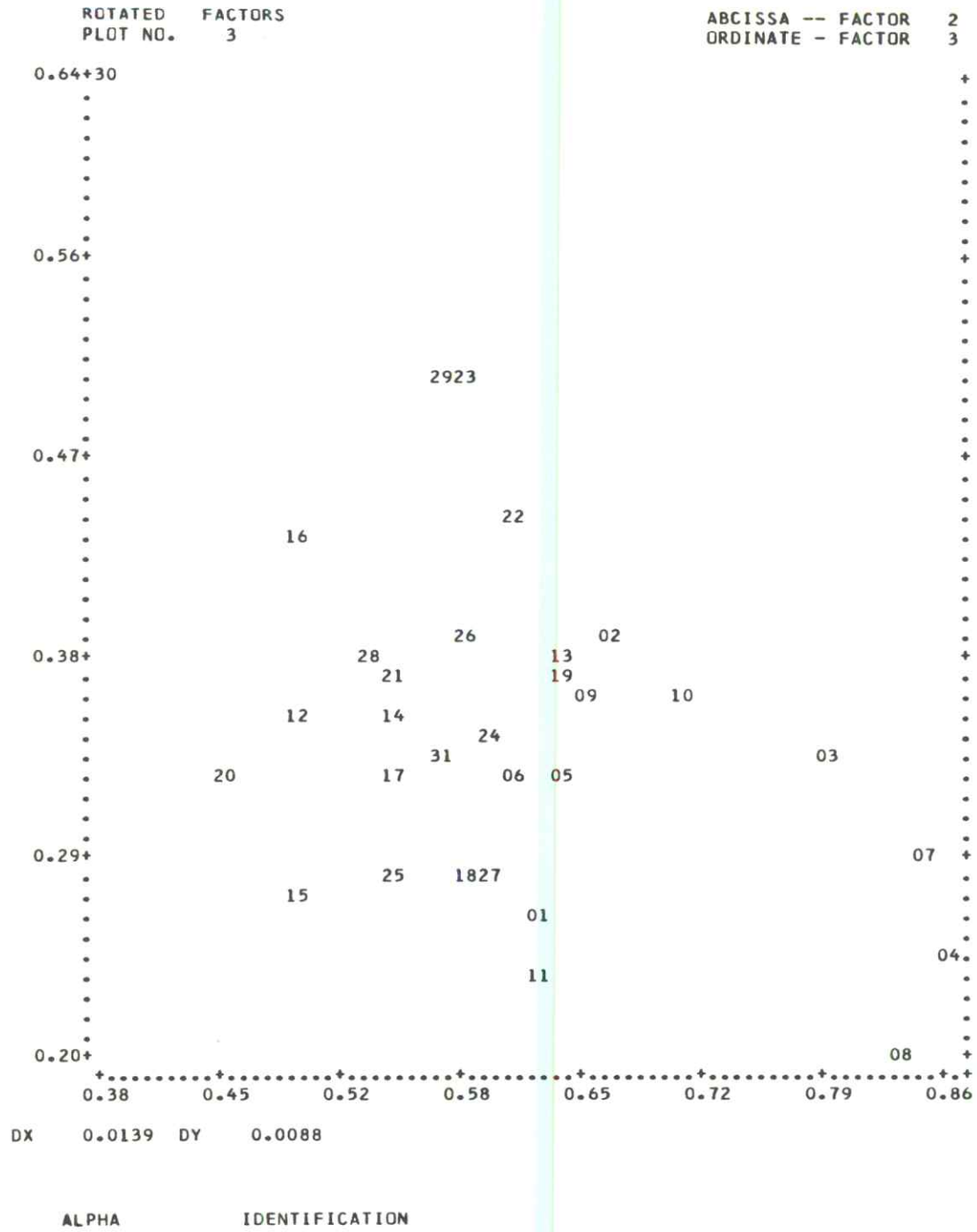


TABLE 17
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

V MATRIX

NAME	INDEX	20	4	30
2008	20	0.8309	0.4472	0.3311
1007	4	0.4373	0.8630	0.2515
2034	30	0.6733	0.3759	0.6367

INVERSE OF V MATRIX

2.3786 -0.8379 -0.9060
-0.5702 1.6004 -0.3358
-2.1787 -0.0588 2.7270

ITERATION CYCLE 1. HIGHEST LOADING IN C MATRIX IS 0.072 IN EXCESS OF 1.000

TABLE 18
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

V MATRIX

NAME	INDEX	15	7	30
2002	15	0.8262	0.4873	0.2823
1012	7	0.4160	0.8581	0.3009
2034	30	0.6733	0.3759	0.6367

INVERSE OF V MATRIX

2.0766 -0.9786 -0.4584
-0.2984 1.6102 -0.6286
-2.0198 0.0841 2.4266

TABLE 19
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

OBLIQUE PROJECTION PROGRAM

OBLIQUE AXES

NAME	INDEX	15	7	30
1001	1	0.791	0.320	-0.082
1004	2	0.272	0.525	0.257
1006	3	0.126	0.814	0.093
1007	4	0.143	0.983	-0.132
1009	5	0.551	0.415	0.079
1010	6	0.635	0.319	0.088
1012	7	0.000	1.000	0.000
1014	8	0.396	0.865	-0.262
1015	9	0.434	0.440	0.177
1017	10	0.280	0.590	0.181
1019	11	0.836	0.334	-0.145
1020	12	0.775	0.041	0.204
1021	13	0.381	0.443	0.229
1023	14	0.678	0.184	0.174
2002	15	1.000	0.000	0.000
2003	16	0.537	0.099	0.399
2004	17	0.762	0.166	0.101
2005	18	0.817	0.230	-0.019
2006	19	0.422	0.429	0.201
2008	20	0.924	-0.065	0.142
2009	21	0.635	0.182	0.221
2011	22	0.246	0.410	0.401
2012	23	0.086	0.389	0.581
2015	24	0.607	0.300	0.136
2016	25	0.888	0.137	-0.006
2017	26	0.485	0.309	0.255
2019	27	0.776	0.275	-0.020
2021	28	0.617	0.158	0.262
2031	29	0.126	0.338	0.589
2034	30	0.000	0.000	1.000
8001	31	0.690	0.219	0.127

TABLE 20
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

REORDERED OBLIQUE PROJECTION MATRIX			
NAME	2002	1012	2034
INDEX	15	7	30
2002 15	1.000	0.000	0.000
2008 20	0.924	-0.065	0.142
2016 25	0.888	0.137	-0.006
1019 11	0.836	0.334	-0.145
2005 18	0.817	0.230	-0.019
1001 1	0.791	0.320	-0.082
2019 27	0.776	0.275	-0.020
1020 12	0.775	0.041	0.204
2004 17	0.762	0.166	0.101
8001 31	0.690	0.219	0.127
1023 14	0.678	0.184	0.174
2009 21	0.635	0.182	0.221
1010 6	0.635	0.319	0.088
2021 28	0.617	0.158	0.262
2015 24	0.607	0.300	0.136
1009 5	0.551	0.415	0.079
2003 16	0.537	0.099	0.399
2017 26	0.485	0.309	0.255
1012 7	0.000	1.000	0.000
1007 4	0.143	0.983	-0.132
1014 8	0.396	0.865	-0.262
1006 3	0.126	0.814	0.093
1017 10	0.280	0.590	0.181
1004 2	0.272	0.525	0.257
1021 13	0.381	0.443	0.229
1015 9	0.434	0.440	0.177
2006 19	0.422	0.429	0.201
2011 22	0.246	0.410	0.401
2034 30	0.000	0.000	1.000
2031 29	0.126	0.338	0.589
2012 23	0.086	0.389	0.581

of each well are given along the left-hand side, in order by code number.

Table 20 is the same oblique projection matrix, re-ordered so that vectors lying close together are printed on near-by lines in the table. The name of each reference well is given at the top of the table.

PROGRAM DESCRIPTION

Figure 4 shows the flow of operations in COVAP. In the R-mode the program will process up to 100 variables observed on any number of cases up to 32,768. In the Q-mode, it will process up to 100 cases each characterized by up to 999 variables. Up to 10 factors can be extracted. The version of the program listed in Appendix I utilizes all but 40 memory locations on a 32K IBM 7090 or 7094 equipped with a standard system tape. Standard deviations are computed with the $(N - 1)$ formula.

Program Options

Data matrix format option. The data matrix may be punched on cards in two ways. Under the standard data matrix format the variables characterizing each case are punched across one card or a set of cards; each card field represents one variable. Under the transpose data matrix format the cases corresponding to each variable are punched across one card or a set of cards; each card field represents one case. The following rules should be noted:

- (1) If an R-mode analysis is desired, the standard data matrix format must be used.
- (2) If a Q-mode analysis is desired and there are fewer than 101 variables, either data matrix format may be used.
- (3) If a Q-mode analysis is desired and there are more than 100 variables, the transpose data matrix format must be used.
- (4) If both R- and Q-mode analyses are desired on one deck of data cards, the standard data matrix format must be used. In this case the number of variables and the number of cases must be less than 101.

Modal sequence option. Four operating sequences are possible on one machine pass. Options 1-3 use input from standard data matrix format. Option 4 uses input from transpose data matrix format.

- (1) The R sequence option performs an R-mode analysis only.
- (2) The Q sequence option performs a Q-mode analysis only.
- (3) The RQ sequence option performs both R- and Q-mode analyses from the same deck of data cards.
- (4) The QQ sequence option performs Q-mode analysis only.

Transformation options. Operating under the R-mode, data may be transformed by any of the following functions.

$$\log_e (\underline{x} + K)$$

$$\log_{10} (\underline{x} + K)$$

$$\underline{x}^K$$

Operating under the Q-mode, each variable may be transformed to the percentage of the observed range of the variable. The program searches each variable for the minimum and maximum

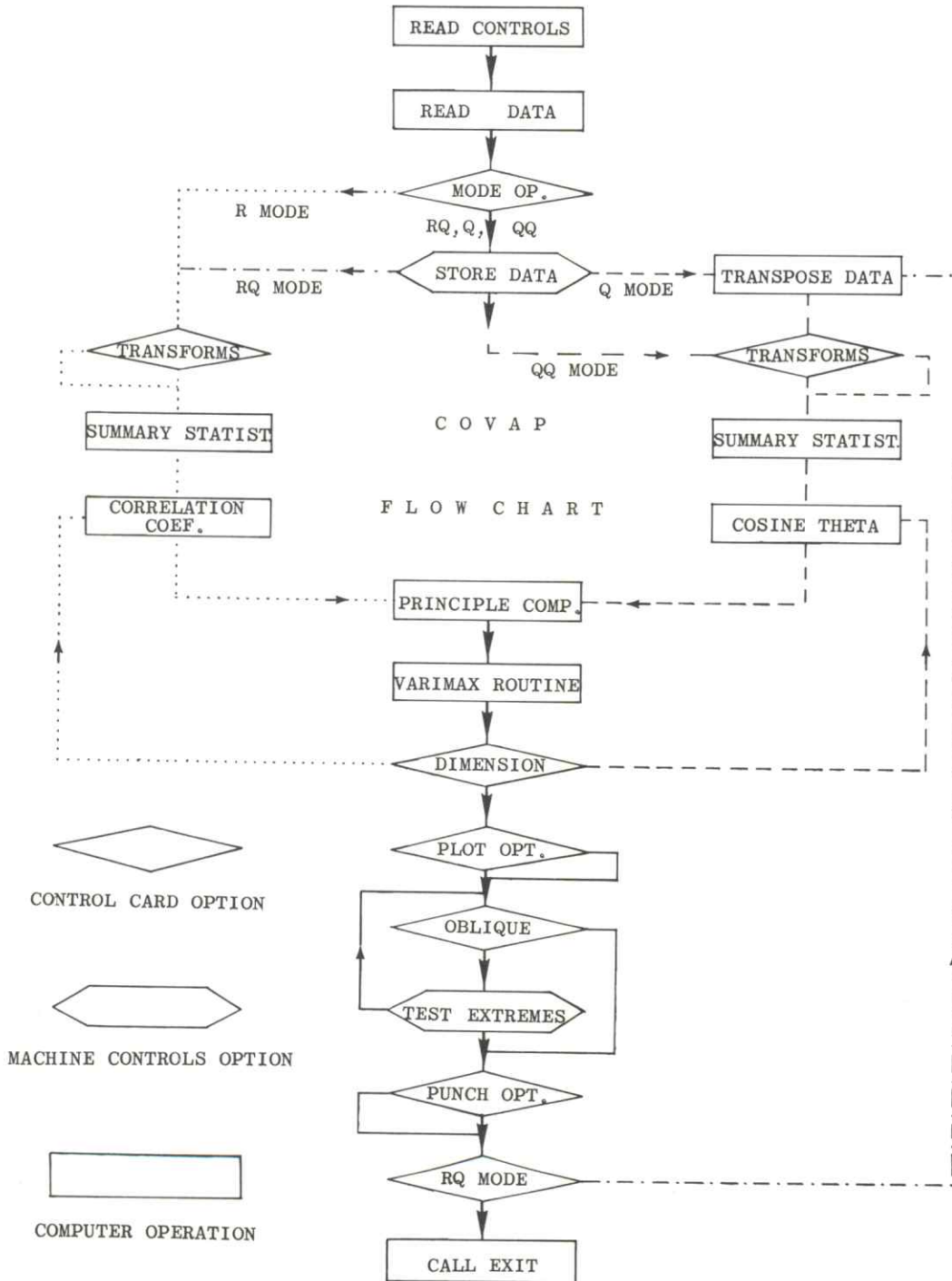


Figure 4.-Flow chart of COVAP program.

value, subtracts the minimum from each observation, and divides the result by the maximum diminished value. The percent-range transformation option may be used when raw variables are not recorded on a uniform scale, or when it is desired to give each variable equal weight in determining the composition of each case.

