A COMPUTER METHOD FOR CONVERTING ORIENTED GEOLOGIC DATA TO RADIAN MEASURE IN A SPHERICAL COORDINATE SYSTEM

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ABSTRACT. — Conversion of geologic compass directions and dip designations to radians is often required for mathematical treatment of oriented data by computer. The method described here permits a geologist to record the data read directly from a Brunton pocket transit in the conventional manner. Data recorded directly on a coding form or in an orderly fashion in field books may be readily key punched. A computer program subroutine that performs the conversion is described.

The method described retains the conventional manner of recording dips and strikes and converts these data by computer to radian measure in spherical coordinates. In this form the information can enter into other mathematical computations or may be plotted by appropriate plotting equipment, according to a particular type of projection. The method is advantageous in that it avoids human errors that may arise from conversion to degrees or radians by a mental or manual calculation. The program is arranged so that it can be added to any other program as a subroutine. Logical errors in the data are detected by the program and automatically excluded from further computations. The conversion computations may be performed several times at each data-collecting station as well as at every station within the region of study.

Throughout the discussion the recorded value for the strike of a plane, as well as that recorded for the plunge direction of a lineation, is referred to as a *geologic compass direction*. The term is used to describe the numbers and letters recorded as data. Strike is defined as the direction of the intersection of any surface with a horizontal plane (Lahee, 1961, p. 6). Plunge direction is defined as the horizontal direction of a vertical plane that contains the lineation. As used here, plunge direction always refers to the direction toward which the lineation is plunging and not the opposite direction.

In a similar manner the value recorded for dip of a surface, as well as that recorded for plunge of a lineation, is referred to as *dip designation*. As in the case of a plane this term is used to describe the numbers and letters recorded as data. Dip designation for planar surfaces is considered to be composed of two parts, namely the *dip angle* and the *dip direction* (Figures 1, 2). For lineations the two parts recorded for dip designation are the *plunge* and

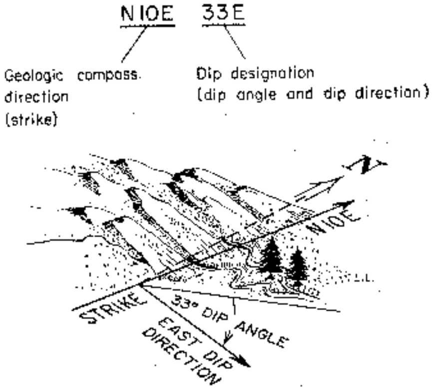

FIGURE 1. Strike and dip of a plane illustrated by an oblique view of tilted strata along an uplift.

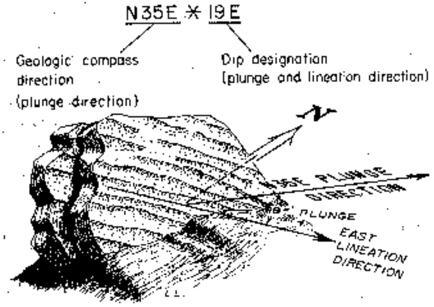

FIGURE 2. Plunge direction and plunge of a lineation as illustrated by an oblique view of ripple marks on tilted strata.

the *lineation direction. Dip angle* is defined as the maximum angle of slope of a surface measured downward from a horizontal plane. Plunge is defined as the angle of slope of a lineation measured downward from a horizontal plane. Dip direction is the approximate cardinal direction (N, S, E, W) in which the planar surface slopes downward. Lineation direction refers to the approximate cardinal direction (N, S, E, W) in which a lineation slopes downward if there is no indication which of the two possible directions of the lineation are under consideration. When a lineation has a single directional orientation, lineation direction refers to the approximate direction in which the lineation or vector is pointed. For example, a feature such as an oriented petrified log might have a single lineation direction or vector based on the root end of the log. A log oriented N40E and plunging at 25 degrees might have the root end down-plunge. This would be recorded as N40E*25N. If the log were turned end for end, retaining the same orientation and plunge, the recording would be N40E*25S.

The computer program was written in Fastran, a language available on the 7094 computer at the University of Illinois. Fastran is similar to Fortran and the subroutine RADIAN described below may be removed from the rest of the program and used with a Fortran II or Fortran IV program.

