COMPUTER-AIDED INTERPRETATION

OF

SEISMIC REFRACTION DATA

BY

NELSON S. RODRIGUEZ
A thesis submitted to the Faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science, Geophysical Engineering.

Signed: [Signature]
Nelson S. Rodriguez

Golden, Colorado
Date: December 6, 1976

Approved:
Dr. T. L. Davis
Thesis Advisor

Dr. G. V. Keller
Head of Department

Golden, Colorado
Date: 12/6, 1976
ABSTRACT

A Fortran IV computer program (SRTDI) has been developed to analyze seismic refraction data. This program is a modified and improved version of a USBM computer program (FSIPl by Scott et al, 1972). The program requires that travel times be picked from seismic records by the interpreter. These times together with the geometric field configuration of source and receivers plus the number of expected subsurface layers are the basic data input to the program. Processing is controlled by the interpreter at the intermediate steps. The SRTDI program has been designed to handle relatively long seismic lines up to 24 receivers per spread, 6 spreads and 2 sources. It checks its own interpretation using a self-adjusting procedure based on the discrepancy between the observed and calculated arrival times. The main output is a two-dimensional layered-earth model drawn connecting the depth point locations calculated for each subsurface interface, underneath every geophone location. The program is able to delineate most subsurface dipping-layer features; even sharply dipping geological structures. It has enough flexibility built in so as to integrate different data-interpretation from the same area.

The program was tested interpreting:

1) Some special qualitatively pre-designed seismic refraction cases dealing with:
   a) a high angle fault
b) an abrupt change of dip at one subsurface layer interface

c) a subsurface irregular topography.

2) A field case: the 1968 seismic refraction line from South Park, Colorado.

The results obtained with the pre-designed cases, supported by the excellent observed-calculated time matching curve, confirm that the program is considerably better than the conventional methods of interpretation, and several other high-speed computerized methods (Mooney, 1973; Scott et al, 1972).

The program performs its job at an average rate of 4.5 depth point calculations per second. In other words, a seismic line of 96 geophone field locations with two shot points per location and solving a three-layer case should expend, on the average, about 45 second of computer time (CPU) using 40K words of variable core. However, if the velocity shows extreme lateral variation (a common case in long spreads), more than one program execution could be needed. Short spread (24 locations) problems associated with common subsurface geological structures can be handled in a straightforward manner. For more complicated and/or longer spread cases, user knowledge about the seismic refraction problem is recommended.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>v</td>
</tr>
<tr>
<td>ILLUSTRATIONS</td>
<td>vi</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>REFRACTION INTERPRETATION PROGRAM</td>
<td>4</td>
</tr>
<tr>
<td>Generalized Program Description</td>
<td>7</td>
</tr>
<tr>
<td>Program Calculations and Algorithms</td>
<td>19</td>
</tr>
<tr>
<td>Apparent Velocities and Sloping</td>
<td>19</td>
</tr>
<tr>
<td>Datum Plane</td>
<td>19</td>
</tr>
<tr>
<td>Velocity Calculation</td>
<td>21</td>
</tr>
<tr>
<td>Delay-time Calculation</td>
<td>23</td>
</tr>
<tr>
<td>Ray Tracing Self-Adjusting Technique</td>
<td>25</td>
</tr>
<tr>
<td>REFRACTION PROGRAM RESULTS</td>
<td>28</td>
</tr>
<tr>
<td>Test Using Pre-Designed Input Data</td>
<td>28</td>
</tr>
<tr>
<td>Test Using Real Field Data</td>
<td>35</td>
</tr>
<tr>
<td>Analysis of Results</td>
<td>52</td>
</tr>
<tr>
<td>Pre-Designed Data</td>
<td>52</td>
</tr>
<tr>
<td>Field Data</td>
<td>56</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>62</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>64</td>
</tr>
<tr>
<td>APPENDIX</td>
<td>66</td>
</tr>
</tbody>
</table>
**ILLUSTRATIONS**

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Logical approach followed by the computer program (block flow diagram)</td>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Shot-geophone field configuration and general subsurface cross section</td>
<td>10</td>
</tr>
<tr>
<td>2 Velocity calculation in dipping-layer case</td>
<td>22</td>
</tr>
<tr>
<td>3 The delay-time approach diagram</td>
<td>24</td>
</tr>
<tr>
<td>4 Ray tracing and adjusting procedure diagram</td>
<td>27</td>
</tr>
<tr>
<td>5 T-D graph-geologic model; most common relationships</td>
<td>29</td>
</tr>
<tr>
<td>6 Fault or buried step case. Raw T-D graph</td>
<td>31</td>
</tr>
<tr>
<td>7 Fault or buried step case. Layer 1 removed T-D graph</td>
<td>32</td>
</tr>
<tr>
<td>8 Fault or buried step case. Smoothed model interpretation</td>
<td>33</td>
</tr>
<tr>
<td>9 Fault or buried step case. Sharp model interpretation</td>
<td>34</td>
</tr>
<tr>
<td>10 Change in dip of subsurface case. Raw T-D graph</td>
<td>36</td>
</tr>
<tr>
<td>11 Change in dip of subsurface case. Layer 1 removed T-D graph</td>
<td>37</td>
</tr>
<tr>
<td>12 Change in dip of subsurface case. Smoothed model interpretation</td>
<td>38</td>
</tr>
<tr>
<td>13 Change in dip of subsurface case. Sharp model interpretation</td>
<td>39</td>
</tr>
<tr>
<td>14 Irregular subsurface topography case. Raw T-D graph</td>
<td>40</td>
</tr>
<tr>
<td>15 Irregular subsurface topography case. Layer 1 removed T-D graph</td>
<td>41</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>16</td>
<td>Irregular subsurface topography case. Smoothed model interpretation</td>
</tr>
<tr>
<td>17</td>
<td>Irregular subsurface topography case. Sharp model interpretation. Left edge of the isolated hole</td>
</tr>
<tr>
<td>18</td>
<td>Irregular subsurface topography case. Sharp model interpretation. Right edge of the isolated hole</td>
</tr>
<tr>
<td>19</td>
<td>Irregular subsurface topography case. Combined model-interpretation</td>
</tr>
<tr>
<td>20</td>
<td>SRTDI interpretation of seismic line R68. South Park. Raw T-D graphs</td>
</tr>
<tr>
<td>21</td>
<td>SRTDI interpretation of seismic line R68. South Park. Layer 1 removed T-D graphs</td>
</tr>
<tr>
<td>22</td>
<td>SRTDI interpretation of seismic line R68. South Park. Smoothed model interpretation</td>
</tr>
<tr>
<td>23</td>
<td>SRTDI interpretation of seismic line R68. South Park. Sharp model interpretation</td>
</tr>
<tr>
<td>24</td>
<td>J. Fatti, 1971, interpretation of seismic refraction line R68</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

The author wishes to express his sincere gratitude to Dr. Thomas L. Davis, who acted as the advisor on this project.

The author is especially grateful to Drs. George V. Keller and Frank A. Hadsell, Colorado School of Mines, for serving on this master committee. Also, the author would like to thank Dr. Alvaro F. Espinoza, U. S. G. S., for providing the initial material to work on, and for his constant encouragement.

The author is also grateful to his wife, Thais, for her enthusiasm and patience typing the first draft of this material and my special thanks go to Linda Jenkins for her marvelous typing of this thesis.
INTRODUCTION

The principle of seismic refraction (Dobrin, 1960; Heiland, 1940; and Nettleton, 1940) is based on the fact that elastic waves travel (most of the time) different velocities through different materials. The elastic parameters and density are the most important factors determining the velocity of any media. For seismic refraction without mode conversion, one may consider that all seismic waves travel through the various media following the laws of physical optics; Snell's law, Fermat's principle and Huygen's principle are the fundamentals upon which refraction theory is based.

The basic methods of seismic refraction interpretation are used to determine the thickness of various refraction strata using velocities and either critical distance or intercept times. To accomplish this, several formulae have been set out by Dobrin (1960), Heiland (1940), and Nettleton (1940), but they frequently involve a tedious and time-consuming approach for multilayer cases. Some improvements can be introduced in the "classical" or "general" methods of interpretation by using nomograms, graphics, or "short cut" assumptions mainly to cut down the time-consuming factor (Knox, 1967; Olhovich, 1959; Slotnick, 1950; and Stulken, 1967). Wavefront methods have also been extensively used to solve the refraction problem providing in several cases better resolution than that previously mentioned (Rockwell, 1967; Schench, 1967). Recently, the most popular methods of interpretation (especially in shallow refraction problems)
have been the method-of-differences (Edge and Laby, 1931) and other slightly different versions, such as the methods developed by Pakiser and Black (1957) and Hobson (1970).

A more comprehensive approach to solve the seismic refraction problem has been developed by Scott et al (1972) combining one of the so-called delay-time methods of interpretation with a ray-tracing technique in a mathematical iterative self-adjusting procedure.

The Colorado School of Mines has considerable seismic refraction data, mostly from the South Park area of Colorado, which have not been interpreted adequately as yet. A computer oriented software system was required to make a fast, reasonably accurate, and economical interpretation of this seismic data. The technique of interpretation selected for the computer program roughly follows the approach used by Scott et al (1972). However, it has been the contribution of this thesis to implement remarkable improvements into the technique to make it perhaps the most advanced of its kind.

The objectives of this thesis are summarized in the following:

a) to create a software system for the processing of seismic refraction data on the C.S.M. PDP-10

b) to test some special seismic refraction cases associated with typical subsurface geologic structures and to prove the capability of this software system to provide reliable geophysical interpretations, and
c) To provide a rigorous seismic refraction data interpretation of one seismic line from South Park Basin, Colorado, which has been previously interpreted using the method-of-differences technique with the aid of a desk calculator.
REFRACTION INTERPRETATION PROGRAM

Those who have attempted to interpret seismic refraction data using a desk calculator or graphical techniques know about the time required to interpret even a relatively simple geologic sequence. Using high speed computers we are able to overcome most of the time consuming factors involved and to concentrate our efforts on improving the reliability of the final results. Several mathematical algorithms and graphical methods are now used to solve the problem of seismic refraction interpretation. Among them the so-called delay-time techniques (Dobrin, 1960) and method-of-differences (Edge and Laby, 1931) are the most popular. Adaptation of these techniques to a high speed computational procedure would speed computations but not necessarily yield better results. On the other hand, a seismic refraction ray-tracing technique could be used to complement or check the results obtained from any of these methods to finally calculate a reliable model interpretation.

Fortunately, a computer program has been developed to do that job with proven success (Scott et al, 1972). Using Scott's program as a framework, new computational devices were built into the program to yield a useable seismic refraction interpretation package. From Scott's program, the new package (SRTDI) preserved, save small modifications, the bulk of programming organization, the general strategy to approach the solution of the problem, and the technique of refraction ray simulation among other things. However, other
major modifications and the addition of computational state-
ments were necessary to build the SRTDI program. These are
related to:

a) adaptation to the PDP-10 time-sharing computer system
   of the Colorado School of Mines
b) adaptation to variable source-receiver geometrical
   configuration
c) reduction in the computer program size and the com-
   puter time expended during its execution
d) layer velocity calculation taking into account
   dipping-layers
e) injection of more flexibility to the program to ac-
   cept different input data from the same problem
   and integrate the results
f) addition of a computational-aid device which helps
   to interpret some typical geological structures
   avoiding, when the interpreter so desires, the
   smoothing technique which is normally practiced
   by the FSIPl program
g) development of different program output displays.

Seismic refraction studies can be classified roughly
according to source-receiver field geometrical configuration
into three major types:

a) long to very long source-receiver field configura-
   tions designed to make deep crustal studies
b) intermediate to long field configurations, designed
   to solve oil exploration and regional subsurface
geological problems, and 

(c) small to intermediate field configurations, designed to solve mining, ground water and civil engineering problems.

Since the last two spreads mentioned above involve most of the applications we are dealing with, an efficient and flexible source-receiver field geometrical configuration able to handle those problems was selected to be used in the SRTDI program.

Successful interpretation of seismic refraction data requires the knowledge of three important relationships before mathematical procedures of data reduction can be applied:

(a) the number of layers represented by the data (time-distance graph) must be established,

(b) each refraction event must be correctly associated with the layer that carries the critically refracted ray along its upper surface (refracted trajectory), and

(c) characteristic forms on the time-distance diagrams must be recognized, located, and associated with the most feasible geologic structure.

Clear final displays and effective control of the calculations from several intermediate results are the key to a reliable interpretation following this complex approach. To assure this, several intermediate exit points are available in the computer program to allow the interpreter to pause to make decisions regarding the seismic event-geologic layer structure relationship.
Generalized Program Description

In this section, the SRTDI computer program is described in a very general way. Information regarding the initial assumptions and the seismic refraction interpretation approach adapted to the computer program is outlined here. In general, repetition of the material exposed in the FSIP1 program publication (Scott et al, 1972) is avoided. Special emphasis has been given to those parts which are new or have been modified from the FSIP1 program. Those who are interested in specific details about some techniques and/or the approach used in both programs will have to consult the reference publications, specifically that one dealing with the FSIP1 program (Scott, et al, 1972).

The computer program described in this thesis, hereafter referred to as SRTDI (Seismic Refraction Two-Dimensional Interpretation), is written in Fortran IV and is operational on the PDP-10 time-sharing computer system. The program is subject to the following restrictions:

a) The number of linked spreads that may be interpreted in one problem may not exceed six, with no more than 24 geophones and 2 shot points per spread.

b) The maximum number of layers that may be interpreted is five.

c) The number of shots per spread can be increased to a maximum of eight by modifying the fortran dimension statements of the arrays.
Several assumptions have been made that facilitate the operation of the program:

a) Refracted rays are assumed to represent minimum travel paths of compressional seismic waves. The angles of incidence and refraction are determined by Snell's law from the horizontal velocities of the refracting layer and the vertical velocities of the overlaying layers. Ray trajectories are generally considered as straight lines. However, first order effects of velocity anisotropy may be taken into account by assigning different vertical and horizontal velocities to the same layer. The horizontal portion of the refracted travel path is traced using the horizontal velocity, and the slanted ray segments are traced using the vertical velocity.

b) Layer velocity is generally assumed to increase with layer depth. Each layer of each spread is assumed to be characterized by a constant horizontal velocity for rays traveling through the layer. A constant velocity for any layer for all spreads can be calculated if the program user so desires. The velocity inversion problem can also be handled in an artificial manner (see Scott et al, 1972).

c) All the interfaces (layer boundaries) are assumed to be representable by a series of straight line segments formed connecting the depth-point locations beneath each geophone. The deepest layer is
assumed to extend to an infinite depth.

d) In multispread problems, spreads are assumed to follow approximately the IN-LINE configuration, but angles of up to 30° between spreads, and between spreads and shot points, are tolerable. Geophone spreads may join end-to-end, they may be separated by moderate distances or they may overlap by as much as half of a spread length. Shot points show be located anywhere outside of the geophone spread to which it is related. These should be set up in associated pairs located offset from both ends of the spread. This means that the program expects an even number of them located at both sides of the spread to which they correspond (see Figure 1).

The SRTDI program consists of a main program and 17 sub-routines which work together in a complex sequence to provide intermediate or final results in accordance with the requirements of the user. Table 1 illustrates a general logic operational sequence (block diagram) followed by the SRTDI program. As illustrated, the program initializes the arrays that will be used during the execution time. Next, it reads the input data which include titles, amount of data coming in, field-geometrical configuration, observed travel times, and additional
SHOT POINT - GEOPHONE FIELD CONFIGURATION
AND
GENERAL SUBSURFACE'S CROSS-SECTION

Figure 1.
START

INITIALIZE ARRAYS.
READ INPUT DATA.
PRINT OUT WHOLE INPUT.

CALCULATE AND PRINT VELOCITY OF LAYER 1
PLOT RAW T-D GRAPH.

EXIT 0

CONSTRUCT SLOPING DATUM PLANE.
CORRECT ARRIVAL TIMES TO NEW DATUM.

PRINT ARRIVAL TIMES
AND PLOT T-D GRAPH CORRECTED TO DATUM.

EXIT 1

CALCULATE VELOCITY AND DELINEATE TOP OF LAYER 2.
PRINT THESE RESULTS.

REMOVE EFFECT OF LAYER 1 FROM OBSERVED TRAVEL TIMES.
PRINT THESE RESULTS.

Table 1.
**Calculus** for layers below layer 1

Print results. Plots T-D graph with layer 1 removed.

**Interpreter's Job**

1. Determine which arrival times will be used in the velocity calculation for layers deeper than layer 2.
2. Select geophone locations where spread will be separated for interpretation of geologic structures.
3. Set up computational devices to be used according to kind of processing desired.

Layers beneath layer 2 are delineated one at a time using delay times procedure.

---

Table 1.
-- continuation --
LAYERS BENEATH LAYER 2 ARE REDELINEATED ONE AT A TIME BY ITERATIVE ADJUSTING PROCESS.

BEFORE LAST ITERATION IF NECESSARY, ALL LAYERS ARE DELINEATED AGAIN ONE AT TIME STARTING IN TOP OF LAYER 2.

PLOTS CROSS SECTION MODEL-INTERPRETATION AND PRINT RESULTS.

END

Table 1.
optional information at the user's discretion to restrict or modify the operation of the program in a variety of ways to be described in the appendix. Data input into the machine is printed out again in convenient form with the headlines "CONTROL DATA INFORMATION," "CONTROL DATA SWITCHES," "VELOCITY DATA," "SHOT POINT AND GEOPHONE DATA," and "SPREAD CONTROL SWITCHES." In this way, information can be easily checked and verified.

The next general stage is to determine the velocity of layer 1 by averaging the individual velocity values computed for all rays that follow direct paths from shot points to geophones. These velocities are printed in a table headed by: "V1 FOR DIRECT RAYS AND DIRECT DISTANCES DD". Besides, a raw time distance graph is plotted if the program user so desires.

The user has two choices: to quit or to continue the processing. In the latter case, a straight line is fitted by the method of least squares through geophone elevation points projected onto the plane of the cross section of the model. This is the construction of the sloping datum plane. However, the user may construct a datum line of his own following the instructions that will be explained in the appendix.

Next, datum corrections are calculated and applied to refraction travel times. These are calculated simply by dividing the velocity of layer 1 into the elevation difference between each geophone or shot position and the corresponding point on the datum plane. If the topographic surface is too abrupt, the sloping datum line could pass beneath the
top of the second layer somewhere along the spread. In this case, wrong datum corrections would be calculated. To avoid this error the SRTDI program is designed to detect these possible cases and use a correction velocity more likely to be the velocity of a second layer to compute that part of the datum correction. After these corrections, the results are printed headed by "ARRIVAL TIMES CORRECTED TO DATUM." Also, at the program user's option, a time-distance graph of datum corrected travel times can be plotted.

At this stage, the program user again has two choices: to exit or to continue the processing. Continuing the processing: the velocity of the second layer is estimated by one of two methods available. The results obtained by the traditional-regression technique (taking into account dipping layer) are printed out under the heading "LAYER 2 VELOCITY AND TIME INTERCEPTS COMPUTED BY REGRESSION." The results obtained by the Hobson-Overton method (Scott et al, 1972) is printed out under the heading "LAYER 2 VELOCITY COMPUTED BY HOBSO-ONOVERTON METHOD." Of the two techniques used to estimate velocity, the Hobson-Overton method is usually slightly superior to the traditional-regression technique. The program computes a weighted average of both velocities in which the weighting factors are the number of observed arrival times used in the different velocity calculations. An additional 50% weighting factor was provided to the value calculated according to the Hobson-Overton method.
After the velocity of the second layer has been established the program proceeds to delineate the interface between layer 1 and layer 2. This is accomplished in two steps by making a first approximation with a modified delay-time analysis, and then improving the accuracy of this result by ray tracing in a self-adjusting procedure. Before this is done, datum corrections are made again, but now taking into account the slant directions of the ray paths. A table is printed giving depths to the top of layer 2 from shot and geophone locations on the datum. Next, the travel times associated with vertical components of ray segments in layer 1 are subtracted from all observed arrival times. The effect of layer 1 is thus removed from the arrival times data. A table is printed out headed by "ARRIVAL TIMES CORRECTED TO BASE OF LAYER 1..." The velocities of all layers beneath layer 2 are then estimated by the two methods described in methods of calculation, as mentioned earlier. These estimates are printed out in tables under the heading: "LAYER # VELOCITY AND TIME INTERCEPTS COMPUTED..." Again, at the user's option a time-distance graph is plotted with the contribution of layer 1 removed.

At this stage of processing, the user has all the elements he needs to complete the input data for the last run of the program. An exit is available and is suggested for use so one can re-evaluate and modify the input data in such a way that the final run can be executed. Decisions regarding which arrival times, and their correct associated
layers are required here for use in the velocity calculation. Information regarding specific geophone locations and subsurface interfaces geographically related to possible subsurface geologic structures is also required. This technique is followed to avoid any smoothing mathematical procedure which could wipe out the sharp subsurface features. This device generates a "ghost" zone" formed by the line segment connecting the previously calculated depth locations corresponding to the surface geophone locations specified as related geographically to the geologic structure. This zone eliminates interface depth calculations related to slant ray paths (ray paths between interfaces) which go through it. However, it does not disturb those refraction ray paths which go through it traveling along the interface. Finally, the user should set up the computational devices or switches to be used, depending on the kind of processing he is interested in. Further details about these devices (switches) are given in the appendix.

Whenever the processing goes through this stage, the layers beneath layer 2 are delineated, one at a time going downward, with the delay-time method providing a first approximation followed by a maximum of three ray-tracing and adjustment procedures. The delay-time first approximation procedure used here is similar to the technique previously described for layer 2, except that for deeper layers the time of the slant path segments in overlying layers are first subtracted from the observed travel times. Again,
the accuracy of the delay-time calculation is tested by the ray tracing procedure as previously done for layer 2. Computed times associated with traced rays are compared with observed travel times and subsurface starting points of the rays are adjusted to absorb any discrepancies. When missed subsurface points beneath geophones result from insufficient data, the program fills in these data points following extrapolation and interpolation criteria.

Those geophone locations selected to separate the spread in order to enhance any subsurface geologic structure are used in this part of the processing. It works in such a way that just an incomplete interrelation or, if the user desires, no interrelation at all is established between the spread sections along those locations; no smoothing process is done along the possible subsurface geological structure.

Several exits are available from the standard processing sequence at the intermediate stage of this time-consuming part of the program execution. A complete explanation of this section is given in the appendix.