Plot option. A varimax factor matrix with up to 99 variables (R-mode) or 99 cases (Q-mode) can be plotted. The projection of every vector on each pair of orthogonal factor axes is given. In effect, this provides a set of two-dimensional slices through the m -space represented by the varimax matrix. If more than one projection falls at a given point, an alphabetic code is printed on the plot and the indices of the corresponding vectors are given at the side of the diagram. By studying all graphs of each set simultaneously it is possible to search for clusters of vectors isolated in m dimensions.

Oblique projection and re-order option. If this option is called, the program will find the m most extreme vectors in the varimax matrix and resolve each vector into these oblique reference vectors. The oblique matrix is also re-ordered by rows so that vectors listed in adjacent portions of the re-ordered matrix generally lie close together in m -space. The re-ordering algorithm for the $n \times m$ matrix has the following steps: (1) Form m submatrices each with m columns, $S_1, S_2, \dots, S_m$, such that all rows of S_1 have their highest absolute value in column 1, all rows of S_2 have their highest absolute value in column 2, etc. (2) Re-order the rows of S_1 by the algebraic rank of elements in column 1, re-order the rows of S_2 by the algebraic rank of elements in column 2, etc.

Punch option. If the oblique and varimax matrices are desired on cards, the program writes them on logical tape number 7 for subsequent card punch.

Communality option. Literature exists on the best means of estimating the communality. In our opinion the most meaningful results are achieved by placing ones in the diagonal of the matrix to be factored (i.e., estimating each communality as one) and extracting as many factors as are judged to be significant. Another commonly used option is provided whereby the communality is estimated as the largest r or $\cos \theta$ in each row.

Dimension control options. Although the ultimate criterion for judging the significance of factors is geological rather than statistical, it is always necessary to begin factor analysis with some formal, a priori procedure for estimating the number of factors to extract. Three optional procedures are available in COVAP. In order to save space, the matrix to be factored is printed only under option 1.

(1) Pre-selection option. Under this procedure the investigator selects in advance the number of factors to rotate. This value (m) may be any number from 1 - 10, and is entered in the appropriate columns (26 - 27 and/or 69 - 70) of the control card. Provided that the cumulative value of the m positive eigenvalues does not exceed unity, m factors are extracted. If the cumulated eigenvalues do exceed unity the value of m is diminished by one and the eigenvalues re-calculated and so on, until a value of m is found which satisfies the cumulative criterion. The same cumula-

tive eigenvalue criterion is also applied to the two dimension control options described below.

(2) Minimum value option. Under this option the investigator selects: m, the maximum number of dimensions that might possibly be of significance; and z, the minimum absolute value desired in any column of the rotated varimax factor matrix. If z is chosen as 0.223, for example, it assures that no factor is retained which does not contribute at least $\underline{z}^2$ (5 percent) to one item in the data matrix.

(3) Trial series option. Under this option the investigator selects: m, the maximum number of factors to rotate; and w, the total number of factor-vector analyses to perform in a series with m, m - 1, m - 2, ...factors.

Multiple problem processing option. Any number of problems, each with a separate data deck and control cards, may be run on one machine pass.

Operating Instructions

The following cards are submitted in order immediately following the PROGRAM DECK and the SYSTEM DATA CARD. The symbol "b" below signifies a blank.

(1) CONTROL CARD

Col. 1 - 6	Problem name (alphanumeric characters).
7 - 9	Number of variables.
10 - 15	Number of cases.
17	Communality option.
	1 Program puts one in diagonal.
	3 Program puts largest row R in diagonal, or largest cos θ .
26 - 27	The value of <u>m</u> . In the R and RQ sequence options, the number of factors to rotate for the R-mode analysis; in the QQ sequence option, the number of factors to rotate for the Q-mode analysis. Leave blank for Q sequence.
29	Number of variable format cards (any number from 1 to 8).
35	Plot control.
	0 Plot option suppressed.
	1 Varimax matrix plotted.
36	R-mode control.
	R For R mode analysis (in R or RQ sequence options).
	b to suppress R-mode analysis, leave blank (Q and QQ sequence options).
39	Q-mode control.
	Q For Q-mode analysis (in Q, RQ, or QQ sequence options).
	b To suppress Q-mode analysis (R sequence option) leave blank.
42	Oblique projection control.
	0 Suppress oblique projection option.

1 Oblique projection and re-order option.

44 Punch control.

0 Option suppressed.

1 Varimax and oblique matrices written on logical tape number 7 for card punch.

45 - 47 Dimension control options. Value(s) of m punched in cols. 26-27 and/or 69-70 represent maximum number of factors to rotate.

b Pre-selection option. Values of m punched in cols. 26-27 and 69-70 determine number of factors.

z Minimum value option. Punch desired three-digit value of z without decimal point, e.g. for z = 0.223 punch 223

-w Trial series option. Punch minus sign followed by desired integer value of w, right justified. For series of three analyses, punch b-3

50 Percent range data transformation option.

0 Option suppressed.

1 Data transformed to percent range in Q sequence only.

Non-linear data transformations. Keypunch value of K with decimal point to call desired option. For example: 0.5 in cols. 66-68 will cause program to take the square root of every value in an R modal sequence. For no transformation leave cols. 51-68 blank.

51 - 56 $\log_e (\underline{x} + K)$; R and QQ sequences only.

57 - 62 $\log_{10} (\underline{x} + K)$; R and QQ sequence only.

63 - 65 $\underline{x}^K$ for Q modal sequence.

66 - 68 $\underline{x}^K$ for R modal sequence.

69 - 70 The value of m. Number of factors to rotate in Q-mode for Q, RQ, and QQ modal sequence options. For QQ sequence only the same value is also punched in cols. 26 - 27. Leave blank for R sequence option.

72 Data matrix format option.

0 Standard data matrix format (R, Q, RQ sequences).

1 Transpose data matrix format (QQ sequence).

(2) PAGE HEADING CARDS (2 CARDS)

Information punched in cols. 1 - 72 of first of these cards and cols. 1 - 54 of second of these cards is printed on the top line of each page of output. Use blank cards if no title is desired.

(3) NAME CARD(S)

Code names in order (12A6 format for each card) are specified for each variable in the R or RQ modal sequence options. For the Q and QQ sequence options names of cases are speci-

fied. Twelve items are described per card. The number of cards required is equal to the integral value of $(N - 1)/12 + 1$, where N is the number of variables or cases. Use blank cards if no code names are desired.

(4) VARIABLE FORMAT CARD(S)

Punching format of data cards is described using the number of cards given in col. 29 of the CONTROL CARD. Data must be read under an F format.

(5) DATA DECK

(6) NAME CARD(S)

Code names in order (12A6 format for each card) are specified for each case if the RQ modal sequence option is used. The number of cards needed is equal to the integral value of $(N - 1) / 12 + 1$, where N is the number of cases. Omit these cards if R, Q, or QQ options are used.

(7) For multiple problem processing, repeat cards (1) through (6) for each additional problem.

(8) FINISH CARD

End of job card. Punch FINISH in cols. 1 - 6.