MEASUREMENT OF PLANAR SURFACES

A generalized computer program that accepts all combinations of geologic compass directions used in measuring planar surfaces is desirable. This means, for example, that a strike and dip of N10E□33E and one of S10W□33S denoting identical orientation of a planar surface should be considered identical by the program. The symbol □ is used to indicate a single blank space. This variety of notation is advantageous in that the readings may be taken from a compass sighting from a position convenient for the field geologist. Other possible readings that denote the same orientation of a planar surface as that indicated above include strikes and dips of N10E□33S and S10W□33E.

Geologic compass direction and dip designation data representing sample measurements which may be converted to spherical coordinates by the computer program are tabulated in the following list.

```
 N10E 33E
S10W 33S
 N10E  33S
S10W  33E
 N00E 00W
 N90E  00N
 N90E  00S
N10W 80NO
N15W  90E
N15W  70WO
N33W 18WO
 N35E*19E
 N35E*19N
 N35E*19
 N35E*
 N35E*19S
 N35E*19W
 N35E*19U
 N35E*90U
 N35E*90
 N35E*00E
 N35E*00N
 N35E*00
 N35E*00S
 N35E*00W
 N35E*00U
 N35E*  U
N01W*10E
 N89E*35N
N01W*00E
N90W*90E
N90W*90W
 N25E*90W
N10W*90E
 S10W  30S
 S10W  35EO
  S10E*12
```

In many instances the data were chosen in order to illustrate extreme conditions. Such extremes as due N, due S, and due E, and due W must be recorded as N00E or N00W, S00E or S00W, N90E or S90E, and N90W or S90W respectively. For vertical sedimentary strata it is advisable to designate the dip direction (N, S, E, W) as being the general direction in which the top of the stratum faces. Horizontal planar surfaces should have a dip designation of 00N, 00S, 00E, or 00W, where 0 is a zero. Any geologic compass direction (except strikes that parallel cardinal dip directions such as N00W 00W) may be used with a horizontal attitude. However, it is suggested that "dip direction and strike" for horizontal planar surfaces be such that it is consistent with other attitudes in the area of study that are not horizontal. FIGURE 1 shows a typical planar surface and a record of the surface measurement.

The letter O, or ø as it may be written in coding, is used to designate overturned bedding planes or surfaces in which the top side either faces downward or has a downward-facing component. In many occurrences there may be no need to distinguish between the top and bottom side of a surface. Joint plane surfaces may be an example of this. In such cases a choice between the overturned and normal positions is arbitrary, and it is suggested that the unoverturned designation be used consistently.

No provision has been made in the program for indicating that a measurement has been made on a plane that is upside down horizontal or even farther overturned.

MEASUREMENT OF SMALL SCALE LINEARS

Features such as ripple marks, parting lineations, and slickenside grooving may be measured with a Brunton pocket transit and the data directly recorded according to geologic compass direction and dip designation. The dip designation, as previously defined, consists of the angle of plunge and any one of four possible lineation directions (N, S, E, W). This form of recording requires an asterisk (*) between the geologic compass direction and dip designation. Plunge direction and strike of a plane are recorded in the same way to conserve space and facilitate key punching. For small scale linears geologic compass directions and dip designations of N35E*19N, N35E*19E, or N35E*19□ may be used to represent a lineation that plunges 19 degrees in the direction N35E and points toward either the N or E. When lineation direction is not reported it is understood to be that of the plunge direction. The allowance for a blank space is primarily for convenience in recording data. A value of N35E* □□□ will be processed as if the lineation were horizontal and directed north 35 degrees east. In this example the two blank spaces for plunge are processed as if they were 00 in value, where 0 is a zero. A record for the inverse of the above values would be either N35E*19S, N35E*19W, or N35E*19U. Here the lineation plunges 19 degrees in the direction N35E but points toward either the south (S), west (W) or up (U). The letter U is applicable only to lineation measurements. A plunge direction cannot be exactly at right angles to the cardinal lineation direction. Thus, N00E*30E is not a valid geologic compass direction aid dip designation.

Moreover, the computer program is arranged so that a lineation is defined by N35E*19□ but the lineation direction must be added to define which way the lineation is pointing. A typical lineation and a record of the lineation measurement are shown in Figure 2. A geologic compass direction is mandatory for all vertical lineations no matter whether they are directed upward or downward.