After the second iteration of ray tracing is completed, the program examines the results to detect possible alignment of kinkiness in layers beneath layer 2. Such alignment suggests a wrong delineation of layer 2, so this layer is adjusted to correct that error. With layer 2 repositioned, all deeper layers are redelineated, one at a time in a downward direction, by using the third and final iteration of the ray
tracing and adjusting procedure.

Finally, the results of depth interpretation, whatever exit has been used from ±3 to ±6, are represented in a table printed under the heading "RAY END FOR SHOT POINTS." If discrepancies between traced and observed travel times exceed a certain value, then the computed coordinates given in the table are flagged with a question mark and the point in question is not used to delineate the associated interface. Although the refraction horizons have not always been smoothed, their position beneath each geophone and shot are presented in another table under the generic heading "SMOOTHED POSITION OF LAYER BENEATH SHOT AND GEOPHONES." Also, a display of a cross-section of the interpreted model is plotted.

Program Calculations and Algorithms

As follows, the main calculation procedures used in the SRTDI program are outlined to help the reader understand the program interpretation approach.

Apparent Velocities and Sloping Datum Plane

A least-squares regression technique is used in the computer to fit a straight line through an ordered sequence of points in the time-distance graph and through the elevations of the geophone stations for the sloping datum calculation case. This mathematical procedure is used to calculate the apparent velocities (T-D graph) and the sloping datum at separated steps during the program execution.
For the apparent velocities case, the calculations and formulae are:

\[ D_i = XG_i - X_s \]
\[ \bar{D} = \frac{\sum_{i=1}^{N} D_i}{N} \]
\[ \bar{T} = \frac{\sum_{i=1}^{N} T_i}{N} \]
\[ V = \frac{\sum_{i=1}^{N} (D_i - \bar{D})^2}{\sum_{i=1}^{N} (D_i - \bar{D})T_i} \]

Where:

- \( XG_i \) = Geophone location (i) horizontal distance from the axis of reference
- \( X_s \) = Shot point location (s) horizontal distance from the axis of reference
- \( T_i \) = Observed travel time associated with the (i) geophone
- \( N \) = Number of geophone locations used in the calculation

For the sloping datum plane case and assuming that \( Y = Bx + A \) is the line's equation obtained in intercepting this plane with the cross section plane, the calculations and formulae are:

\[ \bar{X} = \frac{\sum_{i=1}^{N} XG_i}{N} \]
\[ \bar{E} = \frac{\sum_{i=1}^{N} EG_i}{N} \]
\[ B = \frac{\sum_{i=1}^{N} (XG_i - \bar{X})EG_i}{\sum_{i=1}^{N} (XG_i - \bar{X})^2} \]
\[ A = \bar{E} - B\bar{X} \]

Where:

- \( EG_i \) = Geophone location elevation with respect to the original field datum (sea level)
- \( Y \) = Elevation
- \( X \) = Horizontal distance
Velocity Calculation

Two methods are used to estimate the wave speed or velocity of layers deeper than the first layer. The first method uses the apparent velocities calculated by the least-squares regression technique explained earlier. These velocities are input to a traditional refraction formula which calculates true velocity values. This formula (Hollister and Davis, 1976) has been developed taking into account Snell's law, dipping-layer and geometrical configuration of source and receiver. As an example, a procedure for calculating the velocity of the third layer is developed for the model shown in Figure 2.

The second method used to estimate velocity was developed by the geological survey of Canada (Hobson and Overton, 1968). The technique seeks to find a velocity such that the variation of total delay-time differences \( (\Delta T_i - \Delta X_i/V) \) for a group of geophones is minimized by the least-squares procedure. The algorithm used is:

\[
V = \frac{\sum_{i=1}^{N} \Delta X_i - (\sum_{i=1}^{N} \Delta X_i)^2 / N}{\sum_{i=1}^{N} (\Delta X_i)(\Delta T_i) - (\sum_{i=1}^{N} \Delta X_i)(\sum_{i=1}^{N} \Delta T_i) / N}
\]

Where:

\( V \) = is the desired velocity

\( \Delta T_i \) = is the time difference between arrival times at geophone \((i)\) from two shot points located (offset) at opposite ends of spread

\( \Delta X_i \) = is the corresponding difference between distances to geophone \((i)\) from the two shot points

\( N \) = is the total number of geophones used in the computation
\[ A_{12} = \sin^{-1}(V_1 / V_{2u}) \]
\[ B_{12} = \sin^{-1}(V_1 / V_{2d}) \]
\[ a_{12} = (A_{12} + B_{12}) / 2 \]
\[ D_1 = (A_{12} - B_{12}) / 2 \]
\[ V_2 = V_1 / \sin(a_{12}) \]
\[ A_{13} = A_{12} - D_1 \]
\[ B_{13} = B_{12} + D_1 \]
\[ V_{VL} = V_2 / V_1 \]
\[ A_{23} = \sin^{-1}(V_{VL} \cdot \sin(A_{13})) \]
\[ B_{23} = \sin^{-1}(V_{VL} \cdot \sin(B_{13})) \]
\[ a_{23} = (A_{23} + B_{23}) / 2 \]
\[ V_3 = V_2 / \sin(a_{23}) \]

Where:
\[ V_1, V_2, V_3 \] are seismic refraction velocities.

And
\[ -1 \text{SIN} = \sin^{-1} \]

Figure 2. Velocity calculation in dipping-layer case.
As one can observe, this procedure can only be employed when the geophones receive information from shots located at opposite ends of the spread.

**Delay-time Calculation**

A modified delay-time method is used to delineate the position of any refractor horizon to a first approximation by calculation of coordinates of the points where the refracted rays enter and emerge from the layer beneath the geophone location.

As follows, the method is outlined for the calculations of layer 2, but it is basically the same for any layer:

a) The first step consists of translating each geophone location from its original position to two different equivalent positions on the datum plane, one for the right-traveling rays and the other for the left-traveling rays. Translation is made following the slant line representing the refraction ray path according to Snell's law (Figure 3a). Shot points are translated to the datum plane in a similar manner.

b) The half-intercept time value is used to compute the length of the ray traveling from the shot point to the refracting horizon, and to locate the point of entry beneath each shot point (Figure 3b).

c) With these points established, the delay time associated with each geophone is computed and used to locate the position of the point of emergence of
Figure 3. The delay time approach diagram.
each ray from the refracting horizon upward to the respective geophone. The key assumption in this case is that the sloping datum and the refracting horizon are initially considered parallel. The first approximation to the top of that layer is completed when a straight line is fitted to all points of entry and emergence determined before (Figure 3c).

Ray-Tracing Self-Adjusting Technique

The ray tracing technique consists of tracing a ray from a specified starting point located on the refracting horizon until it arrives at the same elevation as the target geophone. The ray-starting point is computed previously by a rough estimation made under the assumptions of horizontal layering, or from results of previous iterations of the same technique. The orientation of the ray segment emerging from a specified point on the refracting horizon is computed and traced as a function of the refracting horizon's dip and the velocities of the adjoining layers. In upper interfaces the new direction is calculated using the same type of parameters used before, plus the incident ray direction.

Travel time consumed between interfaces is also calculated and carried in a summation. When the final ray segment arrives at the target, the horizontal distance by which the target is missed is computed. In addition, the total theoretical arrival time counted since the ray left the shot
point is compared with the observed one (Figure 4). If the distance error is less than one foot, no horizontal displacement is made in the starting point location. Otherwise, a new ray is established by simply moving the old one over the refracting horizon by the amount of the horizontal error and in the direction required for correction. When the horizontal correction on the interface plane for the starting (emerging) point is over, a correction on the direction of the slant ray immediately follows. If the time error is larger than that the user selected as a comparison, the velocity of the horizon and the direction of the slant ray are used to relocate the starting point. The final effect is similar to that shown in Figure 4.
Figure 4. Ray tracing and adjustment procedure diagram.
REFRACTION PROGRAM RESULTS

Test Using Pre-designed Input Data

Three common subsurface geological structures were simulated, time-distance graphs constructed, and travel times input to the SRTDI program to test its capability to interpret possible subsurface anomalies. The test was simply designed taking a typical data problem and forcing its arrival time-distance information in such a way that the T-D graphs follow the qualitative criteria shown in Figure 5. In Figure 5, one can observe how anomalies in the arrival time (shot-geophone) distance relationship (T-D graph) can be roughly related to possible subsurface geological structures. The SRTDI program user must be able to recognize these kinds of irregularities in the input data and/or from intermediate results of the program to be a successful interpreter. A logical interpretation sequence was followed in each case such that a smoothed model was first interpreted. Following this, a more reliable model was calculated using the new computational device included in the program.

The results presented here are a convenient selection of the program output. In every case, T-D graphs are provided by the computer without straight lines through the points. These were drawn by the interpreter. The model interpretations are shown in diagrammatic way with simple lines connecting the depth points beneath each geophone. Each interface is identified by its corresponding number
Figure 5. T-D graph - geologic model most common relationships. (after Mooney, 1973)
drawn right on the interface line every 5 geophone locations. The ground surface is also drawn without number to identify it and will always be located through the top of the model. The breaks in the interfaces shown in some models identify the locations where the spread has been separated to facilitate the interpretation. Fault lines should be drawn by the interpreter in those places where there are faulted geological structures associated with the anomaly. Figures 6 through 9 show the set of results obtained when data, characterized by a T-D graph showing an irregularity on the apparent third velocity line up (starting at geophone 13 location), was used. The irregularity appears to be related to a fault zone extended through the top of the third layer. Figures 6 and 7 are the raw T-D graph and the layer 1 effect removed T-D graph respectively. In each of the problems presented here, these graphs are provided so that one may observe how the input data looks in the T-D graph expression.

Figure 8 presents the smoothed model interpretation provided by the SRTDI program. Observe that the fault zone is hard to pick from this model. On the other hand, Figure 9 which represents the sharp model, does show the expected subsurface anomaly. The fault zone is observable here and a measure of the throw of the fault in the third layer seems feasible.

Figures 10 through 13 combine the results obtained when the program interpreted an input data dealing with a possible change of dip (downward to the right) in the third layer.
Figure 7. Fault or buried step case, Layer 1 removed T-D graph,
Figure 8. Fault or buried step case, Smoothed model interpretation.
Figure 9. Fault or buried step case. Sharp model interpretation.
This structure is shown on T-D graphs in Figures 10 and 11 where the points line-up associated with the apparent velocity of the third layer changes abruptly upward as if a velocity reduction occurred. Figures 12 and 13 present the logical interpretation sequence of a smoothed model followed by a sharper one.

Figures 14 through 18 present a selected output obtained when the program interpreted an input data characterized by an isolated hole on the top of the third layer. A few offset points from the third velocity segment in the T-D graphs was the feature of interest in the data. As before, Figures 16 through 19 present the smoothed model as a first interpretation step followed by two sharper models obtained by setting up the adequate computational device to delineate first the left edge of the subsurface irregularity (Figure 17) and second the right edge of that subsurface feature (Figure 18). Figure 19 is a composite model obtained from the last two. It provides the best interpretation for this particular problem.

Test Using Real Field Data

A seismic refraction line (R68) recorded by the Colorado School of Mines in 1968 at South Park, Colorado was partially reinterpreted using the SRTDI program.

The seismic line with a length of 15,400 feet was covered by 6 spreads of 24 geophones each, 110 feet group spacing, and 2 shots (end of spread type) per spread. A superposition of one geophone location per spread was used along the line. This
Figure 10. Change in dip of subsurface case, Raw T-D graph.
Figure 11. Change in dip of subsurface case. Layer 1 removed T-D graph.
Figure 12. Change in dip of subsurface case. Smoothed model interpretation.
Figure 13. Change in dip of subsurface case, Sharp model interpretation.
Figure 14. Irregular subsurface topography case, Raw T-D graph.

AN ISOLATED HOLE ON THE TOP OF THIRD LAYER.
Figure 15. Irregular subsurface topography case, Layer 1 removed T-D graph.
Figure 16. Irregular subsurface topography case. Smoothed model interpretation.
Figure 17. Irregular subsurface topography case, Sharp model interpretation. Left edge of the isolated hole.
Figure 18. Irregular subsurface topography case, Sharp model interpretation, Right edge of the isolated hole.
Figure 19. Irregular subsurface topography case.
Combined model interpretation.
seismic refraction line was located in the field over a former seismic reflection line recorded in 1963. Its interpretation was made by Jan Fatti in 1971 using the method-of-differences technique with the aid of a desk calculator. First breaks of the 1963 seismic reflection records covering the same area were used to delineate the top of the second layer. The former interpreter was obliged to do his job assuming that all the arrival times picked from the refraction records came from the top of the third layer. This also assumed that variations in the refraction velocity observed in the T-D graph were related to changes of dip in that interface.

The SRTDI interpretation, presented in this thesis, was made using the same assumptions and following the same approach in order to obtain a fair comparison. However, the program user is not always limited to follow "short cut" assumptions in order to obtain detailed interpretations. The program operates with such versatility that it is often limited by the program user's ability.

Just 4 spreads out of 6 were used in the re-interpretation of this line because they were considered enough for the purpose of testing the program.

Delineation of the top of the second layer was made using the refraction data from the reflection records with the SRTDI program. This interpretation was integrated with the 1968 refraction data to interpret the final model. From Figures 22-24, a sequential display of models show graphically the steps accomplished to arrive at the final model interpretation.
Figure 32. SMTU Interpretation of seismic refraction line 1064, South Park. Smoothed model interpretation.
Figure 2: SEDS Interpretation of seismic refraction line 870, South Park. *SEDs model interpretation.*
After the first trial run of the South Park data, the author realized that the refraction velocity control deserved better consideration. Velocities were calculated for each spread individually from intermediate results of the first run and used as the override velocity information for another execution of the SRTDI program. The accuracy of the results, supported by the observed T-D graph vs. calculated T-D graph curve matching obtained in the second run, improved considerably.

Figures 20 and 21 present the T-D graphs of the 1968 South Park basic seismic refraction input data. In order to visualize the relationship between the former and the new interpretation model of that seismic section, a reduced diagrammatic model taken from the original 1971 interpretation has been included in Figure 24.

**Analysis of Results**

**Pre-Designed Data**

In the first case, Figures 6 through 9, a possible fault exists in the top of the third layer. The smoothed model (Figure 8) does not show any structure that could be associated with a geological fault. Its observed time-theoretic time discrepancies associated with the top of the third layer at geophone locations 7 through 13 were over the range of tolerance selected (10ms), so they have not been used to delineate the second interface (30% of the total locations).
Additionally, 11 out of 46 depth calculations (24% of the total), all for the second subsurface interface, were missing for the same reason—there is a depth calculation beneath each geophone and for each shot associated.

The same data were interpreted using the new computational device and a sharper model (Figure 9) was obtained. In this model, a well defined geological fault (or buried step) of about 150 feet throw can be interpreted beneath geophone locations 13 and 14. The resolution was remarkably improved in such a way that every depth point beneath geophone locations has been accurately defined with time discrepancies within the range of tolerance (10ms). Therefore, just 6 out of 46 depth calculations (15% of the total), all from the second interface, were unsuccessfully calculated. The CPU computer time consumed during these interpretations was 8.96 scs. for sharp model and 8.14 scs. for the smoothed model.

In the second case, a possible change of dip occurs on the top of the third layer. Figure 12 is the first approximation model-interpretation (smoothed one) for this case. It shows a downward change of dip on the top of the third layer starting around geophone locations 18 and 19 which can be associated with the irregularity shown in the observed arrival times from geophone locations 15 through 23. However, the model was delineated without certain knowledge about the third layer depth locations beneath geophones 1 through 19 (83% of the total locations). Therefore, 24 out of 46 possible depth
calculations (52% of the total) related to the second inter­face were missing because of time discrepancies. Subsequently, a sharper model was interpreted—Figure 13. This model was definitely an improvement in comparison with the smoothed one. In this case, geophone locations 16 and 17, associated with the second interface, were the only locations not used in the delineations of the model (9% of the total) and 6 out 46 possible depth calculations (22% of the total), all asso­ciated with the second interface, were not trusted for the interpretation. However, according to this model, a fault zone which was hard to predict from the analysis of the T-D graph, turned out to be involved with the change of dip to yield the anomaly observed in the arrival times. This example serves as a reminder to the interpreter about the necessity of any kind of additional geological information to confirm or reject surprising results such as these.

The reader should remember that the data interpreted were artificial modifications of arrival times in a typical seismic refraction profile. Furthermore, the poor results obtained in the smoothed model could be an indication that this problem case contains more complexity than it apparently shows. The CPU computer time consumed during these interpre­tations was 8.13 secs. for the smoothed model and 8.05 secs. for the sharp model.

In the third case, Figures 14 and 15 present T-D dia­grams of seismic refraction data which show relative delay of the arrival times at geophone locations 12 through 15.
Initially the time anomaly was associated with a possible isolated hole in the top of the third layer and this information guided the logic of the interpretation as is presented here. A first approximation smoothed model (Figure 16) was obtained which barely shows the expected hole around geophone location 12. For this model, the time discrepancies for the second interface at geophone locations 10 and 11 (9% of the total) were over the range of tolerance (10 ms). Because of this discrepancy they were not used to delineate the top of the third layer. Five (5) out of 46 depth calculations (11% of the total), all related to the second interface, were missing for the same reason.

This case illustrates two separated zones with anomalous arrival times associated with each edge of the hole. In order to overcome this difficulty, two models were interpreted here, one set for the left side of the anomaly, and the other for the right side. These two were later integrated into one following a superposition criterion. Figure 17 presents a model which shows the left edge of the subsurface anomaly better defined around geophone locations 11 and 12. Its reliability is supported by the fact that just geophone locations 10 and 13 (9% of the total) were not used in the delineation of the second interface because of relatively high time discrepancies. Therefore, 6 out of 46 depth calculations (about 13% of the total), all related to the third layer, were missing for the same reason.

One the other hand, the right edge model (Figure 18)
is the best-fit interpretation of all the cases. This model shows the right edge of the hole around geophone locations 15 and 16, and only geophone locations 17 and 18 did not provide reliable information from the top of the third layer. Thus, 2 out of 46 total possible depth calculations (4%) were not included in the model delineation. The CPU computer time consumed during these interpretations was 9.23 secs. for the right shaped model, 9.18 secs. for the left shaped model and 9.45 secs. for the smoothed one.

Field Data

Before the results obtained in this section are analyzed, the author wishes to point out that although the most suitable field data were not used here, mainly because of a lack of field information during recording, this case had the advantage of already having a conventional interpretation. Preliminary results which are not presented here showed that some sort of data inconsistency was driving the SRTDI program to provide results which were geologically impossible or just not reliable. To test this possibility, several dozen cases from the same problem were interpreted with the program using variable input values such as the eastern shot point location (B) and the layer velocities.

The shot point location (B) was relocated at 15,070 feet (originally at 18,480 according to the field report) from the first geophone location. With that source and receiver configuration, the final interpretation came out with better observed arrival-time vs. calculated-time matching for several
different subsurface velocity combinations. Therefore, the final model interpretation presented in this work was selected as the best according to its reliability and matching characteristics from that group of results formed using several different subsurface velocities.

As in the pre-designed data cases, a smoothed model and a sharper one was interpreted. In both cases, the first subsurface interface (top of the second layer) was previously delineated from the first breaks of the 1963 seismic reflection line recorded by the Colorado School of Mines exactly on the same line location. The results show that this interface was delineated with a high degree of confidence because just 4 out of 96 total geophone locations (4%) were missing due to time discrepancies over 10 ms. These locations were geophones 4, 5, 6, and 13 of spread A. The SRTDI program execution expended 34 secs. CPU time defining the smoothed model of the first interface.

The final smoothed model (Figure 22) shows two places where sharper geological structures should be used to explain the feature obtained. The first such location was between geophone locations 24 (spread B) and 1 (spread C) where approximately 675 feet jump almost vertical slope for the second interface is interpreted there and between geophone locations 3 and 4 of spread C where approximately 275 feet jump high angle slope was also delineated. For this model, the observed arrival time and calculated time discrepancies at geophone locations 5 through 11 of spread C were over the range of tolerance selected (30 ms). This means that 7
out of 96 possible locations were not used to delineate the second interface. However, 82 out of 96 depth calculations related to the shot point (B) location did not contribute to the final depth value calculation beneath geophone locations 1 (spread A) through 12 (spread D) because of large time discrepancies (over 30 ms.). Therefore 95 out of 192 total depth values, all related to the second interface, could not be used in the final depth calculation for the same reason.

The final sharp model interpretation (Figure 23) presents a more likely geological model than the previous one but it was also slightly inferior with respect to the observed arrival time vs. calculated time matching (time discrepancies). In this case, 3 out of 4 possible subsurface geological structures initially assumed were found near the locations where the T-D graph showed them. Thirteen out of 96 total geophone locations were missing because of time discrepancies over 30 ms; 82 out of 96 depth values (geophone 1, spread A through geophone 12, spread D) provided by the shot point (B) were missing due to the same reason; and 95 out of 192 total depth values, all related to the second subsurface interface, could not be used in the final depth calculation, as occurred in the smoothed case.

The SRTDI program expended about 44 scs. of CPU computer time to delineate the smoothed model and 42 scs. of CPU time for the sharp one.

The main structures presented in the final sharp interpretation can be described as a normal fault on the top of the third layer with 160 feet throw around geophone locations
7 and 8 of spread A. A "horst" structure on the top of the third layer is also shown between geophone location 19 of spread B and location 6 of spread C. The structural relief is about 280 feet extended over 1000 feet laterally.