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APPENDIX I

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* LABEL
CCLVAP COLUMBIA VECTOR ANALYSIS PROGRAM BY MANSON AND IMBRIE 1963
C
C PROGRAM PERFORMS COMPLETE FACTOR-VECTOR ANALYSIS (1) IN THE R-MODE,
C CALCULATING MEAN, ST. DEVIATION, SKEWNESS, AND CORRELATION MATRIX ON
C UP TO 170 VARIABLES. (2) IN THE Q-MODE, CALCULATING MEAN, SUM OF
C SQUARES, AND COSINE THETA MATRIX ON UP TO 100 CASES. OR (3) IN BOTH R
C AND Q MODES. OUTPUT GIVES POSITIVE EIGENVALUES, PRINCIPAL COMPONENTS
C AND VARIMAX FACTOR MATRICIES, PLOTS OF VARIMAX MATRIX, MATRIX OF
C OBLIQUE PROJECTIONS ON EXTREME VECTORS, AND REORDERED OBLIQUE MATRIX.
C
      DIMENSIONA(100,100),B(100,100),C(100),FMT(100),MM(101),HEAD(21),ANCOVA
      IAME(100),XA(2),YA(2),IFMT(100)
      COMMON A,B,C,FMT,MM,HEAD,ANAME
      EQUIVALENCE (FMT,IFMT)
10 READINPUTTAPE5,900,RNN,NV,N,NRN,RBIG,CUT,NRO,NN,ISIR,IDRAW,AM,VORPCOVA
1,PUN,MINBIJ,PMAX,ALOG10,EXPQ,EXP,NROQ,IFQFMT
200 FCRMAT (A6,I3,I6,I2,F4.2,F3.2,I3,2I2,2X12,A6,I1,I2,I3,F3.0,2F6.3,
12F3.0,2I2)
B      W1 = 606060604546
B      W2 = 602421632160
      MCDEA = 1
      MCDE = 1
      AMA = AM
      REWIND 4
      WCRD1=263145316230
B      IF(RNN-WCRD1)11,400,11
11 CCNTINUE
      READINPUTTAPE5,901,(HEAD(1),I=1,21)
      NNRN = NRN
      ARN = RNN
      ARBIG = RBIG
      ACUT = CUT
      ISIRA = ISIR
      IDRAWA = IDRAW
      NY = NN
B      WCRD1=606060702562
B      C(1)=602551514651
B      C(41)=6060646452562
B      C(42)=625060446051
B      C(43)=674421676051
      C(44)=C(41)
      C(45)=C(43)
B      C(46) = 603145476463
      IF (NRN) 13,13,12
12 IF(NRN-7) 14,13,13
13 WCRD2=C(1)
      GCTC15
14 WCRD2=C(NRN+40)
      WCRD9 = WCRD2
15 CCNTINUE
      IF(ISIR)16,17,16
16 CCNTINUE
      WCRD1=606060604546
B      17 CCNTINUE
      WRITEOUTPUTTAPE6,950,HEAD
      WRITEOUTPUTTAPE6,902,RNN,NN,NV,N,WCRD1,WCRD2,
      WCRD8 = WCRD1
      IF(NN)19,19,18
18 IF(WCRD2-C(1))20,19,20
19 WRITEOUTPUTTAPE6,974
      GCTC400
20 CCNTINUE
      RNN=RBIG
      NP = NV
B      WCRD3 = 606060506060
      IF (AM-WCRD3) 2026 ,2025,2026
2025 NP = N

```

CQVA 000
 CQVA 001
 CQVA 002
 CQVA 003
 CQVA --3
 CQVA 005
 CQVA 006
 CQVA 007
 CQVA 008
 CQVA 009
 CQVA 010
 ANCOVA 011
 CQVA 012
 CQVA 013
 CQVA 014
 CQVA 015
 CQVA 016
 CQVA 017
 CQVA 018
 CQVA 019
 CQVA 020
 CQVA 021
 CQVA 022
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 CQVA 024
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 CQVA 29
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 CQVA 063
 CQVA 064
 CQVA 065
 CQVA 066
 CQVA 067

NRU

2026	READINPUT	TAPE5,901,(ANAME(I),I=1,NP)	CCVA 066
	IF(MODE=2)	2027,26,2027	CCVA 069
2027	NN=NN*12		CCVA 070
	NP = N		CCVA 071
	READINPUT	TAPE5,901,(FMT(I),I=1,NN)	CCVA 072
	GCTG(21,21,21,1235,1235,1235),NRN		CCVA 073
21	DC25I=1,NV		CCVA 074
	A(I,2)=0.C		CCVA 075
	A(I,3)=0.C		CCVA 076
	A(I,4)=0.C		CCVA 077
	A(I,5)=0.C		CCVA 078
	DC25J=1,NV		CCVA 079
	B(I,J)=0.C		CCVA 080
25	CONTINUE		CCVA 081
	IF(IFQFMI)24,26,24		CCVA 082
24	N=NV		CCVA 083
	NV=NP		CCVA 084
	NRCI = NRCC		CCVA 085
	NRC=NRCC		CCVA 086
B	AM=516060606060		CCVA 087
26	DC 42 I=1,N		CCVA 088
B	WORD3 = 516060606060		CCVA 089
	IF(MODE=2) 27,800,27		CCVA 090
27	READ INPUT TAPE 5,FMT,(C(J),J=1,NV)		CCVA 091
	IF(AM-WORD3)700,704,700		CCVA 092
700	WRITE TAPE 4,(C(J),J=1,NV)		CCVA 093
B	WORD3 = 516060506060		CCVA 094
	IF (AM-WORD3) 42,703,42		CCVA 095
703	MCDEA = 2		CCVA 096
B	AMA= 516060606060		CCVA 097
704	IF(ALCGE)705,710,705		CCVA 098
705	DC 706 J=1,NV		CCVA 099
706	C(J)=LCGF(C(J)+ALCGE)		CCVA 100
B	W1 = 434627602560		CCVA 101
B	W2 = 746067204234		CCVA 102
710	IF(ALCG10) 711,720,711		CCVA 103
711	DC 712 J=1,NV		CCVA 104
712	C(J) = LCGF(C(J)+ALCG10)*0.43429		CCVA 105
B	W1 = 434627600100		CCVA 106
B	W2 = 607467204234		CCVA 107
720	IF(EXP) 721,28,721		CCVA 108
721	DC 722 J=1,NV		CCVA 109
722	C(J) = C(J)**EXP		CCVA 110
B	W1 = 256747336060		CCVA 111
B	W2 = 746754544234		CCVA 112
28	DC 40 J=1,NV		CCVA 113
	A(J,2)=A(J,2)+C(J)		CCVA 114
	A(J,3)=A(J,3)+C(J)**2		CCVA 115
	A(J,4)=A(J,4)+C(J)**3		CCVA 116
	A(J,5)=A(J,5)+C(J)**4		CCVA 117
	IF (IFQFMI) 32,32,31		CCVA 118
31	A(J,12) = SQRTF(A(J,3))		CCVA 119
	A(J,13) = A(J,3)		CCVA 120
32	DC4JK=J,NV		CCVA 121
	B(J,K)=B(J,K)+C(J)*C(K)		CCVA 122
40	CONTINUE		CCVA 123
42	CONTINUE		CCVA 124
B	W3 = 606521513121		CCVA 125
B	W4 = 224325606060		CCVA 126
	IF(AM-WORD3)801,41,801		CCVA 127
800	MCDEA= 1		CCVA 128
	IDRAW = ICRAWA		CCVA 129
	ISIR = ISIRA		CCVA 130
	RBIG = ARBIG		CCVA 131
	RNN = RBIG		CCVA 132
	CUT = ACUT		CCVA 133
	WRITE OUTPUT TAPE 6,950,HEAD		CCVA 134
	WRITE OUTPUT TAPE 6,902,ARN,NY,NV,N,WORD8,WORD9	,NRQ	CCVA 135
B	AMA = 606060506060		CCVA 136
801	NSAV = N		CCVA 137
	REWIND 4		CCVA 138
	NRC = NRCC		CCVA 139
B	W3 = 606060232162		CCVA 140
B	W4 = 256060606060		CCVA 141
	NROT = NRCC		CCVA 142

	N = NV	CGVA 143
	NV = NSAV	CGVA 144
	CC 802 J = 1,NV	CGVA 145
8C2	READ TAPE 4, (A(IA,J), IA=1,N)	CGVA 146
	REWIND 4	CGVA 147
	IF (PMAX) 810,810,803	CGVA 148
8C3	CC 805 IE = 1,N	CGVA 149
	ALARG = A(1B, 1)	CGVA 150
	SMALA = A(1B,1)	CGVA 151
	CC 804 JE = 1,NV	CGVA 152
	ALARG = MAX1F(A(1B,JB),ALARG)	CGVA 153
8C4	SMALA = MIN1F(A(1B,JB),SMALA)	CGVA 154
	DIFA = ALARG - SMALA	CGVA 155
	CC 806 JE = 1,NV	CGVA 156
8C6	A(1B,JB) = (A(1B,JB)-SMALA)*100./DIFA	CGVA 157
8C5	CONTINUE	CGVA 158
B	W1 = 472551236333	CGVA 159
B	W2 = 605121452725	CGVA 160
810	CC 811 IA=1,N	CGVA 161
811	WRITE TAPE 4, (A(IA,J), J=1,NV)	CGVA 162
	REWIND 4	CGVA 163
	CC29K=1,NV	CGVA 164
	A(K,2)=0.C	CGVA 165
	A(K,3)=0.C	CGVA 166
	A(K,4)=0.C	CGVA 167
29	A(K,5)=0.C	CGVA 168
	CC 840 I=1,N	CGVA 169
	READ TAPE 4, (C(J), J=1,NV)	CGVA 170
	IF (EXPQ) 830,839,830	CGVA 171
830	CC 831 J = 1,NV	CGVA 172
831	C(J) = C(J)**EXPQ	CGVA 173
B	W1= 256747336060	CGVA 174
B	W2 = 746754544234	CGVA 175
839	CC 840 J=1,NV	CGVA 176
	A(J,2)=A(J,2)+C(J)	CGVA 177
	A(J,3) = A(J,3)+ C(J)**2	CGVA 178
	A(J,4) = A(J,4)+C(J)**3	CGVA 179
	A(J,5) = A(J,5)+C(J)**4	CGVA 180
	A(J,12) = SQRTF(A(J,3))	CGVA 181
	A(J,13) = A(J,3)	CGVA 182
	CC 840 K=J,NV	CGVA 183
	B(J,K) = B(J,K)+C(J)*C(K)	CGVA 184
840	CONTINUE	CGVA 185
41	CMO=N	CGVA 186
	NLRMAT = C	CGVA 187
	AM = AMA	CGVA 188
	WRITE OUTPUT TAPE 6, 985, AM, W1, W2	CGVA 189
	MODE = MODEA	CGVA 190
	CM1=N-1	CGVA 191
	CM2=N-2	CGVA 192
	CM3=N-3	CGVA 193
	CP1=N+1	CGVA 194
	CP3=N+3	CGVA 195
	CP5=N+5	CGVA 196
	SEG1=SQRTF((6.0*CM0*CM1)/(CM2*CP1*CP3))	CGVA 197
	SEG2=SQRTF((24.0*CM0*CM1*CM1)/(CM3*CM2*CP3*CP5))	CGVA 198
	DESJ1=1,NV	CGVA 199
	FMT(I)=A(I,2)/CM0	CGVA 200
43	S2=A(I,3)-FMT(I)*A(I,2)	CGVA 201
44	IF (S2) 48,48,45	CGVA 202
48	S2 = 0.0000001	CGVA 203
	S3 = 0.0000001	CGVA 204
	S4 = 0.0000001	CGVA 205
	GC TC 49	CGVA 206
45	S3=A(I,4)-3.0*FMT(I)*A(I,3)+2.0*FMT(I)**3*CM0	CGVA 207
	S4=A(I,5)-4.0*FMT(I)*A(I,4)+6.0*FMT(I)**2*A(I,3)-3.0*FMT(I)**4*CM0	CGVA 208
49	A(I,3) = S2/CM1	CGVA 209
	A(I,4)=((CM0*S3)/(CM1*CM2))/(A(I,3)**1.5)	CGVA 210
	A(I,5)=(CM0*(CP1*S4-3.0*CM1*S2*S2 /CM0)/(CM1*CM2*CM3))/(A(I,3))	CGVA 211
	1,3)*A(I,3))	CGVA 212
B	WCRC3 = E06060506060	CGVA 213
	A(I,11) = SQRTF(A(I,3))	CGVA 214
	A(I,11) = A(I,11)/SQRTF(CM0)	CGVA 215
	IF (AM-WCRC3) 47,50,47	CGVA 216
47	A(I,13) = SQRTF(A(I,3))	CGVA 217

A(I,12)=A(I,11)*SQRTF(0.5+0.25*A(I,5))		COVA	218
50 CCNTINUE		COVA	219
DC80KK=1,NV,50		COVA	220
KKEND=XMINOF(KK+49,NV)		COVA	221
WRITECUTPLTTAPE6,950,HEAD		COVA	222
IF(AM-WCRD3)53,51,53		COVA	223
53 WRITE CUTFUT TAPE 6,903,W3,W4		COVA	224
GC TC 54		COVA	225
51 WRITE CUTFLT TAPE 6,990,W3,W4		COVA	226
54 DC 75 I=KK,KKEND		COVA	227
IF(ABSF(A(I,4)/SEG1)-2.576)55,52,52		COVA	228
B 52 WCRD1=545460606060		COVA	229
GCTC61		COVA	230
55 IF(ABSF(A(I,4)/SEG1)-1.96)60,57,57		COVA	231
B 57 WCRD1=546C60606060		COVA	232
GCTC61		COVA	233
B 60 WCRD1=606C60606060		COVA	234
61 IF(ABSF(A(I,5)/SEG2)-2.576)65,62,62		COVA	235
B 62 WCRD2=545460606060		COVA	236
GCTC71		COVA	237
65 IF(ABSF(A(I,5)/SEG2)-1.96)70,67,67		COVA	238
B 67 WCRD2=546C60606060		COVA	239
GCTC71		COVA	240
B 70 WCRD2=606C60606060		COVA	241
71 IF (AM-WCRD3) 72,73,72		COVA	242
72 WRITEOUTPLTTAPE6,904,I,ANAME(I),FMT(I),	A(I,13)	,A(I	COVA 243
1,4),WORD1,A(I,5),WORD2			COVA 244
GC TC 75			COVA 245
73 WRITECUTPLTTAPE6,995,I,ANAME(I),FMT(I),	A(I,13),A(I,12),A(I		COVA 246
1,4),WORD1,A(I,5),WORD2			COVA 247
75 CCNTINUE			COVA 248
74 WRITECUTPLTTAPE6,905,SEG1,SEG2			COVA 249
80 CCNTINUE			COVA 250
B WCRD3 = 516060606060			COVA 251
DC85I=1,NV			COVA 252
IF(AM-WCRD3) 81,84,81			COVA 253
81 FMT(I) = A(I,3)*CM1+(FMT(I)*A(I,2))			COVA 254
GC TC 85			COVA 255
84 FMT(I) = A(I,3)*CM1			COVA 256
85 CCNTINUE			COVA 257
NA=NV-1			COVA 258
IF (AM - WCRD3) 91,89,71			COVA 259
89 DC90I=1,NV			COVA 260
DC90J=1,NV			COVA 261
B(I,J)=B(I,J)-((A(I,2)*A(J,2))/CM0)			COVA 262
90 CCNTINUE			COVA 263
91 DC95I=1,NA			COVA 264
II=I+1			COVA 265
DC95J=II,NV			COVA 266
B(J,I)=B(I,J)			COVA 267
95 CCNTINUE			COVA 268
GCTC(215,142,215,1235,1235,1235),NRN			COVA 269
142 CCNTINUE			COVA 270
MM(NV+1)=0.0			COVA 271
DC210II=1,NV			COVA 272
DC145I=1,NV			COVA 273
MM(I)=I			COVA 274
145 CCNTINUE			COVA 275
DC150I=II,NV			COVA 276
MM(I)=MM(I+1)			COVA 277
150 CCNTINUE			COVA 278
MM(NV)=II			COVA 279