Some variety of recorded letters and numbers for plunge direction, plunge angle, and lineation direction are provided for in the computer program, but this notation is more restricted than that used for planar surfaces. Horizontal linear features may be recorded with 00 for the angle of plunge and any of the four cardinal directions as the lineation direction. The record N35E*00E may represent such a lineation. Values of N35E*00N, N35E*00□ and N35E*□□□ represent the same lineation direction. The inverse of this direction may be designated by either N35E*00S or N35E*00W, or by N35E*00U or N35E*□□U.

Vertical or nearly vertical lineations might be more accurately measured by the measuring-device method discussed below. However, recordings of N35E*90E, N35E*90N, and N35E*90□ may be used to represent a vertically plunging lineation pointing downward. A vertically plunging lineation pointing upward could be represented by N35E*90W, N35E*90S, and N35E*90U. The geologic compass direction of N35E in these designations means only that this value is consistent with other associated values that have a northeast plunge.

When the dip and strike of a plane that is perpendicular to the lineation itself is to be measured, a device such as that shown in Figure 3 may be used. The data recorded from such measurements define a lineation. The measurements are recorded as a geologic compass direction and dip designation without an asterisk. If the leg of the lineation measuring device points toward the down-dip direction of the lineation, the plane that is measured is considered unoverturned. The leg of the lineation measuring device may be used to point in the direction in which the lineation points. Where the lineation points upward, the leg of the measuring device will also point upward, giving the perpendicular plane a downward-facing component. The plane upon which the dip and strike are measured is then considered to be overturned and the data recorded define an upward-pointing lineation. All conditions that apply to measurement of planar surfaces also apply when the measuring device is used. The face of the planar surface opposite the leg of the measuring device is analogous to the top side of the bedding. For horizontal or nearly horizontal lineations it may be simpler to dispense with the lineation measuring device and measure the lineation direction and angle of plunge, recording it as a geologic compass direction and dip designation separated by an asterisk.

Use of the lineation measuring device is optional for measuring data to be used with the computer program. In many instances the inconvenience of having another piece of field equipment may preclude its use.

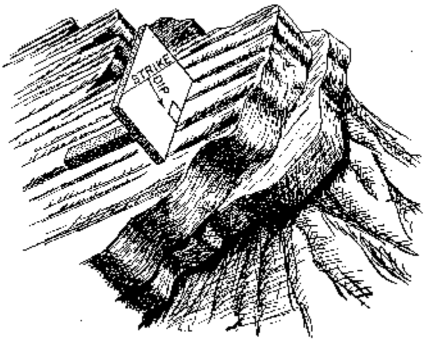

Figure 3. Oblique view of an outcrop and a lineation measuring device that provides a measurement surface perpendicular to the lineation.

Disscussion of Computer Program Operation

The computer program in Appendix A is in two parts—the subroutine RADIAN and a main program for reading data into the computer memory and writing out results. The first data card must contain the letters NSEW*0□U (Figure 4). All data cards subsequent to this first card (except the last one) should have the geologic compass direction and dip designation punched in columns 1 through 9. Although the main program is arranged to read data cards in these particular columns on each card, it may be altered readily to use information punched at any position on the card or any series of geologic compass directions and dip designations on

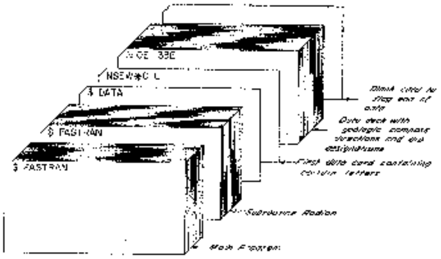

FIGURE 4. Arrangement of computer program punch cards and data punch cards.

each data card. In all such cases subroutine RADIAN would remain unaltered.

Each set of data cards requires a blank card at the end to flag the termination of the data being read into the array in the computer memory. After each data card is read by the computer the oriented geologic data are converted to radian measure. Answers from each computation are stored in an array similar to that in which the original data were stored. For completeness, the azimuth angle and zenith angle are written out by means of the main program along with an indicator for the presence of a lineation (*) and a logical data error (Appendix B).

The program requires about 5 seconds to convert 100 geologic compass directions and dip designations to radians in a 7094 computer. This is computer running time, which does not include the system time of about 10 seconds.