Following are some comments about the basic differences and similarities of the 1971 Fatti interpretation and the SRTDI computer program interpretation:

a) The first interface is similar in both interpretations except at the ends of the whole spread where the SRTDI interpretation shows an up-dipping feature on the second interface which is missing in the Fatti interpretation.

b) Velocities for the first and second layers turned out to be similar in both interpretations. However, a 15% average value increment in the transversal velocity of the second layer was required to improve the reliability of the model.

c) Both models show a general feature which is roughly similar. However, relative depth values of the first subsurface interface with respect to the second interface are quite different, as one can observe in the following table on page 60.

d) In general, the top of the third layer appears deeper on the Fatti model than on the SRTDI model and this could be explained by:

i) the SRTDI program could not use the seismic
<table>
<thead>
<tr>
<th>Layer</th>
<th>Maximum second layer section (feet)</th>
<th>Distance in feet from first geophone location</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,700</td>
<td>5,500</td>
<td>Fatti</td>
</tr>
<tr>
<td></td>
<td>780</td>
<td>5,150</td>
<td>SRTDI Smoothed</td>
</tr>
<tr>
<td></td>
<td>700</td>
<td>3,650</td>
<td>SRTDI Sharp</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Western (to the left) slope value for top of third layer</th>
<th>Extension (feet)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>.201</td>
<td>4,600</td>
<td>Fatti</td>
</tr>
<tr>
<td>.215</td>
<td>3,700</td>
<td>SRTDI Smoothed</td>
</tr>
<tr>
<td>.257</td>
<td>2,500</td>
<td>SRTDI Sharp</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Eastern Section (5500 - 14500 ft.) average second layer section (feet)</th>
<th>Extension (Feet)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1370</td>
<td>4,000</td>
<td>Fatti</td>
</tr>
<tr>
<td>360</td>
<td>1,050</td>
<td>SRTDI Smoothed</td>
</tr>
<tr>
<td>375</td>
<td>950</td>
<td>SRTDI Sharp</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Layer</th>
<th>Weighted Average Velocity (ft/sec)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3,030</td>
<td>Fatti</td>
</tr>
<tr>
<td>1</td>
<td>3,040</td>
<td>SRTDI</td>
</tr>
<tr>
<td>2</td>
<td>6,650</td>
<td>Fatti</td>
</tr>
<tr>
<td>2</td>
<td>7,225</td>
<td>SRTDI</td>
</tr>
<tr>
<td>3</td>
<td>14,300</td>
<td>Fatti</td>
</tr>
<tr>
<td>3</td>
<td>11,000</td>
<td>SRTDI</td>
</tr>
</tbody>
</table>
refracted information provided by the eastern shot point (B or the right one). Perhaps there was not enough control for the depth values of the second interface.

ii) The right field location of the shot point (B) is still questionable insofar as this thesis is concerned.

iii) Fatti's interpretation shows in several places enormous lateral velocity variation for the third layer. However, when this hypothesis was tested in the SRTDI program, the results obtained were clearly unreasonable. Even when velocities were used which were more likely to be the weighted average velocity of the third layer (14,300 ft/sc), the results obtained were similar to the final one presented here, but with inferior time matching characteristics. Possibly some other sort of inconsistency is included in the input data and although SRTDI was able to detect it, it could not reconcile it.
CONCLUSIONS

From this study the following conclusions are drawn:

1. The SRTDI computer program shows remarkable advantages over the conventional hand computation-interpretation methods of seismic refraction data, especially for those problems which cover complex geological situations and/or have long associated seismic lines. Time and cost of interpreter participation are significantly reduced, accuracy and reliability is greatly improved and input data plus general results presentation are better organized and displayed.

2. The SRTDI computer program is a more versatile and reliable computational device to handle the seismic refraction problem than the FSIPl program (Scott et al., 1972). Although both computer programs have been designed to solve generally different problems and objectives, under the same conditions of work, the SRTDI provides a more confident velocity calculation and datum correction, less consumption of computer time (30% less), superior display of final results and more flexibility to approach the solution of the problem.

3. The SRTDI program has been designed to solve a more selective type of source and receiver field configuration. This technique speeds the program execution and filters out possible inconsistencies in the measured input data. At the same time, SRTDI provides more confidence to the user to judge those unreasonable final-interpretation problems. The FSIPl program with almost no restriction
regarding this aspect is more likely to fail in these cases.

4. Efficient utilization of all computational devices in the SRTDI program requires that the user know the general approach followed by the program, the limitations of the mathematical procedures involved and finally a knowledge about seismic refraction prospecting.
REFERENCES


Olhovich, V. A., 1959, Sismologia aplicada: Mexico, ed. Reverte S.A.


APPENDIX

User's Manual

Introduction

This appendix is provided as an aid to those who wish to interpret seismic refraction data using the SRTDI program. The program summary sheet is intended for inclusion in a Geophysics Department Program Summary Manual and should provide the reader sufficient information to use the program satisfactorily. Therefore, an additional part is contained in this appendix—the Program Description. The program description can be used by those who plan to modify the program to suit specific needs.
A.1 Formal Program Name

SRTDI

A.2 Description of Function

SRTDI is designed to interpret any basic seismic refraction data. The output of this program is a value of the depth, beneath each geophone location from all possible refractors. The program is intended to provide approximately layered earth models in cross-sectional displays.

A.2.1 Read Input Data. The following describes the input data organization. Two input files are used. Each file consists of a variable number of cards (records) of 80 spaces. The formal input file name is FORCDR.DAT on the CSM PDP-10 System. Fortran II style input/output statements (READ and PRINT) are used. The sequence of the card is outlined below: (Notes on specific variables are indicated by an asterisk and a number such as *13. These notes are found at the end of this section and should be referred to in order to properly specify the variable in question.

<table>
<thead>
<tr>
<th>First Line or Card</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable or Array Name</td>
</tr>
<tr>
<td>IDENT</td>
</tr>
</tbody>
</table>

which adjusts to the following format:

Format and Column Numbers for Each Variable
(column numbers are beginning column for each variable)

| Column #: | 1 |
| Format:   | 14A5 |
## Second Line or Card

<table>
<thead>
<tr>
<th>Variable or Array Name</th>
<th>Information</th>
<th>Range or Units</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM</td>
<td>Number of spreads</td>
<td>1 to 5</td>
<td>1</td>
</tr>
<tr>
<td>IXIT</td>
<td>Program exit point <em>(1)</em></td>
<td>0 to ±6</td>
<td>0</td>
</tr>
<tr>
<td>NL</td>
<td>Number of layers</td>
<td>2 to 5</td>
<td>2</td>
</tr>
<tr>
<td>NV</td>
<td>Number of velocity cards</td>
<td>0 to 5</td>
<td>0</td>
</tr>
<tr>
<td>NTVE</td>
<td>Switch to overrule</td>
<td>1 to over-</td>
<td>No overrule</td>
</tr>
<tr>
<td></td>
<td>Programmed velocity calculation taking into account dipping layer *(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITWO</td>
<td>Switch to accept additional data from another source *(3)</td>
<td>1 to accept</td>
<td>No acceptance</td>
</tr>
<tr>
<td></td>
<td>the data</td>
<td></td>
<td>of data</td>
</tr>
<tr>
<td>MK11</td>
<td>Number of first spread where additional data will be accepted from *(3)</td>
<td>0 to 5</td>
<td>0</td>
</tr>
<tr>
<td>K111</td>
<td>Number of first geophone where the new data will be accepted from *(3)</td>
<td>0 to 24</td>
<td>0</td>
</tr>
<tr>
<td>MK22</td>
<td>Number of last spread up to additional data will be accepted *(3)</td>
<td>0 to 5</td>
<td>0</td>
</tr>
<tr>
<td>K222</td>
<td>Number of last geophone location up to new data will be accepted</td>
<td>0 to 24</td>
<td>0</td>
</tr>
<tr>
<td>EDAT1</td>
<td>Elevation of first datum point coordinate *(4)</td>
<td>feet</td>
<td>0</td>
</tr>
<tr>
<td>XDAT1</td>
<td>Horizontal position of first datum point coordinate *(4)</td>
<td>feet</td>
<td>0</td>
</tr>
<tr>
<td>EDAT2</td>
<td>Elevation of second datum point coordinate *(4)</td>
<td>feet</td>
<td>0</td>
</tr>
<tr>
<td>XDAT2</td>
<td>Horizontal position of second datum point coordinate *(4)</td>
<td>feet</td>
<td>0</td>
</tr>
<tr>
<td>Variable or Array Name</td>
<td>Information</td>
<td>Range or Units</td>
<td>Default Value</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------------------</td>
<td>----------------</td>
<td>---------------</td>
</tr>
<tr>
<td>SLOPE</td>
<td>Datum equation slope value</td>
<td>ratio</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>Datum equation intercept value</td>
<td>feet</td>
<td>0</td>
</tr>
<tr>
<td>BLIM</td>
<td>Slope limit *(5)</td>
<td>ratio</td>
<td>.5</td>
</tr>
<tr>
<td>TLIM</td>
<td>Time discrepancy limit *(6)</td>
<td>Msec</td>
<td>10.0</td>
</tr>
<tr>
<td>ITRACE</td>
<td>Switch to print the ray trace steps *(7)</td>
<td>1 for print</td>
<td>no print</td>
</tr>
<tr>
<td>JJOFF</td>
<td>Switch for offset shot point adjustment *(8)</td>
<td>1 for no adjustment</td>
<td>adjustment</td>
</tr>
<tr>
<td>NSWAD</td>
<td>Switch to get more sharpness along the subsurface anomalies *(9)</td>
<td>1 for more sharpness</td>
<td>no more sharpness</td>
</tr>
</tbody>
</table>

The formats and beginning column numbers for each variable are given below:

Column #: 1 2 5 7 9 10 11 13 15 17 24 31 38 45 52 59 66 73 78 79 80
Format: I1 I2 I1 I1 I1 I1 I2 I2 I2 I2 F7.1 F7.1 F7.1 F7.1 F7.4 F7.1 F7.2 I1 I1 I1

The formats and Column Numbers for the Third Line or Card:

<table>
<thead>
<tr>
<th>Variable or Array Name</th>
<th>Information</th>
<th>Range or Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSCALE</td>
<td>Arbitrary value that can be used to adjust the T-D output display scale *(10)</td>
<td>Msec</td>
</tr>
<tr>
<td>ESCALE</td>
<td>Arbitrary value that can be used to adjust the cross-section output display scale *(11)</td>
<td>feet</td>
</tr>
</tbody>
</table>

These variables are input in the following format:

Format and Column Numbers:

Column #: 1 6
Format: F5.0 F5.0
Fourth Line

If NV>0 then a number of cards equal to the value of NV are read in.

<table>
<thead>
<tr>
<th>Variable or Array Name</th>
<th>Information</th>
<th>Range or Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Layer Number</td>
<td>0 to 5</td>
</tr>
<tr>
<td>VVA</td>
<td>Vertical Velocity for spread 1 (*12) ft/sec</td>
<td></td>
</tr>
<tr>
<td>VHA</td>
<td>Horizontal Velocity for spread 1 (*13) ft/sec</td>
<td></td>
</tr>
<tr>
<td>VVA</td>
<td>Vertical Velocity for spread 2</td>
<td>ft/sec</td>
</tr>
<tr>
<td>VHA</td>
<td>Horizontal Velocity for spread 2</td>
<td>ft/sec</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

A velocity card for each layer containing at least one velocity value may be input. If the velocities are to be calculated by the program, NV is zero and this card is omitted.

Format and column numbers

Column #: 1 2
Format: II 10(F6.0)

After the last velocity override line, if that is the case, follow:

Fifth Line: the next group of cards corresponds to information about each spread. A card for each spread is input.

<table>
<thead>
<tr>
<th>Variable or Array Name</th>
<th>Information</th>
<th>Range or Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDSFR</td>
<td>Spread symbol</td>
<td>one letter or number</td>
</tr>
<tr>
<td>NJ</td>
<td>Number of shot points</td>
<td>2</td>
</tr>
<tr>
<td>NK</td>
<td>Number of geophones</td>
<td>1 to 24</td>
</tr>
<tr>
<td>NML</td>
<td>Five consecutive switches to inform which layers have arrival times in this spread (*14)</td>
<td>1 for positive answer</td>
</tr>
<tr>
<td>XSHIFT</td>
<td>Inline coordinate shift (*15)</td>
<td></td>
</tr>
<tr>
<td>MIND</td>
<td>An array of switches used to set up special interpretation procedure over critical zones which subsurface geologic structures underneath (*16)</td>
<td>1 for positive answer</td>
</tr>
<tr>
<td>Variable or Array Name</td>
<td>Introduction</td>
<td>Range or Units</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>KPPL</td>
<td>An array which provides the number of geophone location on the left boundary side of the critical zone *(16)</td>
<td>0 - 23</td>
</tr>
<tr>
<td>KPPR</td>
<td>An array which provides the number of geophone location on the right boundary side of the critical zone *(16)</td>
<td>0, 2 - 24</td>
</tr>
<tr>
<td>NGDED</td>
<td>Number of geophones off covering the whole geologically anomalous zone *(16)</td>
<td>0 - 9</td>
</tr>
</tbody>
</table>

The last four variables are repeated five times, one set for each interface.

EWMAX Maximum weathering section *(17) feet
VCOR Correction velocity *(18) X(1000)ft/sec

Which sequentially adjust to the following format:

**Format and Column Numbers**

Column #: 1 2 5 8 13 18 48 53
Format: Al I3 I3 5I1 F5.0 5(I1,I2,I2,I1) F5.0 F5.0

Sixth Line: The data for each shot point is included on a single card (one per shot point)

<table>
<thead>
<tr>
<th>Variable or Array Name</th>
<th>Information</th>
<th>Range or Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDTEST</td>
<td>Spread symbol</td>
<td>must be the same one used in spread control line</td>
</tr>
<tr>
<td>IDSP</td>
<td>Shot point symbol</td>
<td>letter or number</td>
</tr>
<tr>
<td>ESP</td>
<td>Elevation of surface</td>
<td>feet</td>
</tr>
<tr>
<td>XSP</td>
<td>Inline coordinate</td>
<td>feet</td>
</tr>
<tr>
<td>YSP</td>
<td>Transverse coordinate</td>
<td>feet</td>
</tr>
<tr>
<td>ZSP</td>
<td>Depth of shot</td>
<td>feet</td>
</tr>
<tr>
<td>TUH</td>
<td>Uphole time</td>
<td>Msec.</td>
</tr>
<tr>
<td>TFUDGE</td>
<td>Fudge time (19)</td>
<td>Msec.</td>
</tr>
</tbody>
</table>
### Seventh Line

Geophone control line(s). Each geophone is represented by one line.

<table>
<thead>
<tr>
<th>Variable or Array Name</th>
<th>Information</th>
<th>Range OR Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDTEST</td>
<td>Spread symbol</td>
<td>must be the same one used in spread control line</td>
</tr>
<tr>
<td>KTEST</td>
<td>Geophone Number</td>
<td>1 to 24 in sequence</td>
</tr>
<tr>
<td>EG</td>
<td>Elevation of geophone</td>
<td>feet</td>
</tr>
<tr>
<td>XG</td>
<td>Inline coordinate</td>
<td>feet</td>
</tr>
<tr>
<td>YG</td>
<td>Transverse coordinate</td>
<td>feet</td>
</tr>
<tr>
<td>TA</td>
<td>Travel time from S.P.#1</td>
<td>Msec.</td>
</tr>
<tr>
<td>LGC</td>
<td>Switch to indicate if this time is good for velocity calculation (*20)</td>
<td>1 indicates no good</td>
</tr>
<tr>
<td>LG</td>
<td>Layer represented</td>
<td>1 to 5</td>
</tr>
<tr>
<td>TA</td>
<td>Travel time from S.P.#2</td>
<td>Msec.</td>
</tr>
<tr>
<td>LGC</td>
<td>Switch which indicates if this time is good for velocity calculation (*20)</td>
<td>1 indicates no good</td>
</tr>
<tr>
<td>LG</td>
<td>Layer represented</td>
<td>1 to 5</td>
</tr>
</tbody>
</table>

### Format and Column Numbers

Column #: 1 3 5 12 19 26 31 36 41
Format: A1 A2 F7.1 F7.1 F7.1 F5.1 F5.1 F5.1 F5.1

Column #: 1 2 4 11 18 25 30 31 32 37 38...
Format: A1 I2 F7.1 F7.1 F7.1 F5.1 I1 I1 F5.1 I1 I2
Last Line

Containing just the work END starting at the first column.

Additional Input Data

A value of the depth to the second layer beneath each geophone can be input if the variable ITWO has the value 1. A depth value for each geophone location mentioned in the variable K111, MK11, K222, MK22 (see note 3 above) is entered in this file. These values are entered via Fortran IV statements which accept input from unit 12 (i.e., the form is READ (12,96) List where 96 is a format statement number). Each number is in format F12.5 and appears on a separate line (record).

Each run of this program generates a file containing a value of the depth to the second interface for each geophone. This file (written on unit 12) can be used for subsequent runs. Note that the previous version is obliterated by each subsequent run.

Notes

1) Exit points stop the execution of the program at certain convenient stages. Results and plotter displays corresponding to the value of IXIT are:
   0   Raw time versus distance (T-D) plot
   -1  Datum-corrected T-D plot only
   1   Datum-corrected and raw time T-D plots
-2 Layer 1 removed T-D plot only
2 Layer 1 removed and datum-corrected T-D plots
-3 Delay-time depth cross-section plot only
3 Delay-time depth plot and layer 1 removed T-D plot
-4 Delay-time plus 1 ray trace depth plot only
4 Delay-time plus 1 ray trace depth plot and layer 1 removed T-D plot
-5 Delay-time plus 2 ray trace depth plot only
5 Delay-time plus 2 ray trace depth and layer 1 removed T-D plot
-6 Delay-time plus 3 ray trace depth plot only
6 Delay-time plus 3 ray trace depth plot and layer 1 removed T-D plot

2) The velocity calculation taking into account dipping-layers is valid if the subsurface dip patterns are consistent (upward or downward) along the seismic line. For a long seismic line formed for more than one spread, subsurface layer-dip may switch from a downward to upward direction or vice versa along the line. In this case, the interpreter has two choices:

a) to interpret the whole line by sections where the dipping layer is still consistent in one direction;
or,

b) to use the NTVE switch ON to avoid this type of velocity calculation and calculate the velocity using the weighted average procedure (Scott et al, 1972).
3) If the top of the second layer for a particular seismic refraction line has been interpreted or delineated using another source of information (such as drilled holes), then it can be used as known data for the interpretation of the whole subsurface cross-section. When the ITWO switch is ON, it means that previous interpreted data (depth values) are going to be entered in the SRTDI program execution. The specific data is entered through an additional input sequence described below at the end of this section. Therefore, the depth values for the first subsurface interface are going to be preserved for the final model-interpretation from the geophone location number K111 of spread MK11 through geophone location K222 of spread MK22.

4) Either the datum point coordinate or the datum equation constants (but not both) may be used to define the position of the line representing the datum plane (Scott et al, 1972).

5) If the absolute value of the computed slope of refracting horizon segment exceeds the value assigned to BLIM, the ray is propagated as if the segment had the slope BLIM with the sign of the computed slope (Scott et al, 1972).

6) If the absolute value of discrepancy between observed travel time and computed traced ray travel time exceeds TLIM, the corresponding computed depth point
is not used to define the smoothed position of the refracting horizon, and on the table of elevations of ray end points, these questionable depth points are identified by a question mark (Scott et al, 1972).

7) The ray trace print option results in printing a table giving the results of each ray trace attempt made by the program (Scott et al, 1972).

8) For shot points offset from the end of the spread, the program calculates a correction for each geophone which corresponds to the difference between a shot at the offset location and a shot point at the end of the spread. An average of these differences is then calculated and each arrival time at each geophone is adjusted by the amount of this difference. The adjusted times are then used in subsequent calculations. If JJOFF=1, no offset-shot point to the end-of-spread shot point adjustment is made.

9) If this switch is OFF, an average dip of a specified refracting horizon for a specified geophone spread is calculated even across a possible subsurface discontinuity. In this way, the geological anomaly is partially wiped out at the first step of its delineation. On the other hand, this procedure can be avoided by setting the switch ON. In this case, two average layer dips are calculated with the breaking point around the possible discontinuity.
10) When more than one spread is being interpreted, the T-D graph plots will come out separately. In order to compare all the data, it is convenient that the T-D graphs can be arranged side by side in the right sequence and every one with similar scales. To ensure this possibility, the maximum of the observed arrival times should be read into TSCALE variable.

11) When the user is interested in obtaining a specific depth scale for the cross-section display in order to match the smoothed and the sharp model or merely to obtain a convenient vertical magnification of the model, he should fill this space (read by the ESCALE variable) with the maximum depth value of both models or with a convenient depth value which provides the vertical exaggeration desired.

12) If the user wishes to use the same value for horizontal velocity and vertical velocity for any particular spread or layer, the value may be entered as a vertical velocity only, and the horizontal velocity may be left blank (Scott et al, 1972).

13) In multispread problems, if the user wishes to assign the same values of velocity to all spreads, the values may be entered as a vertical and horizontal velocity for the first spread and all others may be left blank (Scott et al, 1972).

NOTE: If the layer velocity lines (or cards) are
not included in the program deck, computer-generated velocity values are used for depth interpretation. In this case, the same computed value is used for vertical and horizontal velocity for all spreads.

14) This variable indicates (during the program execution) whether this spread contains arrival time data from every layer or not. Thus, unnecessary calculations or rechecking are not conducted. The five consecutive switches correspond to the five interfaces that can be interpreted. The first switch corresponds to the ground surface.

15) If XSHIFT is left blank, no horizontal shift is made; otherwise, the value specified is added to all inline coordinate values indicated on shot point and geophone lines that follow.

16) The values of these variables indicate points of possible discontinuity in the subsurface. One discontinuity is allowed on each layer on each spread. The five values in the MIND array indicate the existence of such a possible break in each corresponding layer. If a blank value is inserted for a layer, the layer is assumed continuous across the spread. KPPL and KPPR indicate the exact geophone locations where the spread will be divided in separately interpreted sections. NGDED is an array that is not used at this time.

17) The maximum weathering section (first layer section)
has to be estimated beforehand and entered here to avoid a possible correction error when the geophone elevations are adjusted to the new datum plane. If the elevation correction exceeds the maximum weathering thickness, the additional adjustment is assumed to be within the second layer and the arrival time adjustments are made by the use of an estimated velocity for the second layer (see note 18).

18) A correction velocity for second layer is accepted here to be used to calculate a better arrival time correction for those geophone stations whose relocated positions (elevation value) are underneath the top of the second layer. A default value of 6000 ft/sec is assumed.

19) This value is added to the travel times of all geophones from the shot point in question. The purpose is to provide a correction for a timing error on a seismic record or for time-delay errors due to hole fatigue.

20) Those observed arrival times which have been distorted by a possible subsurface geological structure or by misreading can be isolated from the velocity calculations by setting this switch ON.

A.2.2 Estimate and print out velocity values for layer 1
A.2.3 Plot raw T-D graph
A.2.4 Construct a sloping datum plane and correct the observed arrival time values to the new datum
A.2.5 Print out corrected arrival times and plot T-D graph corrected to datum
A.2.6 Print out interface depth and elevation values of the final model-interpretation. Plot a cross-section of that model
A.2.7 Samples of a typical input file (FORCDR.DAT) and output file (*.LPT) are shown in tables TA.1 and TA.2 respectively.
A.3 Computed Used
   Digital Equipment Corporation PDP-10
A.4 Computer Operating System Used
   DEC-10
A.5 Compiler Used
   F10 compiler
A.6 Magnetic Core Requirements
   To compile 40K
   To run all subroutines 40K
A.7 Programmed by
   J. H. Scott, B. L. Tibbetts, R. G. Burdick, and N. S. Rodriguez
A.8 Documented by
   N. S. Rodriguez
PROGRAM DESCRIPTION

A'.1 Program Name
SRTDI

A'.2 Program Function Description
SRTDI is designed to make a detailed interpretation of seismic refraction profiles providing depth values for each layer interface underneath every receiver location. The program uses conventional delay-time techniques to make a rough first interpretation which is checked and complemented by a ray tracing self-adjusting technique to provide the final model-interpretation. The SRTDI program checks its own interpretation making a curve matching procedure between the observed T-D graph and a calculated T-D graph from the model-interpretation.