IR=MM(1)			COVA 280
DC180J=1,NV			COVA 281
JR=MM(J)			COVA 282
A(1,J)=B(IR,JR)			COVA 283
180 CCNTINUE			COVA 284
DC200I=1,NA			COVA 285
IP1=I+1			COVA 286
DC185J=IP1,NV			COVA 287
A(J,I)=A(I,J)/A(I,I)			COVA 288
185 CCNTINUE			COVA 289
IK=I+1			COVA 290
IR=MM(IK)			COVA 291
DC200J=IK,NV			COVA 292
SUM=0.0			COVA 293

DC170M=1,I	CGVA 294
SUM=SUM+A(IK,M)*A(M,J)	CGVA 295
150 CCNTINUE	CGVA 296
JR=MM(J)	CGVA 297
A(IK,J)=B(IR,JR)-SUM	CGVA 298
200 CCNTINUE	CGVA 299
C(II)=0.0	CGVA 300
DC205I=1,NN	CGVA 301
C(II)=C(II)+A(I,NV)*A(NV,I)	CGVA 302
205 CCNTINUE	CGVA 303
C(II)=C(II)/B(II,II)	CGVA 304
210 CCNTINUE	CGVA 305
215 DC220I=1,NV	CGVA 306
220 FMT(I)=SQRT(FMT(I))	CGVA 307
DC225I=1,NV	CGVA 308
DC225J=I,NV	CGVA 309
225 A(I,J)=B(I,J)/(FMT(I)*FMT(J))	CGVA 310
DC226I=1,NN	CGVA 311
NK=I+1	CGVA 312
DC226J=NK,NV	CGVA 313
226 A(J,I)=A(I,J)	CGVA 314
GCTO(1254,1227,1260,1235,1235,1235),NRN	CGVA 315
1227 DC1230I=1,NV	CGVA 316
A(I,I)=C(I)	CGVA 317
1230 CCNTINUE	CGVA 318
GCTO1280	CGVA 319
1235 DC1240I=1,NV	CGVA 320
READINPUTTAPE5,FMT,(A(I,J),J=1,NV)	CGVA 321
1240 CCNTINUE	CGVA 322
GC TO 1243	CGVA 323
1241 NARN = NRN	CGVA 324
NRC = NRC - 1	CGVA 325
NROT = NRCT - 1	CGVA 326
DC 1242 I=1,NV	CGVA 327
1242 READ TAPE 2,(A(I,J),J=1,NV)	CGVA 328
NRN = NRN+3	CGVA 329
1243 IF(NRN-5)1254,1260,1280	CGVA 330
1254 DC1255I=1,NV	CGVA 331
A(I,I)=1.0	CGVA 332
1255 CCNTINUE	CGVA 333
GCTO1280	CGVA 334
1260 DC1265I=1,NV	CGVA 335
A(I,I)=0.0	CGVA 336
1265 CCNTINUE	CGVA 337
DC1275I=1,NV	CGVA 338
RBIG=ABSF(A(I,I))	CGVA 339
DC1270J=1,NV	CGVA 340
RBIG=MAX1F(ABSF(RBIG),ABSF(A(I,J)))	CGVA 341
1270 CCNTINUE	CGVA 342
A(I,I)=RBIG	CGVA 343
1275 CCNTINUE	CGVA 344
1280 CCNTINUE	CGVA 345
IPAGE=0	CGVA 346
IF(MINBIJ)1285,1290,1285	CGVA 347
1285 REWIND 2	CGVA 348
DC 1286 I = 1,NV	CGVA 349
1286 WRITE TAPE 2,(A(I,J),J=1,NV)	CGVA 350
C	CGVA 351
REWIND 2	CGVA 352
NCRMAT = NCRMAT + 1	CGVA 353
IF (NCRMAT) 1290,1290,2370	CGVA 354
1290 DC2370KK=1,NV,12	CGVA 355
KKEND=XMINOF(NV,KK+11)	CGVA 356
DC2370JSTART=1,KK,12	CGVA 357
JSTGP=XMINOF(NV,JSTART+11)	CGVA 358
IPAGE=IPAGE+1	CGVA 359
IF(XMDDF(IPAGE,2))2353,2353,2350	CGVA 360
2350 CCNTINUE	CGVA 361
WRITEOUTPLTTAPE6,950,HEAD	CGVA 362
WRITEOUTPLTTAPE6,954	CGVA 363
GCTO2354	CGVA 364
2353 CCNTINUE	CGVA 365
WRITEOUTPLTTAPE6,911	CGVA 366
WRITEOUTPLTTAPE6,911	CGVA 367
2354 CCNTINUE	CGVA 368

WRITECUTPLTTAPE6,951,W3,W4,(J,J=JSTART,JSTOP)	COVA 369
IF(KK-JSTART)2360,2360,2355	COVA 370
2355 DC2358I=KK,KKEND	COVA 371
WRITECUTPLTTAPE6,952,I,ANAME(I),(A(I,J),J=JSTART,JSTOP)	COVA 372
2358 CCNTINUE	COVA 373
GCTC237	COVA 374
2360 DC2365I=KK,KKEND	COVA 375
2365 WRITECUTPLTTAPE6,952,I,ANAME(I),(A(I,J),J=JSTART,I)	COVA 376
2370 CCNTINUE	COVA 377
TRACR=0.0	COVA 378
2374 DC2375I=1,NV	COVA 379
TRACR=TRACR+A(I,I)	COVA 380
2375 CCNTINUE	COVA 381
CALL JACCEI (NV,IWARN)	COVA 382
IF(RNN-99.99)11103,11102,11102	COVA 383
1102 RNN=ABSF(FMT(NV))	COVA 384
1103 DC243I=1,NV	COVA 385
IF(FMT(I)-RNN)242,243,2+3	COVA 386
242 NZ1=I-1	COVA 387
GCTC244	COVA 388
243 CCNTINUE	COVA 389
NZ1=N	COVA 390
244 CCNTINUE	COVA 391
DC250I=1,NV	COVA 392
DL248J=1,NV	COVA 393
IF(ABSF(A(J,I))-CUT)248,250,250	COVA 394
248 CCNTINUE	COVA 395
NZ2=I-1	COVA 396
GCTC255	COVA 397
250 CCNTINUE	COVA 398
NZ2=N	COVA 399
255 IF(NRC)257,257,258	COVA 400
257 NRC=20	COVA 401
258 CCNTINUE	COVA 402
SUMT=0.0	COVA 403
KK=N	COVA 404
DC265I=1,NV	COVA 405
SUMT=SUMT+FMT(I)	COVA 406
IF(FMT(I))265,265,260	COVA 407
260 KK=I	COVA 408
265 CCNTINUE	COVA 409
JSTOP=20	COVA 410
C(1)=0.0	COVA 411
DC270I=1,NV	COVA 412
C(1)=C(1)+FMT(I)	COVA 413
IF(SUMT-C(1))267,267,270	COVA 414
267 JSTOP=1	COVA 415
GCTC275	COVA 416
270 CCNTINUE	COVA 417
275 NRG=XMINOF(NRG,NZ1,NZ2,JSTOP,20)	COVA 418
SUMR=0.0	COVA 419
DC280I=1,NRC	COVA 420
SUMR=SUMR+FMT(I)	COVA 421
280 CCNTINUE	COVA 422
C(2)=0.0	COVA 423
C(4)=0.0	COVA 424
DC300J=1,KK,50	COVA 425
WRITECUTPLTTAPE6,950,HEAD	COVA 426
WRITECUTPLTTAPE6,955,NV,NRG	COVA 427
WRITECUTPLTTAPE6,912	COVA 428
NZ1=XMINOF(J+49,KK)	COVA 429
DC300I=J,NZ1	COVA 430
C(1)=(FMT(I)/SUMT)*100.0	COVA 431
C(2)=C(2)+C(1)	COVA 432
C(3)=(FMT(I)/SUMR)*100.0	COVA 433
C(4)=C(4)+C(3)	COVA 434
IF(1-NRG)295,295,285	COVA 435
285 IF(1-JSTOP)297,297,299	COVA 436
295 WRITECUTPLTTAPE6,956,I,FMT(I),C(1),C(2),C(3),C(4)	COVA 437
GCTC300	COVA 438
297 WRITECUTPLTTAPE6,956,I,FMT(I),C(1),C(2)	COVA 439
GCTC300	COVA 440
299 WRITECUTPLTTAPE6,956,I,FMT(I),C(1)	COVA 441
300 CCNTINUE	COVA 442
WRITECUTPLTTAPE6,957,TRACR,NV,SUMT,NRG,SUMR	COVA 443

B	WORD1=644551466321	COVA 444
B	WORD2=632524606060	COVA 445
	IEXIT=1	COVA 446
	IPLAW=IDRAW/10	COVA 447
305	CCONTINUE	COVA 448
	DC307I=1,NV	COVA 449
	C(I)=0.0	COVA 450
	DC307J=1,NRC	COVA 451
	C(I)=C(I)+A(I,J)**2	COVA 452
307	CCONTINUE	COVA 453
	DC310KK=1,NV,40	COVA 454
	KKEND=XMINOF(NV,KK+39)	COVA 455
	DC310JSTART=1,NRC,10	COVA 456
	JSTOP=XMINOF(NRC,JSTART+9)	COVA 457
	WRITECUTPLTTAPE6,950,HEAD	COVA 458
	WRITECUTPLTTAPE6,960,WORD1,WORD2,(J,J=JSTART,JSTOP)	COVA 459
	WRITECUTPLTTAPE6,961,(FMT(J),J=JSTART,JSTOP)	COVA 460
	WRITECUTPLTTAPE6,962,W3,W4,NRC	COVA 461
	WRITECUTPLTTAPE6,911	COVA 462
	DC310I=KK,KKEND	COVA 463
	WRITECUTPLTTAPE6,963,I,ANAME(I),C(I),(A(I,J),J=JSTART,JSTOP)	COVA 464
B	WORD3 = 606051466321	COVA 465
	IF (WORD1 - WORD3)310,308,310	COVA 466
308	IF (PUN) 309,310,309	COVA 467
309	WRITECUTPLTTAPE7,964 ,I,(A(I,J),J=JSTART,JSTOP)	COVA 468
310	CCONTINUE	COVA 469
	IF(NRC-1)311,311,312	COVA 470
311	WRITECUTPLTTAPE6,950,HEAD	COVA 471
	WRITECUTPLTTAPE6,927	COVA 472
	GCTO10	COVA 473
312	CCONTINUE	COVA 474
	GCTG(315,313),IWARN	COVA 475
313	WRITECUTPLTTAPE6,950,HEAD	COVA 476
	WRITECUTPLTTAPE6,970,MAXI	COVA 477
	GCTO10	COVA 478
315	CCONTINUE	COVA 479
	IF(IPLAW-1)320,500,320	COVA 480
500	CCONTINUE	COVA 481
	XA(1)=0.0	COVA 482
	YA(1)=0.0	COVA 483
	NG=1	COVA 484
	NNRC=NRC-1	COVA 485
	DC520I=1,NRC	COVA 486
	II=1+1	COVA 487
	DC520J=II,NRC	COVA 488
	DC510K=1,NV	COVA 489
	FMT(K)=A(K,I)	COVA 490
	C(K)=A(K,J)	COVA 491
510	CCONTINUE	COVA 492
	WRITECUTPLTTAPE6,950,HEAD	COVA 493
	WRITECUTPLTTAPE6,980,WORD1,WORD2,1,NG,J	COVA 494
	CALL APLCT (1,NV,1,1,XA,YA)	COVA 495
	NG=NG+1	COVA 496
520	CCONTINUE	COVA 497
320	CCONTINUE	COVA 498
	GCTG(321,330),IEXIT	COVA 499
321	IF(ISIR)330,325,330	COVA 500
325	CALLRCTATE(NV,NRC)	COVA 501
	IEXIT=2	COVA 502
	IPLAW=XMCCF(ICRAW,10)	COVA 503
B	WORD1=676C51466321	COVA 504
	DC324KK=1,NRC	COVA 505
	SUM=0.0	COVA 506
	DC323I=1,NV	COVA 507
323	SUM=SUM+A(I,KK)**2	COVA 508
324	FMT(KK)=SUM	COVA 509
	GCTG305	COVA 510
330	IF (VCRP) 600,331,600	COVA 511
600	DC 605J=1,NRC	COVA 512
	J10 =(J-1) *10+1	COVA 513
	DC 601 I=1,NV	COVA 514
601	MM(I) = ABSF(A(I,J))*1000.	COVA 515
	CALL HIGHC (MM,LARGEI,NV,LARGEI)	COVA 516
	IF(LARGEI-MINBIJ) 1241,605,605	COVA 517
605	IFMT(J10) = LARGEI	COVA 518

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      CALL COVCRP (NV,NRO ,PUN)
      IF (MINBIJ+1)332,331,331
332 MINBIJ = MINBIJ + 1
      GC IC 1241
331 WRITECUTPLTTAPE6,950,HEAD
      WRITECUTPLTTAPE6,975
      NRN = NNRN
      IF(MCDF-2)899,2026,899
899 GC IC 17
400 CALLEXIT
901 FORMAT(12A6)
902 FORMAT(1HC,10X,54HCOLUMBIA VECTOR ANALYSIS PROGRAM MANSON AND IMBR
      1IE /1H0,10X,12HPROBLEM NAME ,24X,A6,1X/1H0,1X,
      2 72HNUMBER OF FORMAT CARDS,10X,110/1H0,10X,19HNUMBER OF VARIC
      3ABLES,13X,110/1H0,10X,11HSAMPLE SIZE, 21X,110/1H0,10X,8HROTATION,2
      48X,A6/1H0,10X,13HCOMMUNALITIES,23X,A6/
      5
      6 1H0,10X,27HMAXIMUM NUMBER FOR ROTATION,5X,110)
903 FORMAT( 3H0 ,2A6 /12H NO. NAME ,12X,4HMEAN,9X,2H ,12X,COVA
      16HST DEV,8X,2H ,13X,4HSEW,17X,8HKURTOSIS//)
904 FORMAT(1H 14,1X,A6,2(F17.3, 11X ),2(F17.3,A6))
905 FORMAT(2HC , 15HSE - SKEW =F9.3,55X,27H* SIGNIFICANT AT .05 COVA
      1LEVEL /2X,15HSE - KURTOSIS =F9.3,54X,28H** SIGNIFICANT AT .01 LEVCOVA
      2EL)
911 FORMAT(1HC)
912 FORMAT(1H )
927 FORMAT(1HC,10X,24HMATRIX CANNOT BE ROTATED,/1H0,10X,28H- - - CHECCOVA
      1K YOUR PROCB. CARD)
950 FORMAT(1H1,21A6 /)
951 FORMAT(3HC ,2A6 ,/11H NO. NAME,12110)
952 FORMAT(1HC,14,1X,A6,12F10.3)
954 FORMAT(1HC, 50X,22HMATRIX TO BE FACTURED )
955 FORMAT(1HC, 9X,29HTABLE OF POSITIVE EIGENVALUES//36X,27HPERCENT OFCOVA
      1 COMMUNALITY OVER/10X,25HNO. EIGENVALUE ALL (,14,9H) FACTORS,COVA
      217,16H ROTATED FACTORS)
956 FORMAT(112,F12.3,F13.1,F8.1,F14.1,F8.1)
957 FORMAT(1HC,9X,24HTRACE OF ORIGINAL MATRIX,F16.3/10X,16HCOMMUNALITYCOVA
      1 OVER,14,10H FACTORS =,F10.3/130,10H FACTORS =,F10.3)
960 FORMAT(1HC/27X,A6,A6,14HFACTOR MATRIX/1H0,14X,13HFACTOR NUMBER,18COVA
      1,9110)
961 FORMAT(28H SUM SQUARES DOWN COLUMNS ,10F10.3)
962 FORMAT(3HC ,2A6, 11HCOMMUNALITY/12H NO. NAME,15,9H FACTORSCOVA
      1)
963 FORMAT(1H ,14,2X,A6,F10.3,F15.3,9F10.3)
964 FORMAT (13,9F7.4)
970 FORMAT(1HC,//10X,110,2X,49HITERATIONS AND STILL NO CONVERGENCE --
      11 QUIT....)
974 FORMAT(1HC//1H0,19HPCOB. CANNOT BE RUN/1H050HCHECK NO. OF FORMAT COVA
      1ARDS AND COMMUNALITIES OPTION)
975 FORMAT(1HC,//20X,19HPROBLEM IS FINISHED)
980 FORMAT(1HC,4X,2A6,7HFACTORS,35X,17HORDINATE - FACTOR,14/7X,8HPLUT COVA
      1NC.,15,39X,17HABCISSA -- FACTOR,14)
985 FORMAT(1HC,10X,A6,21HMODE FACTOR ANALYSIS /1H0,10X,A6,A6,15H TRANSCOVA
      1FORMATION )
990 FORMAT (2FO 2A6 , /12H NO. NAME ,12X,4HMEAN,9X,2H ,12X,