Throughout the subroutine RADIAN, statements have been used to ascertain the presence of a particular letter or symbol associated with a geologic compass direction or dip designation. If the value after a subtraction is zero, the computer may be directed to a particular computational statement. If either a negative or positive value is obtained, the computer may proceed to the next statement, which directs the computer to try subtracting another letter or symbol. By this method a letter W would be identified on the fourth trial by subtracting N, S, E, and W in sequence from the value in question.

Subroutine RADIAN converts the geologic compass directions to spherical coordinates by using radian measure. The first part of the subroutine converts all geologic compass directions to azimuths measured clockwise around a 360-degree compass. This is done for strikes of planar surfaces as well as plunge directions for lineations. The decision as to which part of the subroutine follows depends on whether an asterisk or a blank space is present between the geologic compass direction and dip designation. If a blank space is present, the azimuth and zenith angles of the planar poles are determined for each recorded dip and strike. To find these the program provides for the arbitrary subtraction of 90 degrees from the strike direction. The subsequent subtraction-IF statements ascertain the dip direction to be either N, S, E, or W and then correct the planar pole azimuth by 180 degrees if necessary. The decision and computational statements are arranged so that the azimuth is always greater than zero degrees but less than or equal to 360 degrees. The zenith angle of the poles is computed by subtracting the angle of dip from 180 degrees. If the dip designation on the data card is followed by the letter O for overturned, the *azimuth* of the planar pole is inverted by subtracting or adding 180 degrees, depending upon which will yield a value greater than zero degrees but equal to or less than 360 degrees. For overturned planar surfaces the angle of dip of the plane is equal to the zenith angle of the planar pole.

When an asterisk is present between the geologic compass direction and dip designation, the recorded attitude is considered to be a measurement of a lineation, or a lineation direction. The program arbitrarily considers lineations to be directed downward; the lineation direction of the measured features may be left blank, as discussed previously. If not left blank, the lineation direction (N, S, E, W, U) serves to indicate which of the two possible lineation directions is under consideration. Much of the lineation computation part of the subroutine RADIAN consists of logic checks and other considerations for extreme cases. In case of a downward-pointing lineation direction, the azimuth that was determined earlier in the program is accepted as the azimuth angle. For upward-pointing lineations this value is reversed by 180 degrees so that the new azimuth is greater than zero degrees but less than or equal to 360 degrees. The plunge is added to 90 degrees to obtain the zenith angle. For upward-pointing lineations the plunge is subtracted from 90 degrees to obtain the zenith angle.

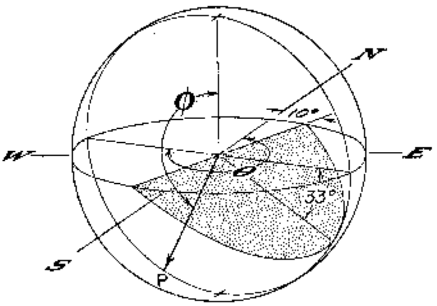

FIGURE 5. Oblique view of an orientation sphere illustrating angles θ and ϕ of a planar pole for a plane striking N10E and dipping 33E. The part of the plane in the lower hemisphere is stippled. P = planar pole, θ = azimuth angle, ϕ = zenith angle. If the plane were overturned the planar pole would be inverted with respect to the illustrated position.

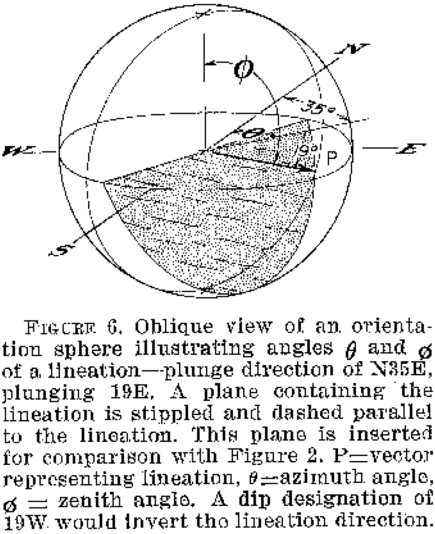

FIGURE 6. Oblique view of an orientation sphere illustrating angles θ and ϕ of a lineation—plunge direction of N35E, plunging 19E. A plane containing the lineation is stippled and dashed parallel to the lineation. This plane is inserted for comparison with Figure 2. P=vector representing lineation, θ=azimuth angle, ϕ = zenith angle. A dip designation of 19W would invert the lineation direction.