SRTDI will handle input (FORCDR DAT, FORL2.DAT) and output (*. , LPT, FORL2.DAT, *.PLT) of data and will start execution of the subroutines (MAIN2, and PLOTT) at the appropriate time. The input of the program is basically the seismic refraction field data, parameters related to the theoretical foundations of the seismic refraction method and general information to modify the interpretation approach at the user's convenience.

A'.3 Program Description
SRTDI controls the whole input and the main output movement basically; calls the subroutine MAIN2 which handles directly or indirectly the most important calculations...
of the whole package.

A'.3.1 Usual Meaning of Formal Parameters

In addition to those mentioned earlier during the description of the input data parameters:

\( VDD = \) Array containing the velocity values (first layer velocity) calculated for each spread and shot point from the direct paths

\( AVVDD = \) Array containing the average velocity calculated for every group of first layer velocities obtained from the same shot

\( VREG = \) Array containing the final regression fitted velocity for every layer

\( D = \) Array containing the direct distance shot-receiver for every shot and every receiver (geophone)

\( NIXIT = \) Switch that indicates if the exit number is positive (0) or negative (1)

\( ES = \) Array containing the exact elevation value of every shot station

\( TR = \) Array containing the \( TA + TFUDGE \) values

\( EDG = \) Datum-projected geophone elevation

\( EDSP = \) Datum-projected shot elevation

\( TVG = \) Geophone time correction to new datum location

\( TVS = \) Shot time correction to new datum location

\( PRG, ERG = \) Arrays containing the distance and elevation coordinate values respectively of the refracted ray end at every interface underneath every
geophone location

KRG = Array which informs about the quality of the PRG, ERG values. A question mark indicates that it is meaningless or a number indicates which subsurface interface is referring

PRS2, ERS2 = Arrays containing the distance and elevation coordinate values respectively of the refracted ray end at every interface, underneath every shot station

KRS2 = Array which informs about the quality of the PRS2, ERS2 values. It uses the same criterion of KRG, except for shot points

ZSG = Array containing the depth values (with respect to the ground surface) of every subsurface interface underneath every shot or geophone station

ERS = Array containing the elevation values of every subsurface interface underneath the shot locations

A'.4 Subroutines

The subroutine program descriptions are arranged as follows. Subroutines MAIN2 and MAIN3 are described as they start the other subroutines which follow in alphabetical order. Each subroutine program is called by its name with a monitor command.

A'.4.1 Subroutine MAIN2

A.4.10 Monitor command name

MAIN2
A'.4.11  Formal Subroutine Name

MAIN2 (*,*)

A'.4.110  Usual Meaning of Appointed Parameters
(out of the COMMON)

*,* = dummy arguments for multiple return form from the subroutine

A'.4.111  Usual Meaning of Formal Parameters
(into the COMMON)

These parameters, in addition to those previously described which also occupy the COMMON storage area, are described here in the order they appear in this subroutine. No further reference of these will be made.

TCG = Arrival time corrections due to surface-to-datum geophone relocations on the slant path

XCG = Geophone distance corrections due to surface-to-datum geophone relocations on the slant path

XINTG = Distance and elevation values respectively for geophone relocated positions on the datum following the slant path

EINTG =

XC = Shot distance correction due to surface-to-datum shot
TC = Arrival time correction due to surface-to-datum shot relocation on the slant path

DSG = D - XC - XCG

TRS2 = Time expended by the ray traveling from the original shot location to the first subsurface interface

TRG = Time expended by the ray traveling from the top of any layer to the original geophone location

ZG = EDG - ERG

ZS2 = EDSP - ERS2

PRP, ERP = Distance and elevation values respectively of every depth point on every subsurface interface underneath every geophone location

TRP = Time expended by the ray traveling from any interface until it reaches the geophone target

TRS = Time expended by the ray traveling from interface to interface before it reaches
the refracted end point underneath the shot point

PREG = Number of values used in the velocity regression calculation taking into account dipping-layer

VHOB = Velocity values calculated according to the Hobson-Overton method

PHOB = Number of values used in the velocity calculation according to the Hobson-Overton method

A' .4.12 Subroutine Function
Calculate velocity for layers deeper than layer 1, computes depth at base of layer 1, and prints these values out.
Remove the effect of layer 1 from the arrival times data.
Start subroutine MAIN3 and call subroutines REGV, HOBV, KENDS, ELCOR, REGRES, HTIME, TIE, AVG, FILLIN AND PLOTT.
Plot T-D graph with layer 1 removed.

A'.4.2 Subroutine MAIN3

A'.4.20 Monitor Command Name
MAIN3

A'.4.21 Formal Subroutine Name
MAIN3 (L1, L2, IZI, *, *)
A'.4.110 Usual Meaning of Appointed Parameters
(out of the COMMON)

L1 = Layer overlaying the layer (L2) which carries the refracted ray on its upper surface

L2 = Layer carrying the refracted ray on its upper surface

IZI = A variable in charge of branching the program execution to a specified statement when the subroutine MAIN3 is called

*,* = Dummy symbols for multiple RETURN from the subroutine

A'.4.111 Usual Meaning of Formal Parameters
(into the COMMON)

These parameters, in addition to those previously described which also occupy the COMMON Storage area, are described according to the order they first appear in the subroutine.

BL1 = Subsurface interface dips calculated by subroutine ADMIG

PRG2, = Intermediate calculated values of the distance and elevation

PG2

ERG2

EG2
coordinates respectively of the refracted ray end at every interface underneath every geophone location. Subroutine RAYUP calculates these values.

\[
TG_2, \quad TRG_2
\]

Intermediate calculated values of travel time between interfaces for rays going upward to reach the geophone target

\[
PS_2, \quad ES_2
\]

The same that PG_2, EG_2 but for rays traveling downward from the shot point location

\[
GTC
\]

Accumulated arrival correction times for any layer and for one spread at a time

\[
GPT
\]

Number of arrival correction times which have been added in GTC but for spread

\[
SPTC, \quad SPPT
\]

Number of arrival correction times which have been accumulated in GTC but for shot associated

A' .4.22 Subroutine Function
Computes depth points at base of every layer deeper than layer 1.
Proceeds with the self-adjusting procedure to check and improve the model-interpretation. Make the trim-up adjust at base of layer 1 before the last pass through the ray tracing technique.

Calls subroutines RAYUP, RAYCOR, KENDS, TIE, HTIME, AVG, and the Function TERP.

A' .4.3 Subroutine ADMIG

A' .4.30 Monitor Command Name
ADMIG

A' .4.31 Formal Subroutine Name
ADMIG (LI, M, TANI)

A' .4.310 Usual Meaning of Appointed Parameters
LI = Layer where the average dip is currently calculated
M = Spread where calculation is currently carried out
TANI = Tangent of the average angle dip (B)

A' .4.32 Subroutine Function
Computes tangent of the average angle of dip (B) of base of layer (LI) for spread (M) by regression of points (PRS2, ERS2) and (PRG, ERG). If the spread is to be interpreted in two separated pieces it calculates two dips. Finally, it applies migration trim-up correction to those points using the average dip previously computed.

A' .4.4 Subroutine AVG
A' .4.40 Monitor Command Name
   AVG
A' .4.41 Formal Subroutine Name
   AVG (X1, X2, L2, PA, EA)
A' .4.410 Usual Meaning of Appointed Parameters
   X1 = Distance which defines the left boundary of the interval
   X2 = Distance which defines the right boundary of the interval
   L2 = Layer which is currently under calculation
   PA,EA = Average coordinate values calculated from the points into the arrays (PRG, ERG) and (PRS2, ERS2) whose distance is inside of the interval formed by X1 - X2
A' .4.42 Subroutine Function
   Computes average coordinate values (PA,EA) for all those points included in arrays (PRG, ERG) and (PRS2, ERS2) whose distance coordinate is larger than X1 but shorter than X2 and whose refractor is layer (L2).

A' .4.5 Subroutine DIP
A' .4.50 Monitor Command Name
   DIP
A' .4.51 Formal Subroutine Name
   DIP (L,M,K1,K2,KK,A,B)
A'.4.510 Usual Meaning of Appointed Parameters

L = Layer which is currently under calculation
M = Spread which is currently under calculation
K1,K2 = First and last indices of geophones respectively which are taken into account for dip calculation
KK = Index of geophone where the dip line has to pass
A = Dip line equation constant (slope)
B = Dip equation constant (intercept)

A'.4.52 Subroutine Function
Computes equation constants A and B (Y = AX + B) by regression line fitted to intermediate elevation values (ERP) from base of layer (L) between geophone index number K1 to K2 with line passing through location defined by geophone index number KK on spread (M).

A'.4.6 Subroutine ELCOR

A'.4.60 Monitor Command Name
ELCOR

A'.4.61 Formal Subroutine Name
ELCOR (TANI, VV, HV, XSG, ESG, ED, BG, I, TC, XC, XINT, EINT)

A'.4.610 Usual Meaning of Appointed Parameters
TANI = Tangent (or slope) of slant path along where geophones and shot points will be relocated
VW := Weighted average velocity of upper layer
HV := Horizontal velocity of the refractor horizon
XSG := Horizontal position (distance) of geophone or shot currently under calculation
ESG := Elevation value of geophone or shot currently under calculation
AD,BD := Intercept and slope, respectively, of the datum equation
I := Parameter to indicate sign of the slope, I=1 for minus, I=2 for plus
TC,XC := Time and distance correction value due to relocated position of the receiver or source
XINT,EINT := Distance and elevation coordinate value of the relocated position of the receiver or source

A’.4.62 Subroutine Function
Finds equivalent positions of shot and geophones on the datum plane and computes the appropriate time (TC) and distance corrections (XC) that are needed to refer them to the datum plane.

A’.4.7 Subroutine EXTRP
A’.4.70 Monitor Command Name
EXTRP
A' .4 .71 Formal Subroutine Name

EXTRP (L,M,K1,K2,A,B,VV)

A' .4 .710 Usual Meaning of Appointed Parameters

L = Layer which is currently under calculation
M = Spread which is currently in the computation
K1 = Index of geophone in spread (M) which occupies the left-edge location of the interval currently under calculation
K2 = Index of geophone in spread (M) which occupies the right edge location of the interval under calculation
A,B = Intercept and slope values of the equation used for computation of (ERP) values
VV = Layer velocity used for computation of the time (TRP) associated

A' .4 .72 Subroutine Function

Computes elevations (ERP) and vertical travel (TRP) times associated with a specified refracting horizon (L) predefined by the equation whose intercept (A) and slope (B) are given.

A' .4 .8 Subroutine FILLIN

A' .4 .80 Monitor Command Name

FILLIN
A'.4.81  **Formal Subroutine Name**
FILLIN (L)

A'.4.810  **Usual Meaning of Appointed Parameters**
L = Layer which is currently under calculation

A'.4.82  **Subroutine Function**
Fills in the missing elevation points (ERP, ERS) and vertical times (TRD, TRS) that cannot be established beneath some shot points and geophones because of a lack of seismic data. Missing values are established by interpolation or extrapolation of nonzero values of (ERP) and (TRP).

A'.4.9  **Subroutine HOBV**
A'.4.90  **Monitor Command Name**
HOBV

A'.4.91  **Formal Subroutine Name**
HOBV (L, NIXIT)

A'.4.910  **Usual Meaning of Appointed Parameters**
L = Layer number whose velocity is currently calculated
NIXIT = Branching flag

A'.4.92  **Subroutine Function**
Computes the velocity of a specified refraction horizon (L) by Hobson-Overton method and prints out the results together with the errors associated with the computation.

A'.4.10  **Subroutine HTIME**
A'.4.100  **Monitor Command Name**
HTIME
A'.4.101 Formal Subroutine Name

HTIME (D1, X1, X2, P1, E1, P2, E2, HV, TH)

A'.4.1010 Usual Meaning of Appointed Parameters

D1 = Source to receiver direct distance for the pair (shot-geophone) currently under calculation

X1 = Horizontal coordinate (distance) of the shot point location

X2 = Horizontal coordinate (distance) of the geophone location

P1, E1 = Distance and elevation values respectively of the refracted ray end beneath shot point location

P2, E2 = Distance and elevation values respectively of the refracted ray end beneath the geophone location

HV = Velocity of the layer which carries the critical refracted ray along its upper surface

TH = Time consumed by the ray traveling that part of the path right on the interface

A'.4.102 Subroutine Function

Computes the horizontal travel time (TH) along the refracted horizon.
A'.4.20  Subroutine KENDS

A'.4.200  Monitor Command Name
KENDS

A'.4.201  Formal Subroutine Name
KENDS (L,M,J,K1,K2,K11,K22)

A'.4.2010  Usual Meaning of Appointed Parameters

L  =  Layer which is currently analyzed by this subroutine job

M  =  Spread which is currently used in this subroutine job

J  =  Shot point index currently used in this subroutine job

K1  =  First geophone index to be tested in this subroutine

K2  =  Last geophone index to be tested in this subroutine

K11  =  Smallest geophone index found as the leftmost boundary of the spread-string searched

K22  =  Largest geophone index found as the other boundary of the spread-string searched

A'.4.202  Subroutine Function

Finds the indices of leftmost (K11) and rightmost (K22) geophones representing, with an arrival time, the layer (L) for shot point (J) and spread (M). An input string of the spread bounded by geophones indices K1 and K2 is tested.
A' .4.30 Subroutine PLOTT

A' .4.300 Monitor Command Name
PLOTT

A' .4.301 Formal Subroutine Name
PLOTT (II)

A' .4.3010 Usual Meaning of Appointed Parameters
II = Flag to branch the plot subroutine
to draw the T-D graphs or the cross-
section models.

A' .4.302 Subroutine Function
Plots all time-distance graphs and model cross-
sections on the plotter device.

A' .4.40 Subroutine RAYCOR

A' .4.400 Monitor Command Name
RAYCOR

A' .4.401 Formal Subroutine Name
RAYCOR (X1, X2, E1, E2, VV, HV, TCOR)

A' .4.4010 Usual Meaning of Appointed Parameters
X1, E1 = Distance and elevation coordinate values of the bottom end point of ray entering or leaving the refractor horizon

X2, E2 = Distance and elevation coordinate values of the point in question, corrected in such a way to minimize observed-calculated time discrepancy
VV = Vertical velocity of the upper layers
HV = Velocity of the refractor horizon
TCOR = Time correction calculated from the observed-calculated time discrepancy

A'.4.402 Subroutine Function
Adjusts the position of the bottom end points of a ray entering or emerging from a refracting horizon so that discrepancies between observed travel times and those obtained by ray tracing are absorbed.

A'.4.50 Subroutine RAYUP

A'.4.500 Monitor Command Name
RAYUP

A'.4.501 Formal Subroutine Name
RAYUP (L,LL,LO,M,I,XO,EO,XLL,ELL,TLL,XL,EL,TL)

A'.4.5010 Usual Meaning of Appointed Parameters
L = Layer which is critically refracting the ray on its upper surface
LL = Horizon immediately overlaying the layer (L) when IREP = 1. Otherwise, LL = L
LO = Horizon overlaying (L) and (LL) or highest layer in the subsurface model
M = Spread currently involved in the calculations
I = Flag to indicate if the ray tracing is right traveling or left traveling

X0,E0 = Distance and elevation coordinate values respectively of the ray ending point within or on the upper boundary of layer (L)

XLL, ELL = X0, E0 respectively when IREP = 1. Otherwise, they provide the coordinates of the point intersection of the ray with the top of layer (LL)

TLL = Ray traveling time from (XLL, ELL) to the surface

XL,EL = Distance and elevation coordinate values respectively, of the starting point for the ray tracing

TL = Total ray traveling time from (XL,EL) to (X0,E0)

A'.4.502 Subroutine Function
Traces a ray upward from a specified starting point (XL,EL) on a refracting horizon until it arrives at the same elevation as the target geophone or shot point. The ray starting point is estimated under the assumption of horizontal layering or from the results of previous iterations of RAYUP before it enters the subroutine.
The orientation of the ray segments emerging from the refracting horizon is computed by the subroutine as a function of the dip of the refracting horizon and the velocities of the adjoining layers. At each layer boundary, the new direction is calculated like the first previously described, but it now takes into account the direction of the ray. When the ray eventually arrives at the elevation of the surface target (geophone, etc.), the lateral distance by which the target is missed is computed. When the error is less than 1 foot, ray tracing is considered complete; otherwise, a new ray starting point is established by relocating the starting point conveniently.

A'.4.60 Subroutine REGRES
A'.4.600 Monitor Command Name
REGRES
A'.4.601 Formal Subroutine Name
REGRES (K1,K2,J,M,L,V,T,PT)
A'.4.6010 Usual Meaning of Appointed Parameters
K1 = Leftmost geophone index from where the regression calculation of velocity is done
K2 = Rightmost geophone index up to where the regression calculation of velocity is done
J  = Shot point which provides the arrival times to be analyzed

M  = Spread to which the geophones belong

L  = Layer where the refracted ray arrival times come from

V  = Velocity calculated by the regression of arrival times (TA) points at distances (D)

T  = Half intercept time at shot point (J) location

PT  = Number of regressed points

A' .4.602 Subroutine Function
Computes velocity (V) by least squares regression of time points (TA) at shot point-geophone distances (D). Only nonzero (TA) for which LG=L and LGC=0 are used in this calculation. Half intercept time at shot point (J) is also calculated.

A' .4.70 Subroutine REGV
A' .4.700 Monitor Command Name
REGV
A' .4.701 Formal Subroutine Name
REGV (L,NIXIT)
A' .4.7010 Usual Meaning of Appointed Parameters
L  := Layer whose velocity is currently under calculation

NIXIT = Branching flag
A'.4.702 Subroutine Function
Computes the velocity and intercept time at a specified shot point for a specified refraction horizon. This is first accomplished by calculating regression velocities which will be the apparent velocities in a formula which calculates true velocity taking into account the dipping-layer effect.

A'.4.80 Subroutine TIE

A'.4.800 Monitor Command Name
TIE

A'.4.801 Formal Subroutine Name
TIE (L2,M,JJ,K11,K22,KT1,KT2,KN,TR,D)

A'.4.8010 Usual Meaning of Appointed Parameters
L2 = Layer which is carrying the refracted ray along its upper surface
M = Spread currently involved in the calculation
J = Shot point location closest to the spread
JJ = Shot point whose arrival times are being corrected to provide an equivalent shot point location on the SP.(J) location
K11 = Index for leftmost geophone receiving refracted ray from layer (L2) due to shot point (JJ)
K22 = Index for rightmost geophone receiving refracted ray from layer (L2) due to shot point (JJ)

KT1 = Index of first geophone on the spread (M)

KT2 = Index of last geophone on the spread (M)

KN = Total number of geophones on the spread

TR = Geophone arrival time corrected by the displacement of the shot (JJ) to the shot (J) position

D = Direct distances shot points-geophones

A'4.802 Subroutine Function

Refers the offset shot point travel times to the end-of-spread shot point locations in order to reduce the velocity errors in velocity calculation, induced by possible errors resulting from extrapolating the position of the deep refraction horizon beyond end-of-spread shots.