      16HSUM SQ,4X,12HSQ RT SUM SQ ,7X,4HSEW,17X,8HKURTOSIS //)
995 FORMAT (1H ,14,1X,A6,F17.3,11X,F17.3,F11.3,2(F17.3,A6))
      END
      LABEL
C JACOBI SUBROUTINE
      SUBROUTINE JACOBI (NV,IWARN)
C
      DIMENSIONF(100,100),B(100,100),C(100),VAL(100),MM(101) ,IFMT(100)
      COMMONCNR,B,C,VAL,MM
      EQUIVALENCE (VAL,IFMT)
      IWARN=1
      FNV=NV
      RCRT=0.0
      RCGI2=0.70710678
      MAXIT=3*NV*NV
      CMIN=0.001
      CMAX=1.0E8
      NAV=NV-1
      ITER=0
      ICYCLE=0

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CRIT=0.5E-05	COVA 594
DC20I=1,NNV	COVA 595
B(I,1)=1.0	COVA 596
II=1+1	COVA 597
DC20J=II,NV	COVA 598
B(I,J)=0.0	COVA 599
B(J,1)=0.0	COVA 600
IF(RCRIT-ABSF(R(I,J)))15,20,20	COVA 601
15 RCRIT=ABSF(R(I,J))	COVA 602
20 CONTINUE	COVA 603
RCRIT=RCRIT*0.9	COVA 604
B(NV,NV)=1.0	COVA 605
25 CONTINUE	COVA 606
ICYCLE=ICYCLE+1	COVA 607
DC5555IDEX=1,NNV	COVA 608
IPLUS=IDEX+1	COVA 609
DC5555JDEX=IPLUS,NV	COVA 610
IF(RCRIT-ABSF(R(IDEX,JDEX)))45,5555,5555	COVA 611
45 SENSELIGHT2	COVA 612
ITER=ITER+1	COVA 613
RIJ=R(IDEX,JDEX)	COVA 614
RII=R(IDEX,IDEX)	COVA 615
RJJ=R(JDEX,JDEX)	COVA 616
SFAC=1.0	COVA 617
C=(2.0*RIJ)/(RII-RJJ)	COVA 618
IFDIVIDEC+ECK90,65	COVA 619
65 AC=C	COVA 620
IF(C)70,125,75	COVA 621
70 AC=ABSF(C)	COVA 622
SFAC=-1.0	COVA 623
75 IF(AC-CMIN)125,125,80	COVA 624
80 IF(AC-CMAX)85,90,90	COVA 625
85 CONTINUE	COVA 626
CCC=1.0/SQRTF(1.0+C*C)	COVA 627
BCCS=RCOT2*SQRTF(1.0+CCC)	COVA 628
BSIN=SFAC*RCOT2*SQRTF(1.0-CCC)	COVA 629
GCTC199	COVA 630
50 CONTINUE	COVA 631
BCCS=RCOT2	COVA 632
BSIN=RCOT2	COVA 633
GCTC199	COVA 634
125 CONTINUE	COVA 635
BSIN=C/2.0	COVA 636
BCCS=1.0-(BSIN*BSIN)/2.0	COVA 637
159 CONTINUE	COVA 638
DC220I=1,NV	COVA 639
CELL=BCCS*R(I,IDEX)+BSIN*R(I,JDEX)	COVA 640
R(I,JDEX)=BCCS*R(I,JDEX)-BSIN*R(I,IDEX)	COVA 641
R(JDEX,I)=R(I,JDEX)	COVA 642
R(I,IDEX)=CELL	COVA 643
R(IDEX,I)=CELL	COVA 644
CELL=BCCS*B(IDEX,I)+BSIN*B(JDEX,I)	COVA 645
B(JDEX,I)=BCCS*B(JDEX,I)-BSIN*B(IDEX,I)	COVA 646
B(IDEX,I)=CELL	COVA 647
220 CONTINUE	COVA 648
CELL=BCCS*BSIN	COVA 649
CCS2=BCCS**2	COVA 650
SIN2=BSIN**2	COVA 651
R(IDEX,JDEX)=CCS2*RIJ-SIN2*RIJ+(RJJ-RII)*CELL	COVA 652
R(JDEX,IDEX)=R(IDEX,JDEX)	COVA 653
CELL=2.0*RIJ*CELL	COVA 654
R(IDEX,IDEX)=CCS2*RII+SIN2*RJJ+CELL	COVA 655
R(JDEX,JDEX)=SIN2*RII+CCS2*RJJ-CELL	COVA 656
IF(ITER-MAXIT)5555,1313,1313	COVA 657
1313 CONTINUE	COVA 658
IWARN=2	COVA 659
WRITECUTPLT TAPE6,899	COVA 660
DC1315I=1,5	COVA 661
WRITECUTPLT TAPE6,900,ITER	COVA 662
1315 CONTINUE	COVA 663
GCTC350	COVA 664
859 FORMAT(1H1)	COVA 665
900 FORMAT(1H0, //10X, I10, 2X, 49HITERATIONS AND STILL NO CONVERGENCE --	COVA 666
11 QUIT....)	COVA 667
5555 CONTINUE	COVA 668

IF(SENSELIGHT2)25,300	COVA 669
300 IF(RCRIT-CRIT)350,350,310	COVA 670
310 RCRIT=RCRIT/5.0	COVA 671
GCTC25	COVA 672
350 CONTINUE	COVA 673
DC380I=1,NV	COVA 674
VAL(1)=-5000.0	COVA 675
DC370J=1,NV	COVA 676
IF(R(J,J)+999999.0)360,370,360	COVA 677
360 IF(VAL(1)-R(J,J))365,365,370	COVA 678
365 VAL(1)=R(J,J)	COVA 679
MM(1)=J	COVA 680
370 CONTINUE	COVA 681
K=MM(1)	COVA 682
R(K,K)=-999999.0	COVA 683
380 CONTINUE	COVA 684
DC400I=1,NV	COVA 685
K=MM(1)	COVA 686
SFAC=SQRT(ABS(VAL(1)))	COVA 687
DC400J=1,NV	COVA 688
R(J,I)=R(K,J)*SFAC	COVA 689
400 CONTINUE	COVA 690
MAXIT=ITER	COVA 691
1500 RETURN	COVA 692
END	COVA 693
* LABEL	COVA 694
C ROTATE SUBROUTINE	COVA 695
C ROTATE SUBROUTINE FOR 100 BY 100	COVA 696
SUBROUTINE ROTATE(N,L)	COVA 697
DIMENSIONA(100,100),P(100,100),H(100),TV(100),IFMT(100)	COVA 698
COMMONA,P,H,TV	COVA 699
EQUIVALENCE(H,IFMT)	COVA 700
EPS=0.00116	COVA 701
JTEST=3	COVA 702
P=1.0	COVA 703
NCCUNT=0	COVA 704
MM=(L*(1-1))/2	COVA 705
TV(1)=0.0	COVA 706
LL=L-1	COVA 707
NV=1	COVA 708
NC=0	COVA 709
FN=N	COVA 710
FFN=FN**2	COVA 711
GENS=1.0/SQRT(2.0)	COVA 712
ZERC=1.E-4	COVA 713
DC 3 I=1,N	COVA 714
3 H(I)=0.0	COVA 715
DC 4 I=1,N	COVA 716
DC 4 J=1,L	COVA 717
4 H(I)=H(I)+A(I,J)*A(I,J)	COVA 718
DC 5 I=1,N	COVA 719
H(I)=SQRT(H(I))	COVA 720
DC 5 J=1,L	COVA 721
5 A(I,J)=H(I,J)/H(I)	COVA 722
222 NV=NV+1	COVA 723
TV(NV)=0.0	COVA 724
LV=NV-1	COVA 725
DC 88 J=1,L	COVA 726
AA=0.0	COVA 727
BB=0.0	COVA 728
DC 77 I=1,N	COVA 729
CC=A(I,J)*A(I,J)	COVA 730
AA=AA+CC	COVA 731
77 BB=BB+CC**2	COVA 732
88 TV(NV)=TV(NV)+(FN*BB-AA**2)/FFN	COVA 733
IF(NV-50)9,999,999	COVA 734
9 IF(ABS(TV(NV)-TV(LV))-1.E-7)11,11,13	COVA 735
11 NC=NC+1	COVA 736
12 IF(NC-JTEST)13,13,999	COVA 737
13 DC 500 J=1,LL	COVA 738
II=J+1	COVA 739
DC 500 K=II,L	COVA 740
IF(NCCUNT-MM)32,500,500	COVA 741
32 IF(ABS(P)-ZERC)14,14,13	COVA 742
10 NCCUNT=0	COVA 743

14	AA=0.0	COVA 744
	BB=0.0	COVA 745
	CC=0.0	COVA 746
	DC=0.0	COVA 747
	DC15 I=1,N	COVA 748
	U=(A(I,J)+A(I,K))*(A(I,J)-A(I,K))	COVA 749
	T=A(I,J)*A(I,K)	COVA 750
	T=T+T	COVA 751
	CC=CC+(U+T)*(U-T)	COVA 752
	DC=DC+2.0*U*T	COVA 753
	AA=AA+U	COVA 754
15	BB=BB+T	COVA 755
	T=DU-2.0*AA*BB/FN	COVA 756
	B=CC-(AA**2-BB**2)/FN	COVA 757
	P=0.25*ATANF(T/D)	COVA 758
	IF(ABSF(P)-ZER0)7,7,69	COVA 759
7	NCCUNT=NCCUNT+1	COVA 760
	GC TC 500	COVA 761
69	TAN4P=T/D	COVA 762
	IF(T-B)1041,1433,1042	COVA 763
1433	IF(T+B-EPS)500,1043,1043	COVA 764
1043	CCS4T=CCNS	COVA 765
	SIN4T=CCNS	COVA 766
	GCTU5000	COVA 767
1041	TAN4T=ABSF(T)/ABSF(B)	COVA 768
	IF(TAN4T-EPS)8000,1100,1100	COVA 769
1100	CCS4T=1.0/SQRTF(1.0+TAN4T**2)	COVA 770
	SIN4T=TAN4T*CCS4T	COVA 771
	GCTU5000	COVA 772
8000	IF(B)1150,500,500	COVA 773
1150	SINP=CCNS	COVA 774
	CCSP=CCNS	COVA 775
	GCTU1000	COVA 776
1042	CTN4T=ABSF(T/B)	COVA 777
	IF(CTN4T-EPS)9000,1200,1200	COVA 778
1200	SIN4T=1.0/SQRTF(1.0+CTN4T**2)	COVA 779
	CCS4T=CTN4T*SIN4T	COVA 780
	GCTU5000	COVA 781
9000	CCS4T=0.0	COVA 782
	SIN4T=1.0	COVA 783
5000	CCS2T=SQRIF((1.0+CCS4T)/2.0)	COVA 784
	SIN2T=SIN4T/(2.0*CCS2T)	COVA 785
	CCST=SQRIF((1.0+CCS2T)/2.0)	COVA 786
	SINT=SIN2T/(2.0*CCST)	COVA 787
	IF(B)1250,1250,1300	COVA 788
1300	CCSP=CCST	COVA 789
	SINP=SINT	COVA 790
	GCTU7000	COVA 791
1250	CCSP=CCNS*CCST+CCNS*SINT	COVA 792
	SINP=ABSF(CCNS*CCST-CCNS*SINT)	COVA 793
7000	IF(T)1400,1400,1000	COVA 794
1400	SINP=-SINP	COVA 795
1000	DC 100 I=1,N	COVA 796
	AA=A(I,J)*CCSP+A(I,K)*SINP	COVA 797
	BB=-A(I,J)*SINP+A(I,K)*CCSP	COVA 798
	A(I,J)=AA	COVA 799
100	A(I,K)=BB	COVA 800
500	CCNTINUF	COVA 801
	GC TC 222	COVA 802
999	DC 6 I=1,N	COVA 803
	DC 6 J=1,L	COVA 804
6	A(I,J)=A(I,J)*H(I)	COVA 805
	RETURN	COVA 806
	END	COVA 807
*	LABEL	COVA 808
C AFLCT	SUBROUTINE	COVA 809
	SUBROUTINE APLCT (L,N,NXAXIS,NYAXIS,XA,YA)	COVA 810
	DIMENSION Y(100),X(100),PLOT(50,12),XA(2),YA(2),OUT(8),B(99),ALPHA	COVA 811
	1(275),DUM*1(100,100),DUMM2(100,100)	COVA 812
	CCPMCN Y,DUMM1,DUMM2,X	COVA 813
1	FCRMT(1H,84X5HALPHA,10X14HIDENTIFICATION)	COVA 814
2	FCRMT(1H,6X1H.,12A6,1H.,11(2XA2))	COVA 815
3	FCRMT(1H,7X,7(10H+.....),1H+,1H.,1H+)	COVA 816
4	FCRMT(1H,4XF6.2,4XF6.2,4XF6.2,4XF6.2,4X6.2,4XF6.2,4XF6.2,4XF6.2)	COVA 817
5	FCRMT(1H,F6.2,1H+,12A6,1H+,11(2XA2))	COVA 818
6	FCRMT(1H0,2HDX,2XF8.4,2X2HDY,2XF8.4)	COVA 819

LSAV = L	CGVA 820
NSAV = N	CGVA 821
XL = X(L)	CGVA 822
XS = X(I)	CGVA 823
YL = Y(L)	CGVA 824
YS = Y(I)	CGVA 825
N = N+L-1	CGVA 826
DC 14 I=L,N	CGVA 827
IF(XL-X(I))7,8,8	CGVA 828
7 XL = X(I)	CGVA 829
8 IF(XS-X(I))10,10,9	CGVA 830
9 XS = X(I)	CGVA 831
10 IF(YL-Y(I))11,12,12	CGVA 832
11 YL = Y(I)	CGVA 833
12 IF(YS-Y(I))14,14,13	CGVA 834
13 YS = Y(I)	CGVA 835
14 CCNTINUE	CGVA 836
IF(XL-XS)102,102,15	CGVA 837
15 IF(YL-YS)102,102,16	CGVA 838
16 DX = (XL-XS)/35.0	CGVA 839
DY = (YL-YS)/49.0	CGVA 840
DC 300 K = 1,50	CGVA 841
DC 300 J = 1,12	CGVA 842
300 PLOT(K,J) = (+6H)	CGVA 843
DC 200 I = 1,275	CGVA 844
200 ALPHA(I) = (+6H)	CGVA 845
ALPHA(1) = (+6HAAAAAA)	CGVA 846
ALPHA(12) = (+6HBBBBBB)	CGVA 847
ALPHA(23) = (+6HCCCCCC)	CGVA 848
ALPHA(34) = (+6HDDDDDD)	CGVA 849
ALPHA(45) = (+6HEEEEEEE)	CGVA 850
ALPHA(56) = (+6HFFFFFF)	CGVA 851
ALPHA(67) = (+6HGGGGGG)	CGVA 852
ALPHA(78) = (+6HHHHHH)	CGVA 853
ALPHA(89) = (+6HJJJJJJ)	CGVA 854
ALPHA(100) = (+6HKKKKKK)	CGVA 855
ALPHA(111) = (+6HLLLLLL)	CGVA 856
ALPHA(122) = (+6HMMMMMM)	CGVA 857
ALPHA(133) = (+6HNNNNNN)	CGVA 858
ALPHA(144) = (+6HOOOOOO)	CGVA 859
ALPHA(155) = (+6HPPPPPP)	CGVA 860
ALPHA(166) = (+6HQQQQQQ)	CLVA 861
ALPHA(177) = (+6HRRRRRR)	CUVA 862
ALPHA(188) = (+6HSSSSSS)	CGVA 863
ALPHA(199) = (+6HTTTTTT)	CGVA 864
ALPHA(210) = (+6HUUUUUU)	CGVA 865
ALPHA(221) = (+6HVVVVVV)	CGVA 866
ALPHA(232) = (+6HWWWWW)	CGVA 867
ALPHA(243) = (+6HXXXXXX)	CGVA 868
ALPHA(254) = (+6HYYYYYY)	CGVA 869
ALPHA(265) = (+6HZZZZZZ)	CGVA 870
B(1) = 000100010001	CGVA 871
B(2) = 000200020002	CGVA 872
B(3) = 000300030003	CLVA 873
B(4) = 000400040004	CGVA 874
B(5) = 000500050005	CUVA 875
B(6) = 000600060006	CGVA 876
B(7) = 000700070007	CLVA 877
B(8) = 001000100010	CGVA 878
B(9) = 001100110011	CGVA 879
B(10) = 010001000100	CGVA 880
B(11) = 010101010101	CGVA 881
B(12) = 010201020102	CGVA 882
B(13) = 010301030103	CGVA 883
B(14) = 010401040104	CGVA 884
B(15) = 010501050105	CGVA 885
B(16) = 010601060106	CGVA 886
B(17) = 010701070107	CGVA 887
B(18) = 011001100110	CGVA 888
B(19) = 011101110111	CGVA 889
B(20) = 020002000200	CGVA 890
B(21) = 020102010201	CGVA 891
B(22) = 020202020202	CGVA 892
B(23) = 020302030203	CGVA 893
B(24) = 020402040204	CGVA 894

B(25) = 020502050205
 B(26) = 020602060206
 B(27) = 020702070207