As a final step, subroutine RADIAN converts azimuth angle and zenith angle from degrees to radians and stores these values in the THETA and PHI array of subscription variables. The value used for π in this conversion is carried to the sixth decimal place. FIGURES 5 and 6 show angles THETA and PHI for the planar surface and plunging lineation illustrated in FIGURES 1 and 2.

When the blank card flagging the end of the data is recognized by the computer, computations cease and the main program directs the computer to write out the stored values of THETA (θ) and PHI (ϕ), along with an indicator as to whether the value represents a plane or a lineation. Appendix B lists output from the sample data cards previously tabulated in the text.

Logical errors in the data cards are located by the program. Appendix C lists eight such logical errors by number. If this type of error is encountered during a computation, the computer will store the number of the error in a subscripted array for future listing and proceed to the next geologic compass direction and dip designation or data card. The absence of an error is indicated by a zero in the output listing (Appendix B), otherwise the error number is listed. Letters or symbols that are accidentally inserted for the numerical compass angles on the data cards will stop the computer. However, numerical values inserted accidentally for letters or symbols will not stop the computer but will be indicated as one of the types of error shown in Appendix C.

ADVANTAGES OF THE COMPUTER METHOD

The computer program presented may be used with Brunton pocket transit measurements on planes, lineations, and directional lineations with no need for a second or third program. The notation for recording data is similar to that commonly used by field geologists and requires no special device, technique, or procedure for obtaining and recording oriented data. However, measuring devices such as that illustrated here (FIGURE 3) or those illustrated by Potter and Pettijohn (1963, p. 78) may be used in measuring oriented data for the described computer program. Measurements on the ceiling of a mine or tunnel may be taken just as readily and recorded as those on a horizontal outcrop. The program is generalized to the extent that it will handle extreme cases, overturned planar surfaces, and various combinations of measurements on the same oriented feature. The program may be used on various types of oriented features in sedimentary, igneous, and metamorphic rocks. There is very little or no restriction on the three-dimensional orientation of the feature measured. Overturned planes or bedding may be just as easily measured and recorded for use with the program as horizontal lineations in which the compass direction is the only important consideration. In all instances the orientation is determined in spherical coordinates.

Radian measure is advantageous in that the values of trigonometric functions for the angles may be readily found by a computer. The data in the form of radian measure may be readily adapted for treatment in numerous ways. These include statistical analysis, such as the work by Scheidegger (1965) and Steinmetz (1962); direct plotting of the data according to an equal-area projection in a manner similar to that described by Fairbairn (1949 p. 276), Robinson et al. (1963), Doell and Altenhofen (1960), and Spencer and Clabaugh (1967); and methods to remove tilt effects such as described by Murray (1966, 1967) and Noble (1964). The conversion subroutine may be added to other programs or supplemented by additional subroutines. Space is available on each data card to add other information, including station number, area of study, and rock unit.

ACKNOWLEDGMENTS

I am grateful to Jack A. Simon and James W. Baxter of the Illinois State Geological Survey for carefully reading the manuscript and offering suggestions.