A'4.90 Function TERP

A'4.900 Formal Function Name

TERP (X1,Y1,X2,Y2,X)

A'4.9010 Usual Meaning of Appointed Parameters

X1,Y1 = Distance and elevation coordinate values respectively of the leftside point
X2, Y2 = Distance and elevation coordinate values respectively of the right-side point

X = Distance of the point whose elevation value is being interpolated

A'.4.901 Function Duty
Computes an interpolated value of elevation (Y) corresponding to the coordinate distance (X) between the 2 points (X1,Y1) and (X2,Y2).
Table TA.1

(input sample)
Table TA.1

46321111424

<table>
<thead>
<tr>
<th></th>
<th>3200</th>
<th>3000</th>
<th>2900</th>
<th>3060</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6900</td>
<td>6500</td>
<td>7500</td>
<td>8000</td>
</tr>
<tr>
<td>A</td>
<td>224</td>
<td>110</td>
<td>10700</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>8795</td>
<td>-110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>8940</td>
<td>15070</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29</td>
<td>131255</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>40</td>
<td>131252</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>53</td>
<td>131246</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>66</td>
<td>131245</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>70</td>
<td>131244</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>87</td>
<td>131240</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>A5</td>
<td>120</td>
<td>131355</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A6</td>
<td>147</td>
<td>131342</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A7</td>
<td>177</td>
<td>131335</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A8</td>
<td>192</td>
<td>131323</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A9</td>
<td>208</td>
<td>131312</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A10</td>
<td>220</td>
<td>131322</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A11</td>
<td>230</td>
<td>131296</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>A12</td>
<td>248</td>
<td>131290</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A13</td>
<td>262</td>
<td>131277</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A14</td>
<td>289</td>
<td>131266</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A15</td>
<td>301</td>
<td>131262</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A16</td>
<td>318</td>
<td>131255</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A17</td>
<td>336</td>
<td>131248</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A18</td>
<td>350</td>
<td>131241</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A19</td>
<td>370</td>
<td>131234</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A20</td>
<td>387</td>
<td>131226</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A21</td>
<td>408</td>
<td>131219</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>A22</td>
<td>420</td>
<td>131199</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>192</td>
<td>131312</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>24</td>
<td>110</td>
<td>11920</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>8795</td>
<td>-110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>8940</td>
<td>15070</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>437</td>
<td>131180</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>455</td>
<td>131170</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>467</td>
<td>131163</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>481</td>
<td>131156</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>493</td>
<td>131143</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>502</td>
<td>131138</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B5</td>
<td>519</td>
<td>131140</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B6</td>
<td>542</td>
<td>131131</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B7</td>
<td>555</td>
<td>131123</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B8</td>
<td>561</td>
<td>131118</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B9</td>
<td>575</td>
<td>131103</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B10</td>
<td>590</td>
<td>31092</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B11</td>
<td>601</td>
<td>31082</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B12</td>
<td>617</td>
<td>31080</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B13</td>
<td>630</td>
<td>31073</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B14</td>
<td>640</td>
<td>31068</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B15</td>
<td>650</td>
<td>31060</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B16</td>
<td>670</td>
<td>31057</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B17</td>
<td>680</td>
<td>31048</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B18</td>
<td>680</td>
<td>31048</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>8818</td>
<td>5280</td>
<td>748</td>
<td>3</td>
</tr>
<tr>
<td>C2</td>
<td>8819</td>
<td>5390</td>
<td>761</td>
<td>3</td>
</tr>
<tr>
<td>C3</td>
<td>8817</td>
<td>5500</td>
<td>773</td>
<td>3</td>
</tr>
<tr>
<td>C4</td>
<td>8815</td>
<td>5610</td>
<td>788</td>
<td>3</td>
</tr>
<tr>
<td>C5</td>
<td>8814</td>
<td>5720</td>
<td>800</td>
<td>3</td>
</tr>
<tr>
<td>C6</td>
<td>8813</td>
<td>5830</td>
<td>813</td>
<td>3</td>
</tr>
<tr>
<td>C7</td>
<td>8812</td>
<td>5940</td>
<td>814</td>
<td>3</td>
</tr>
<tr>
<td>C8</td>
<td>8811</td>
<td>6050</td>
<td>816</td>
<td>3</td>
</tr>
<tr>
<td>C9</td>
<td>8810</td>
<td>6160</td>
<td>818</td>
<td>3</td>
</tr>
<tr>
<td>C10</td>
<td>8810</td>
<td>6270</td>
<td>823</td>
<td>3</td>
</tr>
<tr>
<td>C11</td>
<td>8810</td>
<td>6380</td>
<td>821</td>
<td>3</td>
</tr>
<tr>
<td>C12</td>
<td>8810</td>
<td>6490</td>
<td>823</td>
<td>3</td>
</tr>
<tr>
<td>C13</td>
<td>8810</td>
<td>6600</td>
<td>825</td>
<td>3</td>
</tr>
<tr>
<td>C14</td>
<td>8810</td>
<td>6710</td>
<td>826</td>
<td>3</td>
</tr>
<tr>
<td>C15</td>
<td>8800</td>
<td>6820</td>
<td>830</td>
<td>3</td>
</tr>
<tr>
<td>C16</td>
<td>8796</td>
<td>6930</td>
<td>832</td>
<td>3</td>
</tr>
<tr>
<td>C17</td>
<td>8792</td>
<td>7040</td>
<td>834</td>
<td>3</td>
</tr>
<tr>
<td>C18</td>
<td>8796</td>
<td>7150</td>
<td>836</td>
<td>3</td>
</tr>
<tr>
<td>C19</td>
<td>8800</td>
<td>7260</td>
<td>840</td>
<td>3</td>
</tr>
<tr>
<td>C20</td>
<td>8800</td>
<td>7370</td>
<td>844</td>
<td>3</td>
</tr>
<tr>
<td>C21</td>
<td>8803</td>
<td>7480</td>
<td>848</td>
<td>3</td>
</tr>
<tr>
<td>C22</td>
<td>8803</td>
<td>7590</td>
<td>852</td>
<td>3</td>
</tr>
<tr>
<td>C23</td>
<td>8805</td>
<td>7700</td>
<td>858</td>
<td>3</td>
</tr>
<tr>
<td>C24</td>
<td>8806</td>
<td>7810</td>
<td>865</td>
<td>3</td>
</tr>
</tbody>
</table>

| D  | 8795 | -110 | 000000 |
| D1 | 8795 | -110 |        |
| D2 | 8940 | 15070 |       |
| D3 | 8808 | 7920 | 871  | 3 | 786 | 3  |
| D4 | 8810 | 8030 | 888  | 3 | 773 | 3  |
| D5 | 8814 | 8140 | 897  | 3 | 764 | 3  |
| D6 | 8821 | 8250 | 902  | 3 | 755 | 3  |
| D7 | 8832 | 8360 | 906  | 3 | 751 | 3  |
| D8 | 8845 | 8470 | 912  | 3 | 741 | 3  |
| D9 | 8846 | 8580 | 922  | 3 | 732 | 3  |
| D10| 8845 | 8690 | 932  | 3 | 730 | 3  |
| D11| 8845 | 8800 | 945  | 3 | 725 | 3  |
| D12| 8845 | 8910 | 955  | 3 | 720 | 3  |
| D13| 8845 | 9020 | 965  | 3 | 718 | 3  |
| D14| 8846 | 9130 | 972  | 3 | 718 | 3  |
| D15| 8850 | 9240 | 982  | 3 | 718 | 3  |
| D16| 8850 | 9350 | 990  | 3 | 718 | 3  |
| D17| 8850 | 9460 | 1000 | 3 | 722 | 3  |
| D18| 8850 | 9570 | 1011 | 3 | 718 | 3  |
| D19| 8850 | 9680 | 1022 | 3 | 728 | 13 |
| D20| 8850 | 9790 | 1033 | 3 | 694 | 13 |
| D21| 8850 | 9900 | 1042 | 3 | 695 | 13 |
| D22| 8853 | 10010 | 1052 | 3 | 675 | 13 |
| D23| 8856 | 10120 | 1060 | 3 | 665 | 13 |
| D24| 8859 | 10230 | 1063 | 3 | 658 | 13 |
| D25| 8862 | 10340 | 1068 | 3 | 644 | 13 |
| D26| 8863 | 10450 | 1072 | 3 | 639 | 13 |

**Table TA.1 --continuation--**
Table TA. 2

(Output Sample)
### CONTROL DATA INFORMATION

**SRTDI-INTERPRETATION OF SEISMIC REFRACTION LINE R-68, SOUTH PARK, 1976**

**Table TA. 2**

<table>
<thead>
<tr>
<th>LAYER</th>
<th>VV</th>
<th>VH</th>
<th>VV</th>
<th>VH</th>
<th>VV</th>
<th>VH</th>
<th>VV</th>
<th>VH</th>
<th>VV</th>
<th>VH</th>
<th>VV</th>
<th>VH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3219</td>
<td>0,</td>
<td>0,</td>
<td>3948</td>
<td>0,</td>
<td>0,</td>
<td>2940</td>
<td>0,</td>
<td>3060</td>
<td>0,</td>
<td>0,</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6950</td>
<td>0,</td>
<td>6550</td>
<td>0,</td>
<td>7550</td>
<td>0,</td>
<td>8000</td>
<td>0,</td>
<td>0,</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SPREAD CONTROL SWITCHES**

<table>
<thead>
<tr>
<th>SURFACE</th>
<th>INTERFACE 1</th>
<th>INTERFACE 2</th>
<th>INTERFACE 3</th>
<th>INTERFACE 4</th>
<th>INTERFACE 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHL</td>
<td>MND</td>
<td>KPL</td>
<td>KPR</td>
<td>NGCE</td>
<td>NHL</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**SPTPOINT AND GEOPHONE DATA**

**SPREAD A, 2 SHOTPOINTS, 24 GEOPHONES, XSHIFT = 118.0**

<table>
<thead>
<tr>
<th>SP</th>
<th>ELEV</th>
<th>LOC X</th>
<th>LOC Y</th>
<th>DEPTH</th>
<th>UPHOLE 1</th>
<th>FUDGE ! END SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8795</td>
<td>-118.2</td>
<td>0.0</td>
<td>2.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>A</td>
<td>8942</td>
<td>15075</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**ARRIVAL TIMES + FUDGE ! AND LAYERS REPRESENTED**

<table>
<thead>
<tr>
<th>GEN</th>
<th>ELEV</th>
<th>LOC X</th>
<th>LOC Y</th>
<th>SP</th>
<th>A1</th>
<th>SP</th>
<th>A2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8795</td>
<td>3.0</td>
<td>0.0</td>
<td>29.0</td>
<td>3</td>
<td>1255.0</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>8797</td>
<td>113.0</td>
<td>0.0</td>
<td>40.0</td>
<td>3</td>
<td>1252.0</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>8804</td>
<td>100.0</td>
<td>0.0</td>
<td>53.0</td>
<td>3</td>
<td>1246.0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>8804</td>
<td>33.0</td>
<td>0.0</td>
<td>56.0</td>
<td>3</td>
<td>1245.0</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>8804</td>
<td>440.0</td>
<td>0.0</td>
<td>70.0</td>
<td>3</td>
<td>1244.0</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>8805</td>
<td>550.0</td>
<td>0.0</td>
<td>87.0</td>
<td>3</td>
<td>1243.0</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>8814</td>
<td>663.0</td>
<td>0.0</td>
<td>122.0</td>
<td>3</td>
<td>1355.0</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>8822</td>
<td>770.0</td>
<td>0.0</td>
<td>147.0</td>
<td>3</td>
<td>1342.0</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>8824</td>
<td>880.0</td>
<td>0.0</td>
<td>177.0</td>
<td>3</td>
<td>1335.0</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>8824</td>
<td>990.0</td>
<td>0.0</td>
<td>192.0</td>
<td>3</td>
<td>1323.0</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>8824</td>
<td>1100.0</td>
<td>0.0</td>
<td>208.0</td>
<td>3</td>
<td>1312.0</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>8824</td>
<td>1210.0</td>
<td>0.0</td>
<td>220.0</td>
<td>3</td>
<td>1302.0</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>8824</td>
<td>1320.0</td>
<td>0.0</td>
<td>230.0</td>
<td>3</td>
<td>1296.0</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>8824</td>
<td>1430.0</td>
<td>0.0</td>
<td>240.0</td>
<td>3</td>
<td>1293.0</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>8824</td>
<td>1540.0</td>
<td>0.0</td>
<td>258.0</td>
<td>3</td>
<td>1277.0</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>8824</td>
<td>1650.0</td>
<td>0.0</td>
<td>255.0</td>
<td>3</td>
<td>1266.0</td>
<td>3</td>
</tr>
<tr>
<td>17</td>
<td>8824</td>
<td>1750.0</td>
<td>0.0</td>
<td>313.0</td>
<td>3</td>
<td>1252.0</td>
<td>3</td>
</tr>
<tr>
<td>18</td>
<td>8824</td>
<td>1870.0</td>
<td>0.0</td>
<td>317.0</td>
<td>3</td>
<td>1255.0</td>
<td>3</td>
</tr>
</tbody>
</table>
### SRTDI - INTERPRETATION OF SEISMIC REFRACTION LINE R-60, SOUTH PARK, 1976

#### SPREAD CONTROL SWITCHES

<table>
<thead>
<tr>
<th>Surface</th>
<th>Interface 1</th>
<th>Interface 2</th>
<th>Interface 3</th>
<th>Interface 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPL MIND KPL KPR NGDE</td>
<td>NPL MIND KPL KPR NGDE</td>
<td>NPL MIND KPL KPR NGDE</td>
<td>NPL MIND KPL KPR NGDE</td>
<td>NPL MIND KPL KPR NGDE</td>
</tr>
<tr>
<td>1 1 19 20 0</td>
<td>1 1 19 20 0</td>
<td>1 1 19 20 0</td>
<td>1 1 19 20 0</td>
<td>1 1 19 20 0</td>
</tr>
</tbody>
</table>

#### SHOTPOINT AND GEOPHONE DATA

SPREAD B, 2 SHOTPOINTS, 24 GEOPHONES, XSHIFT = 110.0

<table>
<thead>
<tr>
<th>SP</th>
<th>ELEV</th>
<th>X LOC</th>
<th>Y LOC</th>
<th>DEPTH</th>
<th>UPHOLE</th>
<th>FUDGE</th>
<th>ENO SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### ARRIVAL TIMES + FUDGE + ENO SP

<table>
<thead>
<tr>
<th>Geo Elev</th>
<th>X LOC</th>
<th>Y LOC</th>
<th>SP 01</th>
<th>SP 02</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.0</td>
<td>2.0</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>2.0</td>
<td>2.0</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
<td>2.0</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>4</td>
<td>2.0</td>
<td>2.0</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>2.0</td>
<td>2.0</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>6</td>
<td>2.0</td>
<td>2.0</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>7</td>
<td>2.0</td>
<td>2.0</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>8</td>
<td>2.0</td>
<td>2.0</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>9</td>
<td>2.0</td>
<td>2.0</td>
<td>6.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

---

Table T. 2 — continuation —
SRTDI-INTERPRETATION OF SEISMIC REFRACTION LINE R-68, SOUTH PARK, 1976

**LAYER 3 VELOCITY AND TIME INTERCEPTS COMPUTED BY REGRESSION**

<table>
<thead>
<tr>
<th>SPREAD</th>
<th>VEL</th>
<th>TIME</th>
<th>GEOE</th>
<th>SP</th>
<th>AVG V</th>
<th>AVG T</th>
<th>PIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>8797,</td>
<td>29.9</td>
<td>124</td>
<td></td>
<td>8797,</td>
<td>29.9</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>13908,</td>
<td>134.7</td>
<td>124</td>
<td>8797,</td>
<td>13908,</td>
<td>134.7</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>10669,</td>
<td>143.5</td>
<td>124</td>
<td>10669,</td>
<td>10669,</td>
<td>143.5</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>11677, -13.2</td>
<td>124</td>
<td>11677,</td>
<td>11677,</td>
<td>11677,</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**LAYER 3 VELOCITY COMPUTED BY HOBSO-OWNET METHOD**

| SPREAD  | VEL | SPS | GEOE | IDSP | SE | EP | 1-13 | 2-14 | 3-15 | 4-16 | 5-17 | 6-18 | 7-19 | 8-20 | 9-21 | 10-22 | 11-23 | 12-24 |
|---------|-----|-----|------|------|----|----|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 10545,  |     | 24  | 224  | 3    | 7.11 | 0.001| 0.000| 0.000| 0.000| 0.020| -6.555| 3.582| 3.719| -6.144| 1.994| 7.131| 7.268| 4.425| 3.542| -2.320| -5.183| -3.646| -4.909| -9.771| -6.634| 0.593| 6.864| 7.778|
| 9483,   |     | 24  | 251  | 3    | 0.263| 0.200| -0.000| -0.200| -0.000| 0.020| 0.403| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000|
| 10314,  |     | 24  | 291  | 3    | 0.263| 0.200| -0.000| -0.200| -0.000| 0.020| 0.403| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000| 0.000|

**AVG 10545, FOR 16 POINTS**

**AVG 9483, FOR 5 POINTS**

**AVG 10314, FOR 23 POINTS**

**WTD AVG VELOCITY FOR LAYER 3 = 1.014**
TABLE 2.2

<table>
<thead>
<tr>
<th>SPREAD A</th>
<th>SP A</th>
<th>SP A</th>
<th>SP #</th>
<th>SP #</th>
<th>SP #</th>
<th>SP #</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO</td>
<td>CORR T</td>
<td>-29.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0809,3</td>
<td>4.5</td>
<td>-30.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0809,6</td>
<td>3.9</td>
<td>48,61226,6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0809,9</td>
<td>3.1</td>
<td>80,61220,8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0810,1</td>
<td>3.2</td>
<td>73,61219,1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0810,4</td>
<td>3.3</td>
<td>77,61219,2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0810,7</td>
<td>1.8</td>
<td>93,61217,7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0811,1</td>
<td>3.3</td>
<td>123,61325,6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0811,2</td>
<td>3.4</td>
<td>148,61339,3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0811,5</td>
<td>5.2</td>
<td>176,61335,0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0811,8</td>
<td>-4.8</td>
<td>191,61380,2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0812,1</td>
<td>-5.0</td>
<td>273,61277,9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0812,3</td>
<td>-1.1</td>
<td>235,61271,8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0812,6</td>
<td>-1.4</td>
<td>235,61271,8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0812,9</td>
<td>-1.6</td>
<td>250,61259,3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>0813,2</td>
<td>-2.1</td>
<td>264,61325,6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0813,4</td>
<td>-2.4</td>
<td>287,61324,3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>0813,7</td>
<td>-2.3</td>
<td>303,61232,6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>0814,0</td>
<td>-2.5</td>
<td>119,61223,4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0814,3</td>
<td>-3.0</td>
<td>137,61219,2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0814,5</td>
<td>-3.6</td>
<td>150,61284,3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>0814,8</td>
<td>-4.1</td>
<td>175,61230,8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>0815,1</td>
<td>-4.0</td>
<td>167,61192,9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>0815,4</td>
<td>-4.6</td>
<td>167,61195,3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>0815,6</td>
<td>-4.8</td>
<td>160,61166,1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPREAD B</th>
<th>SP B</th>
<th>SP B</th>
<th>SP #</th>
<th>SP #</th>
<th>SP #</th>
<th>SP #</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO</td>
<td>CORR T</td>
<td>-21.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0815,9</td>
<td>-4.7</td>
<td>437,61144,3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0816,2</td>
<td>-4.6</td>
<td>455,61134,4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0816,5</td>
<td>-4.5</td>
<td>467,61127,3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0816,7</td>
<td>-4.4</td>
<td>481,61129,5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0817,0</td>
<td>-4.0</td>
<td>493,61108,0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0817,3</td>
<td>-3.6</td>
<td>483,61101,4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0817,6</td>
<td>-1.1</td>
<td>419,61105,9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0817,8</td>
<td>-2.7</td>
<td>544,61397,2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0818,1</td>
<td>-2.3</td>
<td>557,61105,7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0818,4</td>
<td>-1.5</td>
<td>564,61105,4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0818,7</td>
<td>-8.4</td>
<td>479,61971,8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0815,9</td>
<td>-0.9</td>
<td>994,61865,6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0819,2</td>
<td>-0.1</td>
<td>609,61835,1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0819,5</td>
<td>-0.2</td>
<td>621,61840,1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>0819,7</td>
<td>-0.2</td>
<td>634,61842,2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0820,0</td>
<td>-4.7</td>
<td>645,61387,6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>0820,3</td>
<td>-4.4</td>
<td>655,61199,4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>0820,6</td>
<td>-0.9</td>
<td>675,61326,9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0820,8</td>
<td>1.6</td>
<td>686,61818,6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0821,1</td>
<td>2.7</td>
<td>695,61811,7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>0821,4</td>
<td>4.1</td>
<td>710,61833,1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>0821,7</td>
<td>3.6</td>
<td>720,61844,5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>0821,9</td>
<td>3.6</td>
<td>716,61864,9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEO</td>
<td>SP</td>
<td>POS</td>
<td>ELEV</td>
<td>SP</td>
<td>POS</td>
<td>ELEV</td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>1200.4</td>
<td>2060.6</td>
<td>6130.2</td>
<td>2</td>
<td>2167.4</td>
<td>2732.7</td>
</tr>
<tr>
<td>3</td>
<td>2078.9</td>
<td>2737.9</td>
<td>6607.4</td>
<td>4</td>
<td>2211.2</td>
<td>2881.8</td>
</tr>
<tr>
<td>5</td>
<td>2266.8</td>
<td>2953.2</td>
<td>6881.8</td>
<td>6</td>
<td>2347.2</td>
<td>2747.5</td>
</tr>
<tr>
<td>7</td>
<td>2515.3</td>
<td>3243.3</td>
<td>6807.1</td>
<td>8</td>
<td>2492.8</td>
<td>3359.6</td>
</tr>
<tr>
<td>9</td>
<td>2561.1</td>
<td>3195.6</td>
<td>6814.1</td>
<td>10</td>
<td>2740.9</td>
<td>0.0</td>
</tr>
<tr>
<td>11</td>
<td>2786.3</td>
<td>3669.8</td>
<td>6836.8</td>
<td>12</td>
<td>2835.6</td>
<td>0.0</td>
</tr>
<tr>
<td>13</td>
<td>3161.3</td>
<td>3561.3</td>
<td>6839.3</td>
<td>14</td>
<td>3630.6</td>
<td>3767.3</td>
</tr>
<tr>
<td>15</td>
<td>3866.1</td>
<td>3875.4</td>
<td>6817.5</td>
<td>16</td>
<td>3800.1</td>
<td>4211.1</td>
</tr>
<tr>
<td>17</td>
<td>4354.3</td>
<td>0.0</td>
<td>0.0</td>
<td>18</td>
<td>4464.9</td>
<td>4394.0</td>
</tr>
<tr>
<td>19</td>
<td>4464.9</td>
<td>4323.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>POSITION</td>
<td>Srf Elev</td>
<td>Depth</td>
<td>Elev</td>
<td>Depth</td>
<td>Elev</td>
</tr>
<tr>
<td>----</td>
<td>----------</td>
<td>----------</td>
<td>-------</td>
<td>------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>118.0</td>
<td>6795.0</td>
<td>71.5</td>
<td>8723.5</td>
<td>142.7</td>
<td>8522.3</td>
</tr>
<tr>
<td>2</td>
<td>229.0</td>
<td>6792.0</td>
<td>73.5</td>
<td>8723.5</td>
<td>142.9</td>
<td>8511.0</td>
</tr>
<tr>
<td>3</td>
<td>330.0</td>
<td>6801.0</td>
<td>76.5</td>
<td>8723.5</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>4</td>
<td>443.0</td>
<td>6800.0</td>
<td>71.0</td>
<td>8729.0</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>5</td>
<td>556.0</td>
<td>6800.0</td>
<td>67.0</td>
<td>8712.5</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>6</td>
<td>669.0</td>
<td>6800.0</td>
<td>104.0</td>
<td>8701.0</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>7</td>
<td>772.0</td>
<td>6800.0</td>
<td>124.4</td>
<td>8689.6</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>8</td>
<td>885.0</td>
<td>6800.0</td>
<td>143.0</td>
<td>8670.2</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>9</td>
<td>998.0</td>
<td>6800.0</td>
<td>160.1</td>
<td>8667.9</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>10</td>
<td>111.0</td>
<td>6800.0</td>
<td>166.4</td>
<td>8660.6</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>11</td>
<td>122.0</td>
<td>6800.0</td>
<td>161.0</td>
<td>8667.9</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>12</td>
<td>133.0</td>
<td>6800.0</td>
<td>142.0</td>
<td>8674.0</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>13</td>
<td>143.0</td>
<td>6800.0</td>
<td>161.1</td>
<td>8659.9</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>14</td>
<td>154.0</td>
<td>6800.0</td>
<td>224.1</td>
<td>8597.9</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>15</td>
<td>165.0</td>
<td>6800.0</td>
<td>225.0</td>
<td>8595.0</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>16</td>
<td>176.0</td>
<td>6800.0</td>
<td>241.3</td>
<td>8579.7</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>17</td>
<td>187.0</td>
<td>6800.0</td>
<td>256.4</td>
<td>8564.1</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>18</td>
<td>198.0</td>
<td>6800.0</td>
<td>273.0</td>
<td>8549.0</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>19</td>
<td>209.0</td>
<td>6800.0</td>
<td>279.5</td>
<td>8548.5</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>20</td>
<td>220.0</td>
<td>6800.0</td>
<td>279.1</td>
<td>8547.9</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>21</td>
<td>231.0</td>
<td>6800.0</td>
<td>260.3</td>
<td>8559.9</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
<tr>
<td>22</td>
<td>242.0</td>
<td>6800.0</td>
<td>265.4</td>
<td>8559.6</td>
<td>142.9</td>
<td>8509.0</td>
</tr>
</tbody>
</table>
C PROGRAM SRTDI, VERSION IMPROVED AND ADAPTED TO CSM PDP-10 COMPUTER

C THIS PROGRAM INTERPRETS REFRACTION SEISMIC DATA FOR UP TO 6 SPREADS
OF UP TO 24 GEOS AND 2 SPS EACH, AND FOR AS MANY AS 5 LAYERS WITH
LAYER VELOCITY INCREASING WITH LAYER DEPTH.