 B(28) = 021002100210
 B(29) = 021102110211
 B(30) = 020003000300
 B(31) = 030103010301
 B(32) = 030203020302
 B(33) = 030303030303
 B(34) = 030403040304
 B(35) = 030503050305
 B(36) = 030603060306
 B(37) = 030703070307
 B(38) = 031003100310
 B(39) = 031103110311
 B(40) = 040004000400
 B(41) = 040104010401
 B(42) = 040204020402
 B(43) = 040304030403
 B(44) = 040404040404
 B(45) = 040504050405
 B(46) = 040604060406
 B(47) = 040704070407
 B(48) = 041004100410
 B(49) = 041104110411
 B(50) = 050005000500
 B(51) = 050105010501
 B(52) = 050205020502
 B(53) = 050305030503
 B(54) = 050405040504
 B(55) = 050505050505
 B(56) = 050605060506
 B(57) = 050705070507
 B(58) = 051005100510
 B(59) = 051105110511
 B(60) = 060006000600
 B(61) = 060106010601
 B(62) = 060206020602
 B(63) = 060306030603
 B(64) = 060406040604
 B(65) = 060506050605
 B(66) = 060606060606
 B(67) = 060706070607
 B(68) = 061006100610
 B(69) = 061106110611
 B(70) = 070007000700
 B(71) = 070107010701
 B(72) = 070207020702
 B(73) = 070307030703
 B(74) = 070407040704
 B(75) = 070507050705
 B(76) = 070607060706
 B(77) = 070707070707
 B(78) = 071007100710
 B(79) = 071107110711
 B(80) = 100010001000
 B(81) = 100110011001
 B(82) = 100210021002
 B(83) = 100310031003
 B(84) = 100410041004
 B(85) = 100510051005
 B(86) = 100610061006
 B(87) = 100710071007
 B(88) = 101010101010
 B(89) = 101110111011
 B(90) = 110011001100
 B(91) = 110111011101
 B(92) = 110211021102
 B(93) = 110311031103
 B(94) = 110411041104
 B(95) = 110511051105
 B(96) = 110611061106
 B(97) = 110711071107
 B(98) = 111011101110
 B(99) = 111111111111

COVA 895
 COVA 896
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 COVA 967
 COVA 968
 COVA 969

IF(NXAXIS)32,32,17	CGVA 970
17 DC 31 I = 1,NXAXIS	CGVA 971
IF(XA(I)-XS)31,18,18	CGVA 972
18 IF(XA(I)-XL)19,19,31	CGVA 973
19 DIFX = XA(I)-XS	CGVA 974
DELX = "X	CGVA 975
J = 1	CGVA 976
20 IPGS = 1	CGVA 977
21 IF(DIFX-DELX)24,22,22	CGVA 978
22 DELX = DELX+CX	CGVA 979
IPGS = IPGS+2	CGVA 980
IF(IPGS-5)21,21,23	CGVA 981
23 J = J+1	CGVA 982
GC TC 24	CGVA 983
24 GC TC (25,25,27,27,29,29),IPGS	CGVA 984
25 DC 26 K = 1,50	CGVA 985
26 PLCT(K,J) = (+6H I)	CGVA 986
GC TC 31	CGVA 987
27 DC 28 K = 1,50	CGVA 988
28 PLCT(K,J) = (+6H I)	CGVA 989
GC TC 31	CGVA 990
29 DC 30 K = 1,50	CGVA 991
30 PLCT(K,J) = (+6H I)	CGVA 992
31 CCNTINUE	CGVA 993
32 IF(NYAXIS)41,41,33	CGVA 994
33 DC 40 I = 1,NYAXIS	CGVA 995
IF(YA(I)-YS)40,34,34	CGVA 996
34 IF(YA(I)-YL)35,35,40	CGVA 997
35 DIFY = YA(I)-YS	CGVA 998
DELY = DY	CGVA 999
K = 1	CGVA1000
36 IF(DIFY-DELY)38,37,37	CGVA1001
37 DELY = DELY+DY	CGVA1002
K = K+1	CGVA1003
GC TC 36	CGVA1004
38 DC 39 J = 1,12	CGVA1005
39 PLCT(K,J) = (+6H-----)	CGVA1006
40 CCNTINUE	CGVA1007
41 DC 88 I = 1,N	CGVA1008
DELX = DX	CGVA1009
DELY = DY	CGVA1010
DIFX = X(I)-XS	CGVA1011
DIFY = Y(I)-YS	CGVA1012
J = 1	CGVA1013
K = 1	CGVA1014
42 IF(DIFY-DELY)44,43,43	CGVA1015
43 DELY = DELY+DY	CGVA1016
K = K+1	CGVA1017
GC TC 42	CGVA1018
44 IPGS = 1	CGVA1019
45 IF(DIFX-DELX)48,46,46	CGVA1020
46 DELX = DELX+CX	CGVA1021
IPGS = IPGS+2	CGVA1022
IF(IPGS-5)45,45,47	CGVA1023
47 J = J+1	CGVA1024
GC TC 44	CGVA1025
48 GC TC (49,49,62,62,75,75),IPGS	CGVA1026
B 49 D = (606000000000+(777000000000*PLOT(K,J)))*(-(606000000000*PLOT(K	CGVA1027
1,J)))	CGVA1028
B E = (404000000000+(777000000000*PLOT(K,J)))*(-(404000000000*PLOT(K	CGVA1 29
1,J)))	CGVA1030
B F = (003100000000+(007700000000*PLOT(K,J)))*(-(003100000000*PLOT(K	CGVA1031
1,J)))	CGVA1032
B G = 600000000000*PLCT(K,J)	CGVA1033
B IF(D)50,53,50	CGVA1034
B 50 IF(E)51,53,51	CGVA1035
B 51 IF(F)52,53,52	CGVA1036
B 52 IF(G)57,54,57	CGVA1037
B 53 PLCT(K,J) = (000077777777*PLOT(K,J))+(777000000000*B(I))	CGVA1038
GC TC 88	CGVA1039
B 54 DC 55 M = 2,266,11	CGVA1040
IF(ALPHA(M)-(+6H)55,56,55	CGVA1041
55 CCNTINUE	CGVA1042
GC TC 88	CGVA1043
56 ALPHA(M) = PLOT(K,J)	CGVA1044
ALPHA(M+1) = B(I)	CGVA1045

B	PLCT(K,J) = (00007777777*PLCT(K,J))+(7770000000*ALPHA(M-1))	CCVA1046
	GC TC 88	CCVA1047
57	DC 58 M = 1,265,11	CCVA1048
B	IF((77770000000*PLCT(K,J))+(77770000000*(-(ALPHA(M))))58,59,58	CCVA1049
58	CONTINUE	CCVA1050
	GC TC 88	CCVA1051
59	JJ = M+2	CCVA1052
	KK = M+10	CCVA1053
	DC 60 MM = JJ, KK	CCVA1054
	IF(ALPHA(MM)-(1+6H))60,61,60	CCVA1055
60	CONTINUE	CCVA1056
	GC TC 88	CCVA1057
61	ALPHA(MM) = B(I)	CCVA1058
	GC TC 88	CCVA1059
B	62 D = (00006000000+(000077770000*PLCT(K,J)))*(-(00006000000*PLCT(KC	CCVA1060
	1,J)))	CCVA1061
B	E = (000040400000+(000077770000*PLCT(K,J)))*(-(000040400000*PLCT(KC	CCVA1062
	1,J)))	CCVA1063
B	F = (000000310000+(000000770000*PLCT(K,J)))*(-(000000310000*PLCT(KC	CCVA1064
	1,J)))	CCVA1065
B	G = 00006000000*PLCT(K,J)	CCVA1066
B	IF(D)63,66,63	CCVA1067
B	63 IF(E)64,66,64	CCVA1068
B	64 IF(F)65,66,65	CCVA1069
B	65 IF(G)70,67,70	CCVA1070
B	66 PLCT(K,J) = (777700007777*PLCT(K,J))+(000077770000*B(I))	CCVA1071
	GC TC 88	CCVA1072
67	DC 68 M = 2,266,11	CCVA1073
	IF(ALPHA(M)-(1+6H))68,69,68	CCVA1074
68	CONTINUE	CCVA1075
	GC TC 88	CCVA1076
69	A = PLCT(K,J)	CCVA1077
	E = 1	CCVA1078
	CALL MCVE(A,E,12,1)	CCVA1079
	ALPHA(M) = E	CCVA1080
	ALPHA(M+1) = B(I)	CCVA1081
B	PLCT(K,J) = (777700007777*PLCT(K,J))+(000077770000*ALPHA(M-1))	CCVA1082
	GC TC 88	CCVA1083
70	DC 71 M = 1,265,11	CCVA1084
B	IF((000077770000*PLCT(K,J))+(000077770000*(-(ALPHA(M))))71,72,71	CCVA1085
71	CONTINUE	CCVA1086
	GC TC 88	CCVA1087
72	JJ = M+2	CCVA1088
	KK = M+10	CCVA1089
	DC 73 MM = JJ, KK	CCVA1090
	IF(ALPHA(MM)-(1+6H))73,74,73	CCVA1091
73	CONTINUE	CCVA1092
	GC TC 88	CCVA1093
74	ALPHA(MM) = B(I)	CCVA1094
	GC TC 88	CCVA1095
B	75 D = (000000006060+(000000007777*PLCT(K,J)))*(-(000000006060*PLCT(KC	CCVA1096
	1,J)))	CCVA1097
B	E = (000000004040+(000000007777*PLCT(K,J)))*(-(000000004040*PLCT(KC	CCVA1098
	1,J)))	CCVA1099
B	F = (000000000031+(000000000077*PLCT(K,J)))*(-(000000000031*PLCT(KC	CCVA1100
	1,J)))	CCVA1101
B	G = 000000006000*PLCT(K,J)	CCVA1102
B	IF(D)76,75,76	CCVA1103
76	IF(E)77,75,77	CCVA1104
77	IF(F)78,75,78	CCVA1105
78	IF(G)83,80,83	CCVA1106
B	79 PLCT(K,J) = (777777770000*PLCT(K,J))+(000000007777*B(I))	CCVA1107
	GC TC 88	CCVA1108
80	DC 81 M = 2,266,11	CCVA1109
	IF(ALPHA(M)-(1+6H))81,82,81	CCVA1110
81	CONTINUE	CCVA1111
	GC TC 88	CCVA1112
82	A = PLCT(K,J)	CCVA1113
	E = 1	CCVA1114
	CALL MCVE(A,E,24,1)	CCVA1115
	ALPHA(M) = E	CCVA1116
	ALPHA(M+1) = B(I)	CCVA1117
B	PLCT(K,J) = (777777770000*PLCT(K,J))+(000000007777*ALPHA(M-1))	CCVA1118
	GC TC 88	CCVA1119
83	DC 84 M = 1,265,11	CCVA1120
B	IF((000000007777*PLCT(K,J))+(000000007777*(-(ALPHA(M))))84,85,84	CCVA1121

84	CONTINUE		COVA1122
	GC TC 88		COVA1123
85	JJ = M+7		COVA1124
	KK = M+10		COVA1125
	DC 86 MM = JJ, KK		COVA1126
	IF (ALPHA(M) - (+6H	)) 86, 87, 86	COVA1127
86	CONTINUE		COVA1128
	GC TC 88		COVA1129
87	ALPHA(MM) = B(I)		COVA1130
88	CONTINUE		COVA1131
	WRITE CUTFUT TAPE 6, 1		COVA1132
	K = 50		COVA1133
	P = YL		COVA1134
	L = 41		COVA1135
	B = 40.0		COVA1136
	M = 2		COVA1137
89	IF (M-266) 50, 90, 92		COVA1138
90	IF (ALPHA(M) - (+6H	)) 91, 92, 91	COVA1139
91	MM = M-1		COVA1140
	NN = M+9		COVA1141
	WRITE CUTFUT TAPE 6, 5, P, (PLOT(K, J), J=1, 12), (ALPHA(I), I=MM, NN)		COVA1142
	GC TC 93		COVA1143
92	WRITE CUTFUT TAPE 6, 5, P, (PLOT(K, J), J=1, 12)		COVA1144
93	M = M+11		COVA1145
	K = K-1		COVA1146
	IF (K) 100, 100, 94		COVA1147
94	IF (K-L) 96, 95, 96		COVA1148
95	P = YS + (B * CY)		COVA1149
	L = L-10		COVA1150
	B = B-10.0		COVA1151
	GC TC 89		COVA1152
96	IF (M-266) 57, 97, 99		COVA1153
97	IF (ALPHA(M) - (+6H	)) 98, 99, 98	COVA1154
98	MM = M-1		COVA1155
	NN = M+9		COVA1156
	WRITE CUTFUT TAPE 6, 2, (PLOT(K, J), J=1, 12), (ALPHA(I), I=MM, NN)		COVA1157
	GC TC 93		COVA1158
99	WRITE CUTFUT TAPE 6, 2, (PLOT(K, J), J=1, 12)		COVA1159
	GC TC 93		COVA1160
100	WRITE CUTFUT TAPE 6, 3		COVA1161
	A = 0.0		COVA1162
	DC 101 M = 1, 8		COVA1163
	OUT(M) = XS + (A * DX)		COVA1164
101	A = A+5.0		COVA1165
	WRITE CUTFUT TAPE 6, 4, (OUT(M), M=1, 8)		COVA1166
	WRITE CUTFUT TAPE 6, 6, DX, DY		COVA1167
	L = LSAV		COVA1168
	N = NSAV		COVA1169
102	RETURN		COVA1170
	END		COVA1171
	FAP		COVA1172
	ENTRY MCVE		COVA1173
MCVE	CLA 2, 4		COVA1174
	STA EB		COVA1175
	CLA 4, 4		COVA1176
	STA HERE		COVA1177
HERE	CLA		COVA1178
	TZE RITE		COVA1179
	CLA 1, 4		COVA1180
	STA AA		COVA1181
	CLA 3, 4		COVA1182
	STA NEXT		COVA1183
NEXT	CLA		COVA1184
	ARS 18		COVA1185
	STA NPL		COVA1186
	AA CAL		COVA1187
	NPL ALS		COVA1188
	TCV EB		COVA1189
	TRA EB		COVA1190
RITE	CLA 1, 4		COVA1191
	STA AR		COVA1192
	CLA 3, 4		COVA1193
	STA TEMP		COVA1194
TEMP	CLA		COVA1195
	ARS 18		COVA1196
	STA NPRT		COVA1197

AR CAL	CGVAL198
NFRT ARS	CGVAL199
BB SLW	CGVAL200
IRA 5,4	CGVAL201
END	CGVAL202
* LABEL	CGVAL203
C COVERP SUBROUTINE	CGVAL204
C	CGVAL205
SUBROUTINE COVERP (N,M,PUN)	CGVAL206
DIMENSION B(100,10),V(10,10),C(100,11),INDEX(100),BFAKE(10,1),	CGVAL207
IC1(10,100,11),DUM1(679,10),ITEST(10,10),DUM(101),NAME(21),TAG(100)	CGVAL208
2,VARTAG(10),IFMT(100)	CGVAL209
COMMON B,V,C,INDEX,BFAKE,C1,DUM1,ITEST,DUM,NAME,TAG	CGVAL210
EQUIVALENCE(ITEST,IFMT)	CGVAL211
C FORM V MATRIX	CGVAL212
NCRD = 1	CGVAL213
KIT = 1	CGVAL214
M1 = (M+1)*2	CGVAL215
R = 10000.	CGVAL216
25 IF (KIT - M1)26,221,221	CGVAL217
221 IF (R-1.) 223,232,223	CGVAL218
223 R = R/10.	CGVAL219
232 KIT = 1	CGVAL220
26 DO 37 K = 1,M	CGVAL221
LINE = ITEST(KIT,K)	CGVAL222
VARTAG (K) = TAG(LINE)	CGVAL223
DO 33 J = 1, M	CGVAL224
33 V (K, J) = B (LINE, J)	CGVAL225
C	CGVAL226
C WRITE V MATRIX	CGVAL227
WRITE CUTFUT TAPE 6,3,(NAME(K),K=1,20)	CGVAL228
WRITE CUTFUT TAPE 6, 679	CGVAL229
679 FORMAT(1HC / 55X,9HV MATRIX ///)	CGVAL230
WRITE CUTFUT TAPE 6,4,(ITEST(KIT,J),J=1,M)	CGVAL231
DO 951 K = 1, M	CGVAL232
INU = ITEST(KIT,K)	CGVAL233
TAGA = TAG(INU)	CGVAL234
951 WRITE CUTFUT TAPE 6,952,TAGA,INU,(V(K,J),J=1,M)	CGVAL235
952 FORMAT (//X A6,3X, 13,2X,10F9.4)	CGVAL236
WRITE CUTFUT TAPE 6, 691	CGVAL237
691 FORMAT (1H0///)	CGVAL238
C	CGVAL239
C INVERT V MATRIX	CGVAL240
DO 10 I = 1, 10	CGVAL241
10 BFAKE (I, 1) = 0.	CGVAL242
MFAKE = 1	CGVAL243
CALL MATINV (V, M, BFAKE, MFAKE, DET)	CGVAL244
C	CGVAL245
C WRITE C INVERSE	CGVAL246
WRITE CUTFUT TAPE 6, 678	CGVAL247
678 FORMAT (1H0 49X 22FINVERSE OF V MATRIX///)	CGVAL248
DO 953 J = 1, M	CGVAL249
953 WRITE CUTFUT TAPE 6, 954, (V (J,K), K = 1, M)	CGVAL250
954 FORMAT (1H0,14X,10F9.4)	CGVAL251
CALL MPRCD (N,M)	CGVAL252
C	CGVAL253
C CHECK ANSWERS	CGVAL254
IF (R-1.) 216,233,216	CGVAL255
216 DO 220 J = 1,M	CGVAL256
DO 218 I = 1,N	CGVAL257
218 INDEX(I) = ABSF(C(I,J))*R	CGVAL258
CALL HTGFC (INDEX,LARGEI,N,LARGEI)	CGVAL259
CK = LARGEI	CGVAL260
IF (CK-R) 215,220,215	CGVAL261
215 IF (CK-CL) 214,220,214	CGVAL262
214 IF(ITEST(KIT,J)-LARGEI) 219,220,219	CGVAL263
219 KIT = KIT + 1	CGVAL264
DO 217 JC = 1,M	CGVAL265
KIN = KIT - 1	CGVAL266
217 ITEST(KIT,JC) = ITEST(KIN,JO)	CGVAL267
LARG = ITEST(KIT,J)	CGVAL268
ITEST(KIT,J) = LARGEI	CGVAL269
CL = LARGEI	CGVAL270
RR = (CL/R)-1.	CGVAL271
WRITE CUTFUT TAPE 6,704,KIN,RR	CGVAL272

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704 FORMAT(1H0 ,6X,15HITERATION CYCLE ,14,35H. HIGHEST LOADING IN C CGVA1273
      1MATRIX IS ,F5.3,20H IN EXCESS OF 1.00 /) CGVA1274
      GC TC 25 CGVA1275
220 CONTINUE CGVA1276
C CGVA1277
C RCLAD C MATRIX CGVA1278
      GC TC 233 CGVA1279
233 DC 234 K = 1, M CGVA1280
      DC 234 I = 1, N CGVA1281
234 C (I,K) = C (I,K) + .0004 CGVA1282
      LCCP = PUN CGVA1283
C WRITE ANSWERS CGVA1284
222 WRITE CPUTUT TAPE 6,3,(NAME(K),K=1,21) CGVA1285
      3 FORMAT (1H1,21A6 // 12X,28HOBlique PROJECTION PROGRAM //55X,14H CGVA1286
      1OBlique AXES //) CGVA1287
      WRITE CPUTUT TAPE 6, 4, (ITEST (KIT,K),K=1,M) CGVA1288
      4 FORMAT (6H NAME ,2X,6H INDEX ,10(6X,13)) CGVA1289
      WRITE CPUTUT TAPE 6, 5 CGVA1290
      5 FORMAT (1H0) CGVA1291
      DC 77 I = 1, N CGVA1292
77 INDEX (I) = 1 CGVA1293
      DC 88 I = 1, N CGVA1294
88 WRITE CPUTUT TAPE 6, 6, TAG(I),INDEX(I),(C(I,K),K=1,M) CGVA1295
      6 FORMAT (1H0,A6,I5,2X,10F7.3) CGVA1296
      IF (PUN) 91,91,89 CGVA1297
89 DC 90 I = 1,N CGVA1298
90 WRITE CPUTUT TAPE 7,3,INDEX(I),(C(I,K),K = 1,M) CGVA1299
      9 FORMAT (13,2X,10F6.3/5X,5F6.3) CGVA1300
91 LCCP = LCCP + 1 CGVA1301
      IF ( LCCP - 2 ) 222, 777, 777 CGVA1302
777 IF (NCHC) 778,778,777 CGVA1303
778 GC TC 111 CGVA1304
779 WRITE CPUTUT TAPE 6,8,(NAME(K) , K=1,21) CGVA1305
      WRITE CPUTUT TAPE 6,702,(VARTAG(I),I=1,M) CGVA1306
      WRITE CPUTUT TAPE 6,703,(ITEST(KIT, I) ,I=1,M) CGVA1307
      8 FORMAT (1H1,21A6 //40X,36HREORDERED OBLIQUE PROJECTION MATRIX /)CGVA1308
702 FORMAT (1H0,14H NAME ,10(2X,A6,2X)) CGVA1309
703 FORMAT (1H0,1X,10H INDEX ,10( 3X,I5,2X)/12H NAME NO. )CGVA1310
      CALL REORD (N,M) CGVA1311
      DC 1000 I = 1,100 CGVA1312
      DC 1000 K = 1,10 CGVA1313
      DC 1000 L = 1,11 CGVA1314
C CGVA1315
C CGVA1316
      INDEX(I) = 0. CGVA1317
      BFAKE(K,1) = 0. CGVA1318
      C(I,L) = 0. CGVA1319
      B(I,K) = 0. CGVA1320
      V(K,K) = 0. CGVA1321
      ITEST (K,K) = 0. CGVA1322
1000 CONTINUE CGVA1323
111 RETURN CGVA1324
      END CGVA1325
* CGVA1326
C REORDER SUBROUTINE CGVA1327
      SUBROUTINE REORD (N,M) CGVA1328
      DIMENSION B(100,10),V(10,10),C(100,11),INDEX(100),BFAKE(10,1), CGVA1329
      1C(10,100,11),DUM1(679,10),ITEST(10,10),DUM(101),NAME(21),TAG(10)CGVA1330
      2,NZ(10) ,IFMT(100) CGVA1331
      COMMON B,V,C,INDEX,BFAKE,C1,DUM1,ITEST,DUM,NAME,TAG CGVA1332
      EQUIVALENCE (ITEST,IFMT) CGVA1333
      NV1 = M + 1 CGVA1334
      DC 19 K = 1,10 CGVA1335
19 NZ(K) = 0 CGVA1336
      DC 40 I = 1,N CGVA1337
      C(I,NV1) = 1 CGVA1338
      SAVE = ABSF(C(I,1)) CGVA1339
      K = 1 CGVA1340
      DC 21 J = 2,M CGVA1341
      AF = ABSF (C(I,J)) CGVA1342
      IF (SAVE - AF ) 20,20,21 CGVA1343
20 SAVE = AF CGVA1344
      K = J CGVA1345
21 CONTINUE CGVA1346
      NZ(K) = NZ(K) + 1 CGVA1347
      NN = NZ(K) CGVA1348

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IF (NN - 99) 39,39,38	COVA1349
38 NZ(K) = NZ(K) - 1	COVA1350
39 DO 30 JK = 1,NV1	COVA1351
C1 (K,NN,JK) = C(I,JK)	COVA1352
30 CONTINUE	COVA1353
40 CONTINUE	COVA1354
DO 100 K = 1, M	COVA1355
NL = NZ(K)	COVA1356
DO 61 KK=1,NL	COVA1357
DO 60 JJ = 1,NV1	COVA1358
60 C(KK,JJ) = C1(K,KK,JJ)	COVA1359
61 CONTINUE	COVA1360
NF = 1	COVA1361
CALL CRCCCL (C,NF,NL,M ,K)	COVA1362
DO 90 KK = 1,NL	COVA1363
LK = C(KK,NV1)	COVA1364
90 WRITE OUTPUT TAPE 6,1,TAG(LK),LK,(C(KK,J),J=1,M)	COVA1365
1 FCRMAT (1F0,A6,I3,2X,10F10.3)	COVA1366
100 WRITE OUTPUT TAPE6,2	COVA1367
2 FCRMAT(1HC)	COVA1368
RETURN	COVA1369
END	COVA1370
* LABEL	COVA1371
C MPRCD MATRIX PRODUCT SUBROUTINE	COVA1372
C	COVA1373
SUBROUTINE MPRCD (N,M)	COVA1374
DIMENSION B(100,10),V(10,10),C(100,11) ,DU(100)	COVA1375
COMMONDU,E,V,C	COVA1376
DO 99 K = 1, M	COVA1377
DO 99 I = 1, N	COVA1378
C (I, K) = 0.0	COVA1379
DO 99 J = 1, M	COVA1380
99 C (I, K) = C (I,K) + B (I,J) * V (J, K)	COVA1381
RETURN	COVA1382
END	COVA1383
* LABEL	COVA1384
C MATINV SUBROUTINE	COVA1385
C MATRIX INVERSION WITH ACCOMPANYING SOLUTION OF LINEAR EQUATIONS	COVA1386
C	COVA1387
SUBROUTINE MATINV(A,N,B,M,DETERM)	COVA1388
C	COVA1389
DIMENSION IPIVOT(10),A(10,10),B(10,1),INDEX(10,2),PIVOT(10)	COVA1390
EQUIVALENCE (IRCW,JRCW), (ICOLUM,JCOLUM), (AMAX, I, SWAP)	COVA1391
C	COVA1392
C INITIALIZATION	COVA1393
C	COVA1394
10 DETERM=1.0	COVA1395
15 DO 20 J=1,N	COVA1396
20 IPIVCT(J)=0	COVA1397
30 DO 550 I=1,N	COVA1398
C	COVA1399
C SEARCH FOR PIVOT ELEMENT	COVA1400
C	COVA1401
40 AMAX=0.0	COVA1402
45 DO 105 J=1,N	COVA1403
50 IF (IPIVCT(J)-1) 60, 105, 60	COVA1404
60 DO 100 K=1,N	COVA1405
70 IF (IPIVCT(K)-1) 80, 100, 740	COVA1406
80 IF (ABSF(AMAX)-ABSF(A(J,K))) 85, 100, 100	COVA1407
85 IRCW=J	COVA1408
90 ICCLUM=K	COVA1409
95 AMAX=A(J,K)	COVA1410
100 CONTINUE	COVA1411
105 CONTINUE	COVA1412
110 IPIVCT(ICCLUM)=IPIVOT(ICOLUM)+1	COVA1413
C	COVA1414
C INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL	COVA1415
C	COVA1416
130 IF (IRCW-ICCLUM) 140, 260, 140	COVA1417
140 DETERM=-DETERM	COVA1418
150 DO 200 L=1,N	COVA1419
160 SWAP=A(IRCW,L)	COVA1420
170 A(IRCW,L)=A(ICOLUM,L)	COVA1421
200 A(ICOLUM,L)=SWAP	COVA1422
205 IF(M) 260, 260, 210	COVA1423

210	DC 250 I=1, M	CGVA1424
220	SWAP=B(IRCW,L)	CGVA1425
230	B(IRCW,L)=B(ICCLUM,L)	CGVA1426
250	B(ICCLUM,L)=SWAP	CGVA1427
260	INDEX(I,1)=IRCW	CGVA1428
270	INDEX(I,2)=ICCLUM	CGVA1429
310	PIVOT(I)=A(ICCLUM,ICCLUM)	CGVA1430
320	DETERM=DETERM*PIVOT(I)	CGVA1431
C		CGVA1432
C	DIVIDE PIVOT ROW BY PIVOT ELEMENT	CGVA1433
C		CGVA1434
330	A(ICCLUM,ICCLUM)=1.0	CGVA1435
340	DC 350 L=1,N	CGVA1436
350	A(ICCLUM,L)=A(ICCLUM,L)/PIVOT(I)	CGVA1437
355	IF(M) 380, 380, 360	CGVA1436
360	DC 370 I=1,M	CGVA1439
370	B(ICCLUM,L)=B(ICCLUM,L)/PIVOT(I)	CGVA1440
C		CGVA1441
C	REDUCE NON-PIVOT ROWS	CGVA1442
C		CGVA1443
380	DC 550 LI=1,N	CGVA1444
390	IF(LI-ICCLUM) 400, 550, 400	CGVA1445
400	I=A(LI,ICCLUM)	CGVA1446
420	A(LI,ICCLUM)=0.0	CGVA1447
430	DC 450 L=1,N	CGVA1448
450	A(LI,L)=A(LI,L)-A(ICCLUM,L)*I	CGVA1449
455	IF(M) 550, 550, 460	CGVA1450
460	DC 500 L=1,M	CGVA1451
500	B(LI,L)=B(LI,L)-B(ICCLUM,L)*I	CGVA1452
550	CONTINUE	CGVA1453
C		CGVA1454
C	INTERCHANGE COLUMNS	CGVA1455
C		CGVA1456
600	DC 710 I=1,N	CGVA1457
610	L=N+1-I	CGVA1458
620	IF (INDEX(L,1)-INDEX(L,2)) 630, 710, 630	CGVA1459
630	JRCW=INDEX(L,1)	CGVA1460
640	JCCUM=INDEX(L,2)	CGVA1461
650	DC 705 K=1,N	CGVA1462
660	SWAP=A(K,JRCW)	CGVA1463
670	A(K,JRCW)=A(K,JCCUM)	CGVA1464
700	A(K,JCCUM)=SWAP	CGVA1465
705	CONTINUE	CGVA1466
710	CONTINUE	CGVA1467
740	RETURN	CGVA1468
750	END	CGVA1469
*	LABEL	CGVA1470
C	CRCCCL SUBROUTINE	CGVA1471
C		CGVA1472
C		CGVA1473
C	GIVEN AN N X MM MATRIX A (100 X 11) WITH ROW INDEX GIVEN AS	CGVA1474
C	LASTCCLUM OF A, THE FIRST AND LAST ROW SEQUENCE NUMBER OF	CGVA1475
C	SUBMATRIX SUBA, NF AND NL, PROGRAM WILL REORDER SUB A BY RANK OF	CGVA1476
C	ELEMENT IN A COLUMN K. ANSWER IN A.	CGVA1477
C		CGVA1478
	SUBROUTINE CRCCCL (A, NF, NL, M, K)	CGVA1479
	DIMENSION A(100,11),SAVE(11)	CGVA1480
	MM = M + 1	CGVA1481
	NLI = NL - 1	CGVA1482
	DC 333 I = NF, NLI	CGVA1483
	NEXT = I + 1	CGVA1484
	DC 11 J = 1, MM	CGVA1485
11	SAVE (J) = A (I, J)	CGVA1486
	DC 333 II = NEXT, NL	CGVA1487
	IF (A (I,K) - A (II, K)) 444, 333, 333	CGVA1488
444	DC 22 J = 1, MM	CGVA1489
	A (I,J) = A (II, J)	CGVA1490
	A (II, J) = SAVE (J)	CGVA1491
22	SAVE (J) = A (I, J)	CGVA1492
333	CONTINUE	CGVA1493
	RETURN	CGVA1494
	END	CGVA1495
*	LABEL	CGVA1496
C	HIGHC SUBROUTINE	CGVA1497
	SUBROUTINE HIGHC (INDEX,LARGEI,N,LARGEJ)	CGVA1498
	DIMENSION INDEX(200)	CGVA1499