APPENDIX A. COMPUTER PROGRAM FOR CONVERTING ORIENTED GEOLOGIC DATA TO RADIAN MEASURE IN A SPHERICAL COORDINATE SYSTEM.

```
$      FASTRAN
$      GO
C
C FREDERICK N. MURRAY
C ILLINOIS STATE GEOLOGICAL SURVEY
C URBANA, ILLINOIS
      DIMENSION THETA1(1000),PHI1(1000),MM(1000),IE(1000),M(8)
      NI=0
      RIT7,1,(M(1),I=1,8)
    1 FORMAT(8A1)
    2 RIT7,3,N1,A1,N2,N3,A2,N4,N5
     3 FORMAT(A1,F2.0,2A1,F2.0,2A1)
      IF(A1+A2)5,4,5
    4 IF(N1+N2+N3+N4+N5-M(7)-M(7)-M(7)-M(7)-M(7))  5,6,5,
    5 NI=NI+1
      CALL RADIAN(N1,A1,N2,N3,A2,N4,N5,THETA1,PHI1,MM,IE,M,NI)
      GO TO 2
    6 WOT6,7,(THETA1(I),PHI1(I),MM(I),IE(I),I=1,NI)
    7 FORMAT(1H1.5X,18HRADIAN MEASURE FOR/6X,74HAZIMUTH—ZENITH
      ANGLE
     1——PLANE SURFACE OR LINEATION (*)    ERROR NO./6X,5HTHETA,7X,3
     2HPHI/(1X,2F12.6,22X,A1,25X,I2))
      END
$      FASTRAN
      SUBROUTINE RADIAN(N1,A1,N2,N3,A2,N4,N5,THETA,PHI,MM,IE,M,NI)
      DIMENSION THETA(1000),PHI(1000),MM(1000),IE(1000),M(8)
      IE(NI)=0
C DOES THE GEOLOGIC COMPASS DIRECTION OR DIP DESIGNATION ANGLE
C HAVE A VALUE OF 91 THROUGH 99 DEGREES
      IF(A1-90.)76,76,75
   75 IE(NI)=8
      RETURN
   76 IF(A2-90.0)77,77,75
```

```
C CONVERSION OF GEOLOGIC COMPASS DIRECTIONS TO AZIMUTHS
   77 IF(N1-M(1))1,3,1
    1 IF(N1-M(2))2,6,2
    2 IE(NI)=1
      RETURN
    3 IF(N2-M(3))4,10,4
    4 IF(N2-M(4))2,5,2
    5 A1=360.-A1
      GO TO 10
    6 IF(N2-M(3))8,7,8
    7 A1=180.-A1
      GO TO 10
    8 IF(N2-M(4)2,9,2
    9 A1=180.+A1
C IS THIS A PLANE OR A LINEATION
   10 IF(N3-M(5))12,11,12
   12 IF(N3-M(7))13,33,13
   13 IE(NI)=2
      RETURN
C DETERMINATION OF AZIMUTH AND ZENITH ANGLE OF PLANAR POLES
   33 IF(A1-90.)36,37,38
   36 A1=(360.-(90.-A1))
      GO TO 40
   37 A1=360.
      GO TO 40
   38 A1=A1-90.
   40 IF(N4-M(1))41,46,41
   41 IF(N4-M(2))43,50,43
   43 IF(N4-M(3))44,56,44
   44 IF(N4-M(4))45,57,45
   45 IE(NI)=3
      RETURN
   46 IF(A1-270.)47,66,48
   47 IF(A1-90.)49,66,65
   48 A1=A1-180.
      GO TO 65
   49 A1=A1+180.
      GO TO 65
   50 IF(A1-270.)51,66,65
   51 IF(A1-90.)65,66,52
   52 IF(A1-180.)49,49,48
   56 IF(A1-135.)53,66,66
   53 IF(A1-180.)49,66,65
   57 IF(A1-360.)55,66,66
   55 IF(A1-180.)65,66,48
   66 IE(NI)=4
      RETURN
   65 IF(N5-M(6))67,70,67
   67 IF(N5-M(7))68,69,68
   68 IE(NI)=5
      RETURN
   69 A2=180.-A2
      GO TO 74
   70 IF(A1-180.)72,72,71
   71 A1=A1-180.
      GO TO 74
   72 A1   A1   180.
C CONVERSION TO RADIANS
   74 THETA(NI)=(A1/180.)*3.141593
      PHI(NI)=(A2/180.)*3.141593
      MM(NI)=N3
      RETURN
C DETERMINATION OF AZIMUTH AND ZENITH ANGLE OF A LINEATION OR
C UNIT VECTOR
   11 IF(N5-M(7))14,100,14
   14 IE(NI)=6
      RETURN
  100 IF(A1-360.)101,105,101
  101 IF(A1-270.)102,107,102
  102 IF(A1-180.)103,105,103
  103 IF(A1-90.)104,107,104
  104 IF(A1)99,109,99
  109 A1=360.
  105 IF(N4-M(3))106,92,106
  106 IF(N4-M(4))99,92,99
  107 IF(N4-M(1))108,92,108
  108 IF(N4-M(2))99,92,99
   92 IE(NI)=7
      RETURN
   99 IF(N4-M(1))16,21,16
   16 IF(N4-M(2))17,22,17
   17 IF(N4-M(3))18,23,18
   18 IF(N4-M(4))19,24,19
   19 IF(N4-M(7))20,30,20
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```
   20 IF(N4-M(8))45,26,45
   21 IF(N1-M(1))26,30,26
   22 IF(N1-M(2))26,30,26
   23 IF(N2-M(3))26,30,26
   24 IF(N2-M(4))26,30,26
   30 A2=A2+90.0
      GO TO 74
   26 IF(A1-180.)27,27,28
   27 A1=A1+180.
      GO TO 29
   28 A1=A1-180.
   29 A2=90.0-A2
      GO TO 74
      END
$     DATA
NSEW*O U
```