C SRTDI MAIN PROGRAM READS THE WHOLE INPUT DATA, PRINT IT OUT, INITIALIZE
VARIABLES AND ARRAYS, COMPUTE VELOCITY OF FIRST LAYER, CALCULATE NEW
SLOPING DATUM THROUGH GEOPHONE ELEVATIONS AND CORRECT THEM, PLOTS T-D
GRAPHS, PRINTS FINAL DEPTH VALUES IN TWO SEPARATED FILES AND PLOT
FINAL CROSS-SECTION INTERPRETATION.

C I ARRAYS
    DIMENSION IDENT(14)
C L ARRAYS
    DIMENSION IL(5), VREG(5), VHOB(5), PREG(5), PHOB(5), ZSG(4), KIL(5)
C M ARRAYS
    DIMENSION NGDEO(6,5),
        2 IDSPR(6), NJ(6), NK(6), XSHIFT(6), EMAX(6), VCOR(6)
C M,L ARRAYS
    DIMENSION BL1(6,5), BL2(6,5);
        2 VVA(6,5), VHA(6,5), NML(6,5), MIND(6,5), KPL(6,5), KPR(6,5)
C J ARRAYS
    DIMENSION TVS(6), AVVOD(6)
C J,M ARRAYS
    DIMENSION EDSP(6,6),
        4 IDSP(6,6), ESP(6,6), XSP(6,6), YSP(6,6), ZSP(6,6), TUH(6,6),
        4 TFUGE(6,6), ES(6,6), ZAV(6,6), SPTD(6,6), SPPT(6,6),
        4 LS(6,6)
C J,M,LR ARRAYS
    DIMENSION ES2(6,6,2), PS2(6,6,2), ES2(6,6,2), TRS2(6,6,2)
C J,M,L ARRAYS
    DIMENSION ERS(6,6,4), TRS(6,6,4)
C J,M,LR ARRAYS
    DIMENSION ERS2(6,6,4,2), PRS2(6,6,4,2), KRS2(6,6,4,2)
C K ARRAYS
    DIMENSION TVG(24), XVG(24), DSG(24), PRP(24), IARR(25)
C K,L ARRAYS
    DIMENSION PRG2(24,2), ERG2(24,2), TRG2(24,2)
C K,I ARRAYS
    DIMENSION TCG(24,2), XCG(24,2), XINTG(24,2), EINTG(24,2)
C K,M ARRAYS
    DIMENSION EDG(24,6), EG(24,6), XG(24,6), YG(24,6),
        8 GTC(24,6), KM1(24,6), GPT(24,6)
C K,M,LR ARRAYS
    DIMENSION PG2(24,6,2), EG2(24,6,2), TG2(24,6,2)
C K,M,L ARRAYS
    DIMENSION ERP(24,6,4), TRP(24,6,4)
DIMENSION LG(24,2,6),
   TA(24,2,6), TR(24,2,6), DG(24,2,6), VDD(24,2,6),
   PRG(24,2,6), ERG(24,2,6), TRG(24,2,6), KRG(24,2,6), ZG(24,2,6)

COMMON COMMON
   IBL, NL, IQUES, ITH0, KM1, IFLAG, IREP, LN,
   IDENT, IL, ZSG, KIL, TVS, AVVD, ECSP, YSP, ZSP, TUH, ZAV,
   SPTC, SPPT, ZS2, PS2, ES2, TRS2, TVG, XVG, PRP, PRG2, ERG2, TRG2,
   TC, XCG, XINTG, EINTG, EDG, YG, GGT, GPT, PG2, EG2, TG2, TR, VDD, ZG, TRG,
   IXIT, NIXIT, DMY1, DMY2, DMY3, MM, MJ, MK, ML, ML1, IL, X, TLIM, A, SLOPE

COMMON COMMON
   COMMON/BLK0/LG
   /BLK1/NM, NJ, NK
   /BLK2/XG, ERP
   /BLK3/TA, DSG
   /BLK4/VBA, VHA
   /BLK5/IDSPR, IDSP, D
   /BLK6/TPR, JOFF
   /BLK7/TRS, ERS, XSP, ESP, LS
   /BLK8/PRG, ERG, KRG, PRS2, ERS2, KRS2
   /BLK9/EG, ES
   /BLK10/BLIM, ITRACE, NSWAC
   /BLK11/VREG, PREG
   /BLK12/VHOB, PHOB, IARR
   /BLK13/NML, MIND, BL1, BL2, KPP, KPPR, NGCED
   /BLK14/LGC
   /BLK16/TSCALE, ESCALE
   /BLK17/NTVE

CONSTANTS
DATA IEND, KBL, KQUES/IEND', ', ', ', ', ','Brien'
DATA KIL/1 ', '2 ', '3 ', '4 ', '5 ', '/
DATA MM, MJ, MK, ML, ML1, IL, X, I1, 11/6, 2, 24, 5, 4, 0, 1/

IBL=KBL
IQUES=KQUES
IL(1)=KIL(1)
IL(2)=KIL(2)
IL(3)=KIL(3)
IL(4)=KIL(4)
IL(5)=KIL(5)

INITIALIZE
NIN=1
DO 600 I=1, MK, 2
IARR(I)=NIN
1860

LARR(I+1)=MIN+12
MIN=MIN+1
600 CONTINUE
1 DO 5 J=1,MJ
   DO 4 M=1,MM
   IDSU(J,M)=IBL
   SPTC(J,M)=0.0
   SPPT(J,M)=0.0
   LS(J,M)=1
   DO 2 L=1,ML1
       ERS(J,M,L)=0,0
       TRS(J,M,L)=0,0
   DO 2 LR=1,2
       ERS2(J,M,L,LR)=0,0
       PWS2(J,M,L,LR)=0,0
       KRS2(J,M,L,LR)=IBL
   CONTINUE
2 DO 3 K=1,MK
   PRG(K,J,M)=0,0
   ERG(K,J,M)=0,0
   TRG(K,J,M)=0,0
   KRG(K,J,M)=IBL
   VGDI(K,J,M)=0,0
   D(K,J,M)=0,0
   LGT(K,J,M)=0
   CONTINUE
3 CONTINUE
4 CONTINUE
AVVDEO(J)=0.0
5 CONTINUE
DO 7 M=1,MM
DO 7 L=1,ML1
VVA(M,L)=0,0
VHA(M,L)=0,0
NGDED(M,L)=0
NML(M,L)=0
MIND(M,L)=0
KPPL(M,L)=0
KPRP(M,L)=0
BL1(M,L)=0,0
BL2(M,L)=0,0
7 CONTINUE
8 CONTINUE
GTC(K,M)=0.0
KM1(K,M)=0.
GPT(K,M)=0.0
DO 8 L=1,ML1
ERK(K,M,L)=0,2
TRP(K,M,L)=0,0
8 CONTINUE
IREP=0
READ INPUT DATA AND PRINT IT OUT

READ 9, IDENT
9 FORMAT (14A5)
IF (IDENT(1),EQ,'END') GO TO 9999

GENERAL CONTROL DATA INFORMATION

READ 10, NM, IXIT, NL, NV, NTVE, ITWO, MK11, K111, MK22, K222, EDAT1,
1XDAT1, EDAZ2, XDAT2, SLOPE, A, BLIM, TLIM, ITRACE, JJOFF, NSWAD
10 FORMAT (I1, I2, 2(I1, I1), 1X, I1, I1, 2(I2, I2), 5X, 4F7, 1, F7, 4, F7, 1,
1 F7, 2, F4, 1, I1, 311)
IF (NL.LE.1) NL=2
IF (NM.EQ.'0') NM=1
READ 11, TSCALE, ESCALE
11 FORMAT (2F5, 0)
IF (BLIM.EQ.'0', 0) BLIM=0.5
IF (TLIM.EQ.'0', 0) TLIM=10.0
LN=NL-1
PRINT 13, IDENT, NM, IXIT, NL, NV, TSCALE, ESCALE,
1 EDA1, XDAT1, EDAT2, XDAT2, SLOPE, A, BLIM, TLIM
13 FORMAT (1H1, 50X, 12HSDRTDI CSM 76/1H0, 14A5/1H0, 24HCONTROL DATA INFO
1RMATION/1H0, T30, 'OVERLIDE VALUES = ', '3X, 'PLOT SCALES', '7X,
2'DATUM POINT COORDINATES', '7X, 'DATUM EQUAT ', '/1H, 5HSERDS', '2X,
319HEXIT LAYERS VELOD, 20X, 'TSCALE', 2X, 'ESCALE', 2(3X, 4HELEV, 4X,
45X POS), 3X, 28HSLOPE INTOPT, BLIM, TLIM/1H, 5H-----, 2X, 4H----,
52(2X, 6H-----), 18X, 10(2X, 6H-----)/1H, I3, 2I7, I8, 22X, F6.0, 2X, F6.0,
6 4F8.1, F8.4, F7.1, F8.2, F8.1)
NIXIT=0
IF (IXIT.EQ.'0') GO TO 14
IXIT=IABS (IXIT)
NIXIT=1
PRINT 16, ITRACE, JJOFF, NSWAD, NTVE, ITWO, MK11, K111, MK22, K222
16 FORMAT (1H0, 'CONTROL DATA SWITCHES', '1H0, 'ISTRACE', '2X, 'OFF', '2X,
1' NSWAD', '2X, 'NTVE', '2X, 'ITWO', '2X, 'MK11', '2X, 'K111', '2X, 'MK22', '2X,
3' K222', '/1H, 6H------, 2X, 3H---, 2X, 5H------, 6(2X, 4H----)/1H, I4, 4X,
412, 3X, I3, 1X, 6(4X, I2))
14 IF (NV.EQ.'3') GO TO 25
PRINT 15, (M, M=1, MM)
15 FORMAT (1H0, '13HVELOCITY DATA/1H0, 9X, 5(6HSPREAD, I2, 6X)/1H0, 1X,
1 5HLAYER, 5(3X, 2HV, 5X, 2HV, 2X)/1H, 6H------, 10(1X, 6H------))

VELOCITY OVERRIDE DATA

DO 20 I=1, NV
READ 17, L, (VVA(M, L), VHA(M, L), M=1, NM)
17 FORMAT (I1, 10F6, 3)
PRINT 19,L1(VVA(H,L),VHA(M,L),M=1,NM)
19 FORMAT (4X,I1,2X,10F7,0)
DO 20 M=1,NM
VVA(M,L)=VVA(H,L)/1000,
VHA(M,L)=VHA(H,L)/1000,
20 CONTINUE

C SPREAD CONTROL INFORMATION

25 DO 60 M=1,NM
READ 27, IDSPR(M),NJ(M),NK(M),(NML(M,L),L=1,ML),XSHIFT(M),
1(MIND(M,L),KPL(M,L),KPR(M,L),NGQED(M,L),L=1,ML),EMAX(M),VCOR(M)
27 FORMAT (A1,2I3,5I1,F5,0,5(I1,I2,I2,L1),2F5,0)
IF(EMAX(M),LE,0.01)EMAX(M)=100,
IF(VCOR(M),LE,0.01)VCOR(M)=6.
PRINT 28,(NML(M,L),MIND(M,L),KPL(M,L),KPR(M,L),NGQED(M,L),L=1,ML),
EMAX(M),VCOR(M)
28 FORMAT (1H0,'SPREAD CONTROL SKITCHES',96X,'CONTROL
VAL.',/1H6,6X,
2'SURFACE',15X,'INTERFACE 1',13X,'INTERFACE 2',13X,'INTERFACE 3',
313X,'INTERFACE 4',1H5,('NML',1X,'
MIND',1X,'KPL',1X,'KPR',1X,
4NGQED',3X),'
EMAX',2X,VCOR/1H,53H---,1X,4H---,1X,3H---,1X,
53H---,1X,4H---,3X),5H---,1X,5H---,/1H,5(12,15,14,15,4),
6F5,0,1X,F5,0)
PRINT 29, IDSPR(M),NJ(M),NK(M),XSHIFT(M)
29 FORMAT (1H0,2X,1H0,27HSHOTPOINT AND GEOPHONE DATA//2X,6HSPREAD,1X,A1,1H,,
1I2,1X,11SHOOTPOINTS,13,1X,19HGEOPHONES, XSHIFT =,F8.1//2X,
25HSP ELEV YLOC YLOC DEPTH UPHOLE T FUDGE T,2X,
36HEND SP/2X,10H==--------,6(1X,8H----------)
XLAST=-9999999,
JN=NJ(M)

C SHOT POINTS CONTROL INFORMATION

DO 35 J=1,JN
READ 31, IDTEST, IDSP(J,M),ESP(J,M),XSP(J,M),YSP(J,M),ZSP(J,M),
1TUH(J,M),TFUDGE(J,M)
31 FORMAT (A1,1X,A2,3F7,1,3F5,1)
IF (IDTEST,NE,0,OR,XSP(J,M),LT,XLAST) GO TO 9992
PRINT 33, IDSP(J,M),ESP(J,M),XSP(J,M),YSP(J,M),ZSP(J,M),TUH(J,M),
1TFUDGE(J,M)
33 FORMAT (1H,H2X,1F8.1,5F9.1)
ESP(J,M)=ESP(J,M)-ZSP(J,M)
XLAST=XSP(J,M)
35 CONTINUE
PRINT 41, (IDSP(J,M),J=1,MJ)
41 FORMAT (1H9,35X,46HARRIVAL TIMES + FUDGE T AND LAYERS REPRESENTED/
129H3 GEO ELEV X LOC Y LOC 2X,2(5X,3HSP ,A2),2X,
2 10H==--------,2(1X,8H----------),2X,8(2X,7H----------)
XLAST=-9999999,
KN=NK(M)
C GEOPHONES CONTROL AND ARRIVAL TIMES INFORMATION

DO 55 K=1,KN
READ 43, IDTEST,KTEST,EG(K,M),XG(K,M),YG(K,M),
1 (TA(K,J,M),LGC(K,J,M),LG(K,J,M),J=1,JN)
43 FORMAT (A12,F7.1,8(F5.1,I11,I1))
1 IF (IDTEST,NE,IDSPR(M),OR,KTEST,NE,K,OR,XG(K,M),LT,XLAST)
1 GO TO 9990
DO 44 J=1,JN
44 CONTINUE
PRINT 45, K,EG(K,M),XG(K,M),YG(K,M),
1 (TA(K,J,M),LGC(K,J,M),J=1,JN)
45 FORMAT (2X,12,F8.1,2F9.1,2X,8(F7.1,1X,I1))
XLAST=XG(K,M)
55 CONTINUE
IF (M,NE,NM,OR,NIXIT,EG,0) PRINT 57, IDENT
57 FORMAT (1H1.14A5)
60 CONTINUE

C READ DEPTH VALUES FOR TOP OF LAYER 2 PREVIOUSLY INTERPRETED

IF(ITWO,EQ,0)GO TO 99
DO 98 M=1,NM
KN=NK(M)
DO 96 K=1,KN
READ(12,97)ERP(K,M,1)
97 FORMAT(1H1,F12.5)
KM1(K,M)=0
IF(M,LT,MK11,OR,M,GT,MK22)GO TO 96
IF(M,EQ,MK11,AND,K,LT,K111)GO TO 96
IF(M,EQ,MK22,AND,K,GT,K222)GO TO 96
KM1(K,M)=1
96 CONTINUE
98 CONTINUE

C COMPUTE V1 USING DIRECT DIST DD FROM SHOT TO GEOS FOR WHICH LG=1

99 NCONT=1
KCONT=0
IF (NIXIT,EG,0) PRINT 100
100 FORMAT (1H0,1X,42HV1 FOR DIRECT RAYS AND DIRECT DISTANCES DD)
SUM1=0,0
PTS1=0,0
DO 150 M=1,NM
150 FORMAT (1H0,1X,42HV1 FOR DIRECT RAYS AND DIRECT DISTANCES DD)
SUM1=0,0
PTS1=0,0
IF(NML(M,1),EQ,0)GO TO 149
IF(NIXIT,NE,0)GO TO 105
NCONT2=NCONT+2
IF(KCONT,NE,NCONT2)GO TO 105
NCONT = NCONT + 1
PRINT 101
101 FORMAT (1H1, 1X, 42HV1 FOR DIRECT RAYS AND DIRECT DISTANCES DD)
105 SUM2 = 0.0
PTS2 = 0.0
JN = NJ(M)
DO 120 J = 1, JN
SUM3 = 0.0
PTS3 = 0.0
KN = NK(M)
DO 110 K = 1, KN
IF (LG(K, J, M), NE, 1) GO TO 110
D(K, J, M) = SQRT ((EG(K, M) - ES(J, M))**2 + (XG(K, M) - XSP(J, M))**2)
VDD(K, J, M) = D(K, J, M) / TA(K, J, M)
PTS3 = PTS3 + 1.0
SUM3 = SUM3 + VDD(K, J, M)
PTS2 = PTS2 + 1.0
SUM2 = SUM2 + VDD(K, J, M)
PTS1 = PTS1 + 1.0
SUM1 = SUM1 + VDD(K, J, M)
110 CONTINUE
IF (PTS3, EQ, 0.0) GO TO 115
AVVDD(J) = SUM3 / PTS3
GO TO 120
115 AVVDD(J) = 0.0
120 CONTINUE
IF (PTS2, EQ, 0.0) GO TO 126
SUM2 = SUM2 / PTS2
126 IF (NIXIT, EQ, 1) GO TO 150
PRINT 131, IDSPR(M), (IDSP(J, M), J = 1, MJ)
131 FORMAT (1H0, 1X, 6HSPREAD, 1X, A1, 4X, 4HGEO, 8(6X, 3HSP, A1, 4X)/
114X, 3H---, 8(2X, 12H---V1---DD---))
DO 140 K = 1, KN
PRINT 135, K, (VDD(K, J, M), D(K, J, M), J = 1, JN)
135 FORMAT (15X, 12, 8(3PF8.0, 0PF6, 1))
140 CONTINUE
PRINT 143, SUM2, (AVVDD(J), J = 1, JN)
143 FORMAT (1X, 3HAVG, 2X, 3PF7.0, 0PF6, 1))
149 KCONT = KCONT + 1
150 CONTINUE
IF (PTS1, EQ, 0.0) GO TO 152
SUM1 = SUM1 / PTS1
152 VREG(1) = SUM1
IF (VREG(1), LE, 0.0) VREG(1) = 1.5
156 IF (NIXIT, EQ, 0) PRINT 157, SUM1
157 FORMAT (1H0, 1X, 10HAVG OF ALL, 3PF7.0)
C APPLY XSHIFT TO XSP AND XG ARRAYS
C ALSO COMPUTE DIR DIST BETWEEN (XSP, YSP) AND (XG, YG) IF LG , NE, 1
C
DO 180 M=1,NM
  JN=NJ(M)
  KN=NK(M)
  IF(XSHIFT(M),LE,0.01)GO TO 164
  DO 165 K=1,KN
    XG(K,M)=XG(K,M)*XSHIFT(M)
  165 CONTINUE
  DO 164 J=1,JN
    XSP(J,M)=XSP(J,M)*XSHIFT(M)
  164 CONTINUE
  DO 170 K=1,KN
    IF (LG(K,J,M),NE,1)
      !D(K,J,M)=SORT ((XG(K,M)-XSP(J,M)**2+(YG(K,M)-YSP(J,M)**2)
    170 CONTINUE
  175 CONTINUE
  180 CONTINUE

TEST FOR DOING RAW TIME T-D PLOT

  IF (IXIT,EQ,0.0,OR,IXIT,EQ,1.1,AND,IXIT,EQ,0) GO TO 202
  GO TO 205
  202 CALL PLOTT(1)
  IF (IXIT,EQ,0) GO TO 1

FIT STRAIGHT LINE THRU GEO ELEVATIONS

  205 IF (SLOPE,NE,0.0,OR,A,NE,0.0) GO TO 225
  IF (XDAT1,NE,0.0,OR,XDAT2,NE,0.0) GO TO 220
  SUM1=0.0
  SUM2=0.0
  PTS=0.0
  DO 212 M=1,NM
    KN=NK(M)
    DO 210 K=1,KN
      SUM1=SUM1+XG(K,M)
      SUM2=SUM2+EG(K,M)
      PTS=PTS+1.0
    210 CONTINUE
  212 CONTINUE
  XBAR=SUM1/PTS
  EBAR=SUM2/PTS
  SUM1=0.0
  SUM2=0.0
  DO 216 M=1,NM
    KN=NK(M)
    DO 214 K=1,KN
      DIFF=XG(K,M)-XBAR
      SUM1=SUM1+DIFF*EG(K,M)
      SUM2=SUM2+DIFF**2
    214 CONTINUE
  216 CONTINUE
  SLOPE=SUM1/SUM2
A=EBAR-SLOPE*XBAR
GO TO 225
222 SLOPE=(EDAT2-EDAT1)/(XDAT2-XDAT1)
A=EDAT1-SLOPE*XDAT1
225 DO 230 M=1,NM
KN=NX(M)
DO 226 K=1,KN
EDG(K,M)=A*SLOPE*XG(K,M)
C CHECKING FOR SLOPING DATUM ELEVATION UNDER TOP OF LAYER 2

DTD=EG(K,M)-EDG(K,M)
IF(DTD,LT,EWMAX(M))GO TO 226
PRINT 224,K,M
224 FORMAT(' GEOPHONE ',12,5X,' HAS BEEN RELOCATED UNDERNEATH OF TOP OF LAYER 2/')
226 CONTINUE
JN=NJ(M)
DO 227 J=1,JN
227 EDSP(J,M)=ES(J,M)
DO 228 J=1,2
EDSP(J,M)=A+SLOPE*XSP(J,M)
228 CONTINUE
230 CONTINUE
C VELOCITY OVERRIDE CARD ANALYSIS -- SET ANY ZERO V=V NONZERO

IF (VVA(1,1).NE.0,0) GO TO 242
DO 240 M=1,NM
VVA(M,1)=VREG(1)
240 CONTINUE
GO TO 246
242 IF (NM.LE.1) GO TO 246
DO 244 M=2,NM
IF (VVA(M,1).EQ.0,0) VVA(M,1)=VVA(1,1)
244 CONTINUE
246 DO 250 L=2,NL
IF (VVA(1,L).EQ.0,0) GO TO 250
IF (VHA(1,L).EQ.0,0) VHA(1,L)=VVA(1,L)
IF (NM.LE.1) GO TO 250
DO 248 M=2,NM
IF (VVA(M,L).EQ.0,0) VVA(M,L)=VVA(1,L)
IF (VHA(M,L).EQ.0,0) VHA(M,L)=VHA(1,L)
248 CONTINUE
250 CONTINUE
C COMPUTE AND APPLY VERTICAL TIME CORRECTIONS TO DATUM -- PRINT RESULTS

300 IF (VIXIT.LE.1) GO TO 303
PRINT 57, IDENT
PRINT 322, A, SLOPE
302 FORMAT (1H9,46HARRIVAL TIMES CORRECTED TO DATUM (DATUM ELEV = ,F8.1
1,4H + , , (F8,4,25H)X), AND PLOT POSITIONS D )
303 DO 400 M=1,NM
   VV=VVA(M,1)
   JN=NJ(M)
   KN=NK(M)
C FIRST PRECOMPUTE GEO TIME CORR
   DO 304 K=1,KN
   EEE=EDG(K,M)-EG(K,M)
   EE=(EE+ENMAX(M))
   IF (EE.LT.0.00001) GO TO 305
305 TVG(K)=EEE/VV
304 CONTINUE
C THEN COMPUTE SP TIME CORR
   DO 306 J=1,JN
   TVS(J)=EDSP(J,M)-ES(J,M)/VV
   IF (TUH(J,M),NE,0,0) TVS(J)=TVS(J)+TUH(J,M)-ZSP(J,M)/VV
306 CONTINUE
C APPLY DATUM CORRECTIONS
   DO 332 K=1,KN
   IF (LG(K,J,M),NE,1.AND,TR(K,J,M),NE,0,0) TA(K,J,M)=TR(K,J,M)+
   1 TVS(J)*TVG(K)
330 CONTINUE
332 CONTINUE
C PRINT RESULTS
   IF (NIXT,EQ,1) GO TO 400
   PRINT 333, IDSPR(M),(IDSP(J,M),J=1,MJ),(EDSP(J,M),J=1,JN)
383 FORMAT (1H9,1X,7HSPREAD ,A1,7,8(12X,3HSP ,A1)/1H0,7X
1 14HELEV : ,14X,8(F10,1,4X))
   PRINT 385, (TVS(J),J=1,JN)
385 FORMAT (9X,1H/9X,1H,3X,6HCOOR T,8(F12,1,2X))
   PRINT 387
387 FORMAT (1X,3HGE0,5X,1H,10X,8(14H --T----D----))
   DO 389 K=1,KN
   PRINT 389, K,EDG(K,M),TVG(K),(TA(K,J,M),J=1,JN)
389 FORMAT (1X,12,F8,1,F7,1,2X,8F6,1)
390 CONTINUE
400 CONTINUE
C C EXIT POINT TEST AND BRANCH
C IF (IXIT,GT,2) CALL MAIN2($1,$2200)
IF (IXIT,EQ,2.AND,NIXIT,NE,0) CALL MAIN2($1,$2200)
C PLOT T-D GRAPH
C
450 CALL PLOTT(1)
C
IF (IXIT.EQ.1) GO TO 1
C
C PRINT RESULTS -- DEPTHS COMPUTED FROM REFRACTION ARRIVALS
C
2200 DO 2222 M=1,NM
    PRINT 57, IDENT
    PRINT 2201, IDSPR(M), (IDSP(J,M), J=1,MJ)
2201 FORMAT (1H0,8H SPREAD, A1,3X,32HRAY END POINTS BENEATH GEOPHONES/1H0,4H GEO,14X,6(8X,3HSP, A1)/1H4,4H GEOL,10X,6(8X,3HSP, A1)/1H4,17X, 6(2X,10H------L--))
C
    K N = NK(M)
    J N = NJ(M)
C
    DO 2210 K=1,KN
    PRINT 2203, K, (PRG(K,J,M), LG(K,J,M), J=1,JN)
2203 FORMAT (1H0,13,15X,3HPOS, (F9.1, I12, 1X))
    PRINT 2205, (ERG(K,J,M), KRG(K,J,M), J=1,JN)
2205 FORMAT (1H0,17X,4HELEV, (F9.1, 1X, A1, 1X))
    PRINT 2207
2207 FORMAT (1H )
    2210 CONTINUE
C
    PRINT 2211
    2211 FORMAT (1H ,33HRAY END POINTS BENEATH SHO T POINTS)
C
    DO 2220 L2=2,NL
    L=L2-1
    J N 1 = J N - 1
    PRINT 2213, L2, (PRS2(J,M,L,1), J=1,JN1,2)
2213 FORMAT (1H0,2HL=,U ,4X,5HRIGHT, 6X, 3HP OS, (F9.1, F12, 1X))
    PRINT 2205, (ERS2(J,M,L,1), KRS2(J,M,L,1), J=1,JN1,2)
    PRINT 2217, L2, (PRS2(J,M,L,2), J=2,JN2,2)
    PRINT 2205, (ERS2(J,M,L,2), KRS2(J,M,L,2), J=2,JN2,2)
2217 FORMAT (1H0,2HL=,U ,4HLEFT, 7X, 3HP OS, (F9.1, F12, 1X))
    PRINT 2220 CONTINUE
2220 CONTINUE
C
C PRINT RESULTS -- INTERP-EXTRAP PTS AT SPS AND GEOS
C
    DO 2260 M=1,NM
    J 1 =1
    J 2 = NJ(M)
    PRINT 57, IDENT
    PRINT 2231, IDSPR(M), (L,L=2,NL)
2231 FORMAT (1H0,8H SPREAD, A1,3X,28HSMOOTHED POSITION OF LAYERS , 1 32HBENEATH SHO T POINTS AND GEOPHONES/1H0,35X,4(5HLAYER,I2,11X))
C
PRINT 2233
2233 FORMAT (1H0,25H SP POSITION SURF ELEV,4(5X,12H DEPTH ELEV,1X)/
1 1H,25H --- ------ ----- ----- ------ ------ ------ ------ ------
1 4(4X,14H--------------))
C
DO 2246 J=J1,J2
DO 2240 L=1,LN
ZSG(L)=0,0
IF (ERS(J,M,L),GT,0,0) ZSG(L)=ESP(J,M)-ERS(J,M,L)
2240 CONTINUE
PRINT 2243, IDSP(J,M),XSP(J,M),ESP(J,M),(ZSG(L),ERS(J,M,L),L=1,LN)
2243 FORMAT (1H0,2X,4I1,2FH,1,4(2X,2F8,1))
2246 CONTINUE
C
PRINT 2249
2249 FORMAT (1H0,4H GEO/1H ,4H ---)
KN=NK(M)
DO 2258 K=1,KN
DO 2252 L=1,LN
ZSG(L)=0,0
IF (ERP(K,M,L),GT,0,0) ZSG(L)=EG(K,M)-ERP(K,M,L)
2252 CONTINUE
PRINT 2255, K,XG(K,M),EG(K,M),(ZSG(L),ERP(K,M,L),L=1,LN)
2255 FORMAT (1H0,13I2,5F11,1,4(2X,2F8,1))
WRITE(12,2256)ERP(K,M,1)
2256 FORMAT (1H0,F12.5)
2258 CONTINUE
2260 CONTINUE
C
C PLOT DEPTH GRAPH
C
CALL PLOTT(2)
GO TO 1
C
9990 PRINT 9991
9991 FORMAT (1H0,40H ERROR ON INPUT DATA, COMPUTATION HALTED)
C
9999 STOP
END
SUBROUTINE MAIN2(*,*)

C Calculates the velocity for layers deeper than layer 1
C Computes depth values at base of layer 1 and print out these
C Results, removes the time contribution of layer 1 from the
C Arrival times. Start subroutine MAIN3 and call subroutines REGV,
C H08V, KENDS, ELCOR, REGRES, HTIME, TIE, AVG, FILLIN
C and PLOT. Plots T-D graph with layer 1 removed

C
DIMENSION IDENT(14)
DIMENSION IL(5),VREG(5),VHOB(5),PREG(5),PHCB(5),ZSG(4),KIL(5)
DIMENSION NGED(6,5),
2 IDSPR(6),NJ(6),NK(6),XSHIFT(6),EWMAX(6)
DIMENSION BL1(6,5),BL2(6,5),
2 VHA(6,5),VHA(6,5),NML(6,5),MIND(6,5),KPPL(6,5),KPPR(6,5)
DIMENSION TVS(6),AVVD(6)
DIMENSION EDSP(6,6),
4 IDSP(6,6),ES2(6,6),ES2(6,6),ES2(6,6),ES2(6,6),TUH(6,6),
4 TFUDGE(6,6),ES(6,6),ES2(6,6),SPTC(6,6),SPPT(6,6),
4 LS(6,6)
DIMENSION ZS2(6,6,2),PS2(6,6,2),ES2(6,6,2),TRS2(6,6,2)
DIMENSION ERS(6,6,4),TRS(6,6,4)
DIMENSION ERS2(6,6,4,2),PRS2(6,6,4,2),KRS2(6,6,4,2)
DIMENSION TVG(24),XVG(24),DSG(24),PRP(24),IARR(25)
DIMENSION PRG2(24,2),ERG2(24,2),TRG2(24,2)
DIMENSION TCG(24,2),XCG(24,2),XINTG(24,2),EINTG(24,2)
DIMENSION EDG(24,6),EDG(24,6),XG(24,6),YG(24,6),
8 GTC(24,6),KMC(24,6),GPT(24,6)
DIMENSION PG2(24,6,2),EG2(24,6,2),TG2(24,6,2)
DIMENSION ERP(24,6,4),TRP(24,6,4)
DIMENSION LGC(24,2,6),
9 TA(24,2,6),TR(24,2,6),LG(24,2,6),D(24,2,6),VDD(24,2,6),
9 PRG(24,2,6),ERG(24,2,6),TRG(24,2,6),KRG(24,2,6),ZG(24,2,6)

C
UNLABELED COMMON
COMMON IBL,NL,NL,TVS,AVVD,EDSP,TVS,TVS,TVS,PRP,PRP,PRP,PRP,
2 IDENT,IL,ZSG,KIL,TVS,AVVD,EDSP,YSP,ZSP,TUH,ZAV,
3 SPTC,SPPT,ZS2,PS2,ES2,TRS2,TVG,XVG,PRP,PRP,PRP,PRP,ERG2,TRG2,
4 TCG,XCG,XINTG,EINTG,EDG,YG,GTC,GPT,GCG,EG2,TG2,TR,VDD,ZG,TRG,
5 IXIT,NIXIT,DMY1,DMY2,DMY3,MM,MJ,MK,ML,ML1,ZL,ZL,T1,2,2,2,2,2,2,2,2,2

C
LABELED COMMON

COMMON/BLK0/LG
1 /BLK1/NM,NJ,NK
2 /BLK2/XG,ERP
3 /BLK3/TG,DSG
4 /BLK4/VHA,VHA
5 /BLK5/IDSP,ERP,DSG,D
6 /BLK6/TRP,10FF
DO REGRESSION VELOCITY COMPUTATION FOR TOP OF LAYER 2

IZI=0
IF(NIXIT,EQ,0) PRINT 57,IDENT
L1=1
L2=2
CALL REGV(L2,NIXIT)
IF(PREG(2),GT,0.0) GO TO 1005
IF(VVA(1,2),GT,0.0) GO TO 1020
1001 IF(NIXIT,EQ,0) PRINT 1002, L2
1002 FORMAT (1H0, 46HNOT ENOUGH POINTS TO DEFINE VELOCITY FOR LAYER,12,
118H USE OVERRIDE CARD)
GO TO 9999

DO HOBBIN-OVERTON VEL COMPUTATION FOR TOP OF LAYER 2

1005 CALL HOBV(L2,NIXIT)
C
IF(VVA(1,2),NE,0.0) GO TO 1020
VV=(VREG(2)*PREG(2)+1.5*VHOB(2)*PHOB(2))/(PREG(2)+1.5*PHOB(2))
DO 1008 M=1,NM
VVA(M,2)=VV
VHA(M,2)=VV
1008 CONTINUE
C
IF(NIXIT,EQ,0) PRINT 1011, L2,VV
1011 FORMAT (1H0,4X,2(8H----)/1H0,26HWTD AVG VELOCITY FOR LAYER,12,
1 2H =,3PF7.0)
GO TO 1025
C
1020 IF(NIXIT,EQ,0) PRINT 1021
1021 FORMAT (1H0,18HOVERRIDE CARD USED)
C
C COMPUTE DEPTH PTS AT BASE OF LAYER 1
C
C SPREAD LOOP
C
1025 IF(ITRACE,NE,0.AND.IXIT.GE,4) PRINT 1027, L2
1027 FORMAT (1H1,45HINTERMEDIATE RESULTS OF RAY TRACING FOR LAYER,12)
IFLAG=0
DO 1060 M=1,NM
JN=NJ(M)
KN=NK(M)
VV=VVA(M,L1)
HV=VHA(M,L2)
IF (HV,LE,VV) GO TO 9992
RAD2=HV**2-VV**2
RAD=SQRT (RAD2)
TANSG=VV/RAD
VOCOSG=TANSG*HV
VVCOSG=VV*RAD/HV

C PRECOMPUTE DATUM ELEV CORR FOR ALL GEOS AND STORE V AND TRIG CONS
DO 1034 K=1,KN
C I=1 FOR RIGHT-GOING RAYS, 2 FOR LEFT-GOING
DO 1033 I=1,2
CALL ELCOR(TANSG,VV,HV,XG(K,M),EG(K,M),A,SLOPE,I,TCG(K,I),
1 XCG(K,I),XINTG(K,I),EINTG(K,I))
1033 CONTINUE
1034 CONTINUE

C SP LOOP
C
J=1
JJ=J
C INITIALIZE FOR RIGHT-GOING RAYS
C
I=1
II=2
K1=1
K2=KN
C
C COMPUTE ELEV TIME CORR AND DIRECT DISTS
C
1036 CALL KENDS(2,M,J,K1,K2,K11,K22)
IF (K11.EQ.0) GO TO (1044,1048),I
CALL ELCOR(TANSG,YY,HV,XSP(J,M),ES(J,M),A,SLOPE,II,TC,XC,XINT,EINT
1)
C
C ENTRY POINT FOR OUTLYING SHOTPOINTS AFTER TIE CORRECTION IS MADE
C
1037 DO 1038 K=K11,K22
IF (LG(K,JJ,M),NE,2) GO TO 1038
TA(K,JJ,M)=TR(K,JJ,M)+TC+TCG(K,I)
DSG(K)=D(K,J,M)+XC*XCG(K,I)
1038 CONTINUE
C
C EXTRAP TIME AT SP AND COMPUTE COORD OF END PT CF RAY BENEATH SP
C
CALL REGRES(K11,K22,JJ,M,2,V,T,PT)
IF (PT,EQ.0.) GO TO (1044,1048),I
Z=T*VOCOSG
TS=Z/VVCOSG
C COMPUTE COORD OF RAY END PTS AT GECS

1041 DO 1043 K=K11,K22
   IF (LG(K,JJ,M),NE.2) GO TO 1043
   CALL HTIME(D(O(K,JJ,M),XSP(JJ,M),XG(K,M),PRS2(JJ,M,1,I),0.,1
   XINTG(K,I),0.,HV,TH)
   PG2(K,M,I)=XG(K,M)
   EG2(K,M,I)=EG(K,M)
   Z=TA(K,JJ,M)-TS-TH)*VVCOSG
   ERG(K,JJ,M)=EINTG(K,I)-Z
   IF (EG(K,M),GT,ERG(K,JJ,M)) GC TO 1042
   ERG(K,JJ,M)=EG(K,M)
   PRG(K,JJ,M)=XG(K,M)
   TRG(K,JJ,M)=0.00001
   GO TO 1043
1042 TRG(K,JJ,M)=(EG(K,M)-ERG(K,JJ,M))/VVCOSG
   ZTAN=Z*TANSIG
   IF (I,EQ.2) ZTAN=-ZTAN
   PRG(K,JJ,M)=XINTG(K,I)-ZTAN
1043 CONTINUE

C TEST FOR DOING OUTLYING SPS LEFT CF SPREAD, RIGHT-GOING RAYS

1044 IF (I,EQ.2) GO TO 1048
   JJ=JJ+2
   IF (JJ,GT,JN) GO TO 1046
   CALL KENDS(Z,M,JJ,1,KN,K11,K22)
   IF (K11,EQ.0) GO TO 1044
   IF(M,EQ.1,AND.JJOFF,EQ.0)GO TO 1045
   JJ=JJ
   GO TO 1037
1045 CALL TIE(2,M,J,JJ,K11,K22,1,KN,KN,TR,D)
   GO TO 1037

C INITIALIZE FOR LEFT-GOING RAYS

1046 I=2
   J=2
   JJ=J
II=1
K1=1
K2=KN
GO TO 1036

C TEST FOR DOING OUTLYING SPS RIGHT OF SPREAD, LEFT-GOING RAYS

1048 JJ=JJ+2
   IF (JJ.GT.JN) GO TO 1060
   CALL KENDS(2,M,JJ,1,KN,K11,K22)
   IF (K11.EQ.0) GO TO 1048
   IF(M.EQ.NM.AND.JJOFF.EQ.0)GO TO 1045
   JJ=JJ
   GO TO 1037

1060 CONTINUE

C COMPUTE AVG ELEV OF BASE OF LAYER 1 AT SPS AND GEOS

1200 DO 1400 M=1,NM
   VV=VVA(M,1)
   TANSG=VV/SQRT(VHA(M,2)**2-VV**2)
   IF (IFLAG.EQ.0) CALL ADMIG(i,M,TANSG)
   JN=NJ(M)
   KN=NC(M)
   DG2=(XG(KN,M)-XG(1,M))/FLOAT(KN*KN-2)
   DO 1255 K=1,KN
C PREVIOUSLY INTERPRETED DEPTH VALUE FOR TCP LAYER 2 ARE PRESERVED,
   IF(ITWO.EQ.1.AND.KM1(K,M).EQ.1)GO TO 1253
   ERP(K,M,1)=0.
   TRP(K,M,1)=0.
   PRP(K)=0.
   DO 1230 J=1,JN
      ZG(K,J,M)=0.
      IF (LG(K,J,M).EQ.2.AND.TRG(K,J,M).NE.0.)
         ZG(K,J,M)=EDG(K,M)-ERG(K,J,M)
   1230 CONTINUE
   IF (K.EQ.1) GO TO 1235
   X1=(XG(K,M)+XG(K-1,M))/2.
   GO TO 1240
1235 X1=XG(1,M)-DG2
1240 IF (K.EQ.KM) GO TO 1245
   X2=(XG(K+1,M)+XG(K,M))/2.
   GO TO 1250
1245 X2=XG(KN,M)+DG2
1250 CALL AVG(X1,X2,2,PRP(K),ERP(K,M,1))
   GO TO 1255
1253 PRP(K)=XG(K,M)
1255 CONTINUE
   DO 1285 K=1,KN
   IF (ERP(K,M,1).EQ.0.) GO TO 1285
   KK=K
IF (PRP(K), GT, XG(K, M)) GO TO 1270
1260 KK = KK + 1
IF (KK, GT, KN) GO TO 1280
IF (ERP(KK, M, 1), EQ, 0.) GO TO 1260
GO TO 1275
1270 KK = KK - 1
IF (KK, LT, 1) GO TO 1280
IF (ERP(KK, M, 1), EQ, 0.) GO TO 1275
GO TO 1275
1275 ERP(K, M, 1) = ERP(PRPR(K), ERP(K, M, 1), PRP(KK), ERP(KK, M, 1), XG(K, M))
1280 PRP(K) = XG(K, M)
TRP(K, M, 1) = (EG(K, M) - ERP(K, M, 1))/VV
1285 CONTINUE
DO 1325 J = 1, JN
TRS(J, M, 1) = 0.
ERS(J, M, 1) = 0.
ZS2(J, M, 1) = 0.
ZS2(J, M, 2) = 0.
ZAV(J, M) = 0.
IF (J, GT, 2) GO TO 1325
DO 1322 LR = 1, 2
IF (ERS2(J, M, 1, LR), EQ, 0.) GO TO 1302
ZS2(J, M, LR) = EPS(J, M) - ERS2(J, M, 1, LR)
ZAV(J, M) = ZAV(J, M) + ZS2(J, M, LR)
1302 CONTINUE
1325 CONTINUE
1400 CONTINUE
C
C FILL IN MISSING POINTS
C
CALL FILLIN(1)
IF (IFLAG, EQ, 2, OR, IXIT, LE, 3, OR, (IFLAG, EQ, 1, AND, IXIT, EQ, 4))
1 GO TO 1061
IFLAG = IFLAG + 1
L1 = 1
L2 = 2
IREP = IFLAG + 1
IZ1 = 1
CALL MAIN3(L1, L2, IZ1, $1200, $1300)
C
C PRINT TABLE OF DEPTHS AT SPS AND GEOS
C
1061 IF (NXIT, EQ, 1) GO TO 1070
PRINT 57, IDENT
PRINT 1062
1062 FOR I = 1, 96
DEPTH FROM DATUM TO BASE OF LAYER 1)
DO 1066 M = 1, NM
KN = NK(M)
PRINT 1063, IDSPR(M), (IARR(I), I = 1, 24)
1063 FORMAT (I1, 36H DEPTH FROM DATUM TO BASE OF LAYER 1 D MG= NM
DO 1065 J = 1, 2
1065 FORMAT (I1, 1H)
PRINT 1064, IDSP(J,M), ZS2(J,M,1), ZS2(J,M,2), ZAV(J,M),
1(ZG(K,J,M), K=1, KN)
1064 FORMAT (1H0, 13X, A1, 1X, 3F7.1, F5.1, 11F7.1/T38, 12F7.1/)
1065 CONTINUE
1066 CONTINUE
C PRINT HEADING FOR RESULTS
C
PRINT 57, IDENT
PRINT 1068
1068 FORMAT (1H0, 48HARRIVAL TIMES : CORRECTED TO BASE OF LAYER 1, AND ,
1 23HELEV OF BASE OF LAYER 1)
C COMPUTE CORRECTED TA FOR T-D PLOT
C
1070 DO 1092 M=1, NM
   JN=NJ(M)
   KN=NK(M)
   DO 1082 J=1, JN
      IF(J.EQ.1) GO TO 1077
      IF (JOFF, NE, .0, AND, M, NE, .1, AND, M, NE, NM) GO TO 1077
      IF(J.EQ.2) GO TO 1077
      IF(MOD(J, 2).EQ.0) GO TO 1075
      JJ=1
   GO TO 1076
   1075 JJ=2
   1076 TRS(J,M,1)=TRSU(J,M,1)
1077 DO 1080 K=1, KN
      IF(LG(K,J,M).EQ.1.0, TR(K,J,M).EQ.0.0) GO TO 1078
      TA(K,J,M)=TR(K,J,M)-TRP(K,M,1)-TRS(J,M,1)
   GO TO 1080
1078 TA(K,J,M)=0.0
1080 CONTINUE
1082 CONTINUE
C PRINT RESULTS
C
IF (NIXIT.EQ.1) GO TO 1092
PRINT 383, IDSPR(M), (IDSP(J,M), J=1, MJ), (ERS(J,M,1), J=1, JN)
PRINT 385, (TRS(J,M,1), J=1, JN)
PRINT 387
DO 1090 K=1, KN
PRINT 389, K, ERP(K,M,1), TRP(K,M,1), (TA(K,J,M), J=1, JN)
1090 CONTINUE
1092 CONTINUE
C COMPUTE VELOCITIES FOR DEEPER LAYERS BY REGRESSION AND HOBSON METHOD
C
IF (NL.LE.2) GO TO 1110
DO 1100 L=3, NL
IF (NIXIT.EQ.0) PRINT 57, IDENT
1100 CONTINUE
CALL REGV(L,NIXIT)
IF (PREG(L),GT.0,0) GO TO 1296
IF (VVAU(1,L),GT.0,0) GO TO 1102
L2=L
GO TO 1001

1096 CALL HOBV(L,NIXIT)
IF (VVA(1,L),NE.0,0) GO TO 1098

VV=(VREG(L)*PREG(L)+1.5*VHCB(L)*PHCB(L))/(PREG(L)+1.5*PHOB(L))
DO 1097 M=1,NM
VVA(M,L)=VV
VHA(M,L)=VV
CONTINUE
IF (NIXIT,EQ.0) PRINT 1011, L,VV
GO TO 1100

1098 IF (NIXIT,EQ.0) PRINT 1021
1100 CONTINUE

1110 IF (NIXIT,EQ.1,AND,IIXIT.GE.3) CALL MAIN3(L1,L2,IZI,$1200,$1300)
PLT. T-D GRAPh (LAYER 1 REMOVED)

CALL PLOTT(L)
IF (IXIT,EQ.2) RETURN 1
CALL MAIN3(L1,L2,IZI,$1200,$1300)
RETURN 2

57 FORMAT(1H1,14A5)
383 FORMAT(1H0,1X,7HSPREAD ,A1,7X,8(10X,3HSP ,A1)/1H0,7X
1 14HELEV . . . . . ,8(F10.1,4X))
385 FORMAT (9X,1H,3X1H,,3X,6HCORR T,8(F12,1,2X))
387 FORMAT (1X,3HGE0,5X,1H,,10X,8(14H ----T-----D-----))
389 FORMAT (1X,12,F8,1,F7,1,2X,8F6.1)

9992 PRINT 9993, L1,L2
9993 FORMAT(1H0,25HVElOCTy INVERSION, LAYER,12,10H AND LAYER,12,
1 19H COMPUTATION HALTED)

9999 STOP
END
SUBROUTINE MAIN3(L1,L2,IZI,...)
C
C COMPUTES DEPTH VALUES, BENEATH EVERY GEOPHONE LOCATION, FROM
C BASE OF EVERY LAYER DEEPER THAN LAYER 1.
C PROCEEDS WITH THE RAY TRACING AND SELF-ADJUSTING PROCEDURE TO
C CHECK AND COMPLEMENT THE MODEL INTERPRETATION.
C MAKES THE TRIM-UP ADJUSTMENT AT BASE OF LAYER 1 BEFORE THE LAST
C PASS THRU THE RAY TRACING TECHNIQUE.
C
DIMENSION IDENT(14)
DIMENSION IN(5),VREG(5),VH08(5),PREG(5),PHCB(5),ZSG(4),KIL(5)
DIMENSION NGDED(6,5),
2 IDSPR(6),NJ(6),NK(6),XSHIFT(6),EMAX(6)
DIMENSION BL1(6,5),BL2(6,5),
2 VVA(6,5),VHA(6,5),NML(6,5),MIND(6,5),KPPL(6,5),KPRR(6,5)
DIMENSION TYV(6),AVVDD(6)
DIMENSION EDSF(6,6),
4 IDSP(6,6),SHSP(6,6),XSP(6,6),YSP(6,6),ZSP(6,6),TUH(6,6),
4 TFUDGE(6,6),ES(6,6),ZAV(6,6),SPTC(6,6),SPPT(6,6),
4 LS(6,6)
DIMENSION LS(6,6)
DIMENSION ZS2(6,6,2),PS2(6,6,2),ES2(6,6,2),TRS2(6,6,2)
DIMENSION ERS(6,6,4),TRS(6,6,4)
DIMENSION ERS2(6,6,4,2),PST2(6,6,4,2),KRS2(6,6,4,2)
DIMENSION TVS(24),XVS(24),CYS(24),PRF(24),IARR(25)
DIMENSION PRG2(24,2),ERG2(24,2),TRG2(24,2)
DIMENSION TCM2(24,2),XCM2(24,2),XINTG(24,2),EINTG(24,2)
DIMENSION EAV2(24,6),EG(24,6),XG(24,6),YG(24,6),
8 GT(24,6),KML(24,6),GLT2(24,6)
DIMENSION PG2(24,6,2),EG2(24,6,2),TG2(24,6,2)
DIMENSION ER(24,6,4),TPR(24,6,4)
DIMENSION LG(24,6,4),
9 TA(24,6,4),TR(24,6,4),LG(24,6,4),DG(24,6,4),VDDG(24,6,4),
9 PRG(24,6,4),ERG(24,6,4),TRG(24,6,4),KR(24,6,4),ZG(24,6,4)

C UNLABELED COMMON
C
COMMON IBL,NL,INES,ITWO,KNM,IFL,IREP,LN,
2 IDENT,IL,ISG,KLU,TVS,AVVDD,ECSP,YSP,ZSP,TUH,ZAV,
3 SPCT,SPPT,TT2,PS2,ES2,TRS,TVG,XVG,PRP,PRG2,ERG2,TRG2,
4 TCM,XCM,XINTG,EINTG,EDG,YC,CTM2,CM3,F2,P2,TG2,TMR,D2,DD,ZG,TRG,
5 IMX,INXIT,DMY,DMY2,DMY3,MM,MJ,ML,ML1,IL1,IT,TLIM,A,SLOPE

C LABELED COMMON
C
COMMON /BLK0/LG
1 /BLK1/NM,NJ,NK
2 /BLK2/XG,ERP
3 /BLK3/TA,DSP
4 /BLK4/VHA,SHSP
5 /BLK5/IDSPR,SP2,SP
6 /BLK6/TRP,JJOFF
IF (IZI, EQ, 1) GO TO 2002

COMPUTE DEPTH POINTS AT BASE OF LAYER L, L.GT.2

LAYER LOOP -- REFRACTION IS BETWEEN L1 AND L2

2000 IF (NL, LE, 2) RETURN 2

L2=3

2001 L1=L2-1

IF (ITRACE, NE, 0) PRINT 1027, L2

1027 FORMAT (1H14S, INTERMEDIATE RESULTS OF RAY TRACING FOR LAYER, 12)

LL=L1-1

IFLAG=0

IF (IREP, EQ, 4) GO TO 2002

IREP=1

SPREAD LOOP

2002 M=1

IZI=0

IXREP=IXIT-IREP

2003 JN=NJ(M)

JNJ=JN-1

KN=K(M)

HV=VHA(M, L2)

HV2=HV**2

VV=VVA(M, L1)

IF (HV, LE, VV) GO TO 9992

TANSG=VV/SQRT(HV2-VV**2)

VOCOSG=TANSG*HV

IF (IREP, EQ, 2) GO TO 2005

BL1(M, L2)=0, 0

BL2(M, L2)=0, 0

2005 J1=1

J2=JN

PRECOMPUTE TIME AND MIGRATION CORR FOR ALL GECS, SPREAD M

ALSO CLEAR WORKING STORAGE

2007 DO 211 K=1, KN
DO 2008 LR=1.2
PRG2(K,LR)=0.0
ERG2(K,LR)=0.0
TRG2(K,LR)=0.0
2008 CONTINUE
IF (IREP,GT,1) GO TO 2011
DO 2009 LR=1.2
PG2(K,M,LR)=0.0
EG2(K,M,LR)=0.0
TG2(K,M,LR)=0.0
2009 CONTINUE
RAD=SQRT(HV2-VVA(M,1)**2)
TVG(K)=TRP(K,M,1)*HV/RAD
XVG(K)=(EG(K,M)-ERP(K,M,1))*VVA(M,1)/RAD
IF (LL,LE,1) GO TO 2011
DO 2010 L=2,LL
RAD=SQRT(HV2-VVA(M,L)**2)
TVG(K)=TVG(K)*TRP(K,M,L)*HV/RAD
XVG(K)=XVG(K)*TRS(K,M,L-1)-ERS(K,M,L))/V1/RAD
2010 CONTINUE
2011 CONTINUE
C
C SP LOOP
C
J=J1
2012 JJ=J
C
C COMPUTE TIME AND MIGR CORR AT SP J
C
IF (IFLAG,.NE.0) GO TO 2018
ISPLT=0
IF (ES(J,M),LE,ERS(J,M,LL)) GC TO 2016
TC=0.0
XC=0.0
NONE=0
DO 2015 L=1,LL
IF (ES(J,M),LT,ERS(J,M,L)) GO TO 2015
IF (IREP,EQ,1) GO TO 2013
LS(J,M)=L
GO TO 2018
2013 V1=VVA(M,L)
RAD=SQRT(HV2-V1**2)
IF (NONE,EQ,0) GO TO 2014
XC=XC*(ERS(J,M,L-1)-ERS(J,M,L))/V1/RAD
TC=TC+TRS(J,M,L)*HV/RAD
GO TO 2015
2014 XC=(ES(J,M)-ERS(J,M,L))*V1/RAD
TC=((ES(J,M)-ERS(J,M,L))*HV)/(V1*RAD)
LS(J,M)=L
NONE=1
2015 CONTINUE
GO TO 2017
2016 LS(J,M)=L1
   IF (IREP+GT,1) GO TO 2018
   DZ=ERS(J,M,LL)-ES(J,M)
   ISPLT=1
2017 IF (ISPLT,EQ.0) GO TO 2018
   TLLS=-DZ*VOCOSG/VV*2
   ELLS=ERS(J,M,LL)
   DS=-DZ*TANSG
   XLLS=XSP(J,M)

C INITIALIZE FOR RIGHT-GOING RAYS; INNER SHOTPOINTS
C
2018 IF(J,EQ,2)GO TO 2019
   I=1
   II=2
   SGN=1,0
   CALL KENDS(L2,M,J,1,KN,K11,K22)

C
2019 IF (K11,EQ.0) GO TO 2040
   IF (IREP+GT,1) GO TO 2021
   IF (ISPLT,EQ.0) GO TO 2023
   XLLS=XSP(J,M)+X*SGN
   TLLS=TC
   IF (ITRACE,EQ.0) PRINT 2020,IREP,ICSPR(M),IDSP(J,M),IZ,II,L2,L1,1
   LS(J,M),XSP(J,M),ES(J,M),XLLS,ELLs,TLLS,DMY1,DMY2,DMY3,BL1(M,L2),2
   B2(M,L2)
2020 FORMAT(1H0,35HIREP SPR SP G I L LL L0 X0/XL1,7X,2HE0,6X,3HXLL
   1,6X,3HELL,6X,3HTLL,7X,2HXL,7X,2HEL,7X,2HTL,5X,15HBLL EPS N/2
   1H ,I3,2(3X,A1),5I3,8F9.1,2F9.4)
   CALL RAYUP(L2,L1,LS(J,M),M,II,XSP(J,M),ES(J,M),XLLS,1
   ELLS,TLLS,DMY1,DMY2,DMY3)
   DS=(XLLS=XSP(J,M))*SGN
   GO TO 2023

C
2021 IF (LS(J,M),GT,L1) GO TO 2022
   IF (ITRACE,EQ.0) PRINT 2022,IREP,ICSPR(M),IDSP(J,M),IZ,II,L2,L1,1
   LS(J,M),XSP(J,M),ES(J,M),PS2(J,M,I),ES2(J,M,I),OMY1,2
   PRS2(J,M,I),ERS2(J,M,L1,I),TRS2(J,M,I),BL1(M,L2),BL2(M,L2)
   CALL RAYUP(L2,L2,LS(J,M),M,II,XSP(J,M),ES(J,M),1
   ELLS,TLLS,DMY1,PRS2(J,M,L1,I),ERS2(J,M,L1,I),TRS2(J,M,I))
   GO TO 2023
2022 PRS2(J,M,L1,I)=XSP(J,M)
   ERS2(J,M,L1,I)=ES(J,M)
   TRS2(J,M,I)=0,0
   PS2(J,M,I)=XSP(J,M)
   ES2(J,M,I)=ES(J,M)

C ENTRY PT FOR OUTLYING SHOTPOINTS AFTER TIE CORRECTION IS MADE
DO 2030 K=K11,K22
  IF (LG(K,JJ,M),NE,L2) GO TO 2030
  IF (IREP,GT,1) GO TO 2026
  IF (TG2(K,M,I),NE,0,0) GO TO 2025
  PG2(K,M,I)=XG(K,M)-XVG(K)=SGN
  TG2(K,M,I)=TVG(K)
  IF (ITRACE,NE,0) PRINT 2020,IREP,DISPR(M),DISP(JJ,M),K,I,L2,L1,I1,
  1 XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),TG2(K,M,I),DMY1,DMY2,DMY3,
  2 BL1(M,L2),BL2(M,L2)
  CALL RAYUP(L2,L1,I,M,XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),
  1 TG2(K,M,I),DMY1,DMY2,DMY3)
  2025
  DG=(XG(K,M)-PG2(K,M,I))*SGN
  TA(K,JJ,M)=TR(K,JJ,M)-TLLS-TG2(K,M,I)
  IF (ITRACE,NE,0) PRINT 2020,IREP,DISPR(M),DISP(JJ,M),K,I,L2,L1,I1,
  1 XG(K,H),EG(K,M),PG2(K,M,I),EG2(K,M,I),TG2(K,M,I),DMY1,DMY2,DMY3,
  2 BL1(M,L2),BL2(M,L2)
  CALL RAYUP(L2,L1,I,M,XG(K,H),EG(K,M),PG2(K,M,I),EG2(K,M,I),
  1 TG2(K,M,I),DMY1,DMY2,DMY3)
  2026
  IF (TRG2(K,I),NE,0,0) GO TO 2028
  PRG2(K,I)=PRG(K,JJ,M)
  TRG2(K,I)=TRG(K,JJ,M)
  IF (ITRACE,NE,0) PRINT 2020,IREP,DISPR(M),DISP(JJ,M),K,I,L2,L1,I1,
  1 XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),TG2(K,M,I),DMY1,PRG2(K,I),ERG2(K,I),
  2 TRG2(K,I),BL1(M,L2),BL2(M,L2)
  CALL RAYUP(L2,L1,I,M,XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),
  1 TG2(K,M,I),DMY1,PRG2(K,I),ERG2(K,I),TRG2(K,I))
  2028
  PRG(K,JJ,M)=PRG2(K,I)
  ERG(K,JJ,M)=ERG2(K,I)
  TRG(K,JJ,M)=TRG2(K,I)
  2030 CONTINUE

C
  IF (IREP,GT,1) GO TO 2035
  CALL REGRES(K11,K22,JJ,M,L2,V,T,PT)
  IF (PT,EQ,0,0) GO TO 2040
  Z=T*VOCOSG
  IF (Z,LE,0,0) Z=0,
  TS=Z*VOCOSG/VV**2
  TRS2(JJ,M,I)=TLLS+TS
  ERS2(JJ,M,L1,I)=ELL5-Z
  PRS2(JJ,M,L1,I)=XLLS*Z*TANG*SGN
  DO 2034 K=K11,K22
  IF (LG(K,JJ,M),NE,L2) GO TO 2034
  CALL HTIME(D(K,JJ,M),XSP(JJ,M),XG(K,M),PRS2(JJ,M,L1,I),0,0,
  1 PG2(K,M,I),0,0,HV,TH)
  Z=(TA(K,JJ,M)-TS-TH)*VOCOSG
  IF (Z,LT,0,0) Z=0,0
  TG=Z*VOCOSG/VV**2
  TRG(K,JJ,M)=TG2(K,M,I)+TG
  ERG(K,JJ,M)=EG2(K,M,I)+Z
  PRG(K,JJ,M)=PG2(K,M,I)-Z*TANG*SGN
  2034 CONTINUE
  GO TO 2040

C
2035 SUM1=0.0
PTS1=0.0
DO 2037 K=K11,K22
   IF (LG(K,JJ,M),NE.,L2) GO TO 2037
   KRG(K,JJ,M)=IBL
   CALL HTIME(D(K,JJ,M),XSP(JJ,M),XG(K,M),PRS2(JJ,M,L1,I),
   1 ERS2(JJ,M,L1,I),PRG2(K,I),ERG2(K,I),HV,TH)
   TCOR=(TR(K,JJ,M)-TRS2(JJ,M,L1,I)-TH-TRG2(K,I))/2.0
   X2=PRG2(K,I)
   E2=ERG2(K,I)
   CALL RAYCOR(PG2(K,M,I),X2,EG2(K,M,I),E2,VV,HV,TCOR)
   PRG(K,JJ,M)=X2
   ERG(K,JJ,M)=E2
   TRG(K,JJ,M)=TRG(K,JJ,M)+TCOR
   IF (ABS(TCOR).LE.TLIM) GO TO 2036
   KRG(K,JJ,M)=IQUES
   GO TO 2037

2036 PTS1=PTS1*1.0
   SUM1=SUM1+TCOR
   IF (IXREP,.EQ.,0,.EQ.,L2,.EQ.,2) GO TO 2037
   GTC(K,M)=GTC(K,M)+TCOR
   GPT(K,M)=GPT(K,M)+1.0
   CONTINUE

2037 IF (PTS1,.EQ.,0,.EQ.,0) GO TO 2040
   IF (IXREP,.GT.,2,.OR.,L2,.EQ.,2) GO TO 2038
   SPTC(JJ,M)=SPTC(JJ,M)*SUM1
   SPPT(JJ,M)=SPPT(JJ,M)*PTS1
   TCOR=SUM1/PTS1
   CALL RAYCOR(PS2(J,J,M,I),PRS2(JJ,M,L1,I),ES2(J,J,M,I),ERS2(JJ,M,L1,I),
   1 VV,HV,TCOR)
   TRS2(JJ,M,I)=TRS2(JJ,M,I)+TCOR
   KRS2(JJ,M,L1,I)=IBL
   IF (ABS(TCOR).GT.TLIM) KRS2(JJ,M,L1,I)=IQUES
   GO TO 2038

C TEST FOR DOING OUTLYING SPS LEFT OF SPREADS, RIGHT-GOING RAYS
C
2040 IF (I,.NE.,1) GO TO 2070
2042 JJ=JJ+2
   IF (JJ,.GT.,JJN) GO TO 2046
   CALL KENDS(L2,M,JJ,1,KN,K11,K22)
   IF (K11,.EQ.,0) GO TO 2042
   IF (IREP,.EQ.,1) GO TO 2080
2043 TRS2(JJ,M,I)=TRS2(J,J,M,I)
   PRS2(JJ,M,L1,I)=PRS2(JJ,M,L1,I)
   ERS2(JJ,M,L1,I)=ERS2(JJ,M,L1,I)
   PS2(JJ,M,I)=PS2(JJ,M,I)
   ES2(JJ,M,I)=ES2(JJ,M,I)
   GO TO 2023

C INITIALIZE FOR LEFT-GOING RAYS, INNER SHOTPOINTS
C
2046 \ J=2 \\
 I=2 \\
 II=1 \\
 SGN=\ -1.0 \\
 CALL KENDS(L2,M,J,1,KN,K11,K22) \\
 GO TO 2012 \\
 C  \\
 C TEST FOR DOING OUTLYING SPS RIGHT OF SPREADS, LEFT-GOING RAYS \\
 C  \\
 2070 JJ=JJ+2 \\
 IF (JJ,GT,JN) GO TO 2093 \\
 CALL KENDS(L2,M,JJ,1,KN,K11,K22) \\
 IF (K11,EQ.0) GO TO 2070 \\
 IF (IREP,NE,1) GO TO 2043 \\
 C  \\
 C MAKE TIE CORR FOR OUTLYING SP \\
 C  \\
 2080 CALL TIE(L2,M,J,JJ,K11,K22,1,KN,KN,TR,D) \\
 GO TO 2023 \\
 C  \\
 2093 IF (IREP,EQ,1)CALL ADMJG(L1,M,TANSG) \\
 M=M+1 \\
 IF (M,LE,NM) GO TO 2003 \\
 IF (IFLAG,NE,0) RETURN 1 \\
 C  \\
 C END OF SP LOOP AT 2093, END OF SPREAD LOOP AT 2093 + 2. \\
 C  \\
 C COMPUTE AVG COORDS(P1,E1),(P2,E2) IN ADJACENT INTERVALS BETWEEN GEOS, \\
 AND THEN INTERPOLATE TO FIND SMOOTHED ELEV PTS (ERP) AT GEO PCS (XG) \\
 BETWEEN THE TWO INTERVALS. THEN COMPUTE LAYER VERT TRAVEL TIME (TRP) \\
 C  \\
 DO 2096 M=1,NM \\
 JN=NJ(M) \\
 KN=NK(M) \\
 DO 2094 J=1,JN \\
 TRS(J,M,L1)=0.0 \\
 ERS(J,M,L1)=0.0 \\
 2094 CONTINUE \\
 DO 2095 K=1,KN \\
 IF (ITWO,EQ,1.AND