```

LARGEI = 1
  LARGEI = INDEX(1)
  CC 20 I = 2,N
  IF (LARGEI - INDEX(1)) 10,20,20
10 LARGEI = INDEX(1)
  LARGEI = 1
20 CONTINUE
RETURN
END

```

```

COVA1500
COVA1501
COVA1502
COVA1503
COVA1504
COVA1505
COVA1506
COVA1507
COVA1508

```

APPENDIX II

APPENDIX II. JOB SET UP FOR TEST EXAMPLE

```

*      DATA
FOX RQ 6      31 1      4 1      1R Q 1
R AND Q MODE TESTS OF COVAP PROGRAM ON FOX PROBLEM

```

3

```

TOTAL SAND SHALENONCLA CARB EVAP
(22X, 6 F 6.0 )
0101671001003.55003.10000845000266000350000229000024000205
0101671004003.40002.30000906000337000432000137000060000077
0101671006003.30001.15000844000451000311000082000042000040
0101671007002.95000.20000447000293000116000038000012000026
0101671009004.85003.10001001000348000450000203000017000186
0101671010005.00002.60000933000275000435000223000041000182
0101671012004.35000.60000374000240000110000024000024000000
0101671014002.60001.85000608000365000148000095000020000075
0101671015002.85002.35000640000224000304000112000014000098
0101671017004.30001.15000614000255000272000087000028000059
0101671019003.80002.90000915000295000355000265000043000222
0101671020004.00003.60001139000179000643000317000020000297
0101671021004.95002.25000702000237000341000124000039000085
0101671023002.30002.60000464000104000242000118000018000100
0101672002003.65003.70001118000180000568000370000000000370
0101672003004.20003.85001224000207000758000259000011000248
0101672004004.40004.25001204000277000610000317000010000307
0101672005005.10004.10001144000310000520000314000012000302
0101672006005.50003.80001048000362000510000176000012000164
0101672008003.45004.80001162000130000659000373000013000360
0101672009003.30005.10001003000224000542000237000021000216
0101672011003.10005.55000721000229000400000092000012000080
0101672012003.00006.20000775000223000477000075000028000047
0101672015005.50004.20001023000295000501000227000018000209
0101672016005.30004.30001114000246000528000340000032000308
0101672017004.60005.70000955000267000502000186000024000162
0101672019002.20004.50000532000157000238000137000000000137
0101672021002.30005.50000562000120000316000126000000000126
0101672031005.10005.75001005000271000637000097000008000089
0101672034001.40005.55000530000030000461000039000000000039
0101678001005.80003.40001126000270000558000298000068000230
  1001  1004  1006  1007  1009  1010  1012  1014  1015  1017  1019  1020
  1021  1023  2002  2003  2004  2005  2006  2008  2009  2011  2012  2015
  2016  2017  2019  2021  2031  2034  8001
R TEST 13      8 1      4 1      1R      1

```

KANSAS GEOLOGICAL SURVEY COMPUTER CONTRIBUTIONS

Special
Distribution
Publication

- () 3. BALGOL program for trend-surface mapping using an IBM 7090 computer, by J. W. Harbaugh, 1963. \$0.50
- () 4. FORTRAN II program for coefficient of association (Match-Coeff) using an IBM 1620 computer, by R. L. Kaesler, F. W. Preston, and D. I. Good, 1963. \$0.25
- () 9. BALGOL programs for calculation of distance coefficients and correlation coefficients using an IBM 7090 computer, by J. W. Harbaugh, 1964. \$0.50
- () 11. Trend-surface analysis of regional and residual components of geologic structure in Kansas, by D. F. Merriam and J. W. Harbaugh, 1964. \$0.50
- () 12. FORTRAN and FAP program for calculating and plotting time-trend curves using an IBM 7090 or 7094/1401 computer system, by W. T. Fox, 1964. \$0.50
- () 13. FORTRAN program for factor and vector analysis of geologic data using an IBM 7090 or 7094/1401 computer system, by Vincent Manson and John Imbrie. \$0.50

Report
of
Studies

- () 170-3 Mathematical conversion of section, township, and range notation to Cartesian Coordinates, by D. I. Good, 1964. \$0.25

Bulletin

- () 171 A computer method for four-variable trend analysis illustrated by a study of oil-gravity variations in southeastern Kansas, by J. W. Harbaugh, 1964. . . in press

Reprints (available for limited time)

- () Computer helps map oil structures, by D. F. Merriam and J. W. Harbaugh (reprinted from The Oil and Gas Journal, v. 61, no. 47, 1963). no charge
- () Use of trend-surface residuals in interpreting geologic structures, by D. F. Merriam (reprinted from Stanford University Publications, Geological Sciences, v. 9, no. 2, 1964). no charge

COMPUTER CONTRIBUTIONS
Kansas Geological Survey
University of Kansas
Lawrence, Kansas

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KANSAS GEOLOGICAL SURVEY COMPUTER PROGRAM
THE UNIVERSITY OF KANSAS, LAWRENCE

PROGRAM ABSTRACT

Title (If subroutine state in title):

COVAP -- Columbia Vector Analysis Program

Computer: IBM 7090 or 7094/1401

Date: July 27, 1964

Programming language: FORTRAN II

Author, organization: Vincent Manson and John Imbrie, Columbia University, New York 27, N. Y.

Direct inquiries to: Authors or

Name: Daniel F. Merriam

Address: Kansas Geological Survey
University of Kansas, Lawrence

Purpose/description: A FORTRAN program for performing a complete factor and vector analysis in one machine operation in the R-mode, Q-mode, or both. In the R-mode, program calculates mean, standard deviation, skewness, and kurtosis for up to 100 variables; output includes a correlation matrix, table of positive eigenvalues, principle components factor matrix, varimax factor matrix, and a set of X-Y plots for each pair of factor axes; extreme vectors are identified in the varimax matrix and used as reference factors for an oblique projection matrix; and the oblique matrix is re-ordered to facilitate inspection. In the Q-mode, the program has a limit of 100 cases and will perform the same sequence of operations, substituting the square root of the sum of squares for the standard deviation, and $\cos \theta$ for the correlation coefficient. Optional data transformations of several types are included.

Mathematical method: Factor analysis modified by vector analysis.

Restrictions, range: Up to 100 variables in the R-mode, any number of cases; up to 100 cases in the Q-mode, any number of variables.

Storage requirements: 32K

Equipment specifications:

Memory 20K 40K 60K K

Automatic divide: Yes No

Indirect addressing: Yes No

Other special features required Monitor control.

Additional remarks (include at author's discretion: fixed/float, relocatability; optional: running time, approximate

number of times run successfully, programming hours) For 100 x 100 matrix, approximately 5 minutes

and 3,000 lines of output. Program has been thoroughly tested, run over 100 times in

various options at several IBM 7090 and 7094 installations around the country. In short,

it works.