Appendix B. Computer Program Output from Oriented Geologic Data Listed In Text.

```
  RADIAN MEASURE FOR
  AZIMUTH——ZENITH ANGLE——PLANE SURFACE OR LINEATION (*)      ERROR
  THETA        PHI
4.886922    2.565634                                                 0
4.886922    2.565634                                                 0
4.886922    2.565634                                                 0
4.886922    2.565634                                                 0
1.570797    3.141593                                                 0
3.141593    3.141593                                                 0
6.283186    3.141593                                                 0
1.396264    1.396264                                                 0
4.450590    1.570797                                                 0
4.450590    1.221731                                                 0
4.136431     .314159                                                 0
 .610865    1.902409                    *                            0
 .610865    1.902409                    *                            0
 .610865    1.902409                    *                            0
 .610865    1.570797                    *                            0
3.752468    1.239184                    *                            0
3.752458    1.239184                    *                            0
3.752458    1.239184                    *                            0
3.752458     .000000                    *                            0
 .610865    3.141693                    *                            0
 .610865    1.570797                    *                            0
 .610865    1.570797                    *                            0
 .610865    1.570797                    *                            0
3.752458    1.570797                    *                            0
3.752458    1.570797                    *                            0
3.752458    1.570797                    *                            0
3.752458    1.570797                    *                            0
3.124140    1.396264                    *                            0
1.553343    2.181662                    *                            0
3.124140    1.570797                    *                            0
1.570797     .000000                    *                            0
4.712389    3.141593                    *                            0
3.577925     .000000                    *                            0
2.967060     .000000                    *                            0
4.886922    2.617994                                                 0
1.745329     .610865                                                 0
2.967060    1.780236                    *                            0
```

Appendix C. Data Error Types Which May Be Recognized By The Computer Program.

```
ERRORS
NO.    TYPE
 1. AT LEAST ONE OF THE DIRECTION LETTERS OF THE GEOLOGICAL COM-
    PASS DIRECTION IS INCORRECT OR MISSING.  ERRORS IN THE DIP DESIG-
    NATION MAY ALSO BE PRESENT.
 2. THERE IS SOME CHARACTER BESIDES * OR (BLANK) BETWEEN THE GEO-
    LOGIC COMPASS DIRECTION AND THE DIP DESIGNATION.
 3. THE DIP DIRECTION IS MISSING OR INCORRECT.  THE LETTER U CANNOT
    BE USED WITH PLANAR SURFACE DIP DESIGNATIONS.
 4. A GEOLOGIC COMPASS DIRECTION FOR A PLANAR SURFACE (STRIKE) CAN-
    NOT PARALLEL THE CARDINAL DIP DIRECTION.  THAT IS SUCH VALUES
    AS N00W 10S AND N90W 15W ARE NOT VALID FOR A PLANAR SURFACE.
 5. THERE IS SOME CHARACTER BESIDES O OR (BLANK) IN THE OVERTURNED
    DESIGNATION COLUMN.
 6. A LINEATION OR DIRECTIONAL ITSELF IS NOT CONSIDERED AS BEING
    OVERTURNED.  THE PLANES WHICH BEAR THE LINEATION ARE CON-
    SIDERED OVERTURNED.
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7. A GEOLOGIC COMPASS DIRECTION FOR A LINEATION OR DIRECTIONAL
   CANNOT BE AT EXACTLY RIGHT ANGLES TO THE CARDINAL LINEATION
   DIRECTION. THAT IS SUCH VALUES AS N00W*10W AND N90W*15S ARE NOT
   VALID FOR A LINEATION OR A DIRECTED LINEATION.
8. AT LEAST ONE OF THE RECORDED ANGLES IS OVER 90 DEGREES.
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Manuscript received February 28, 1967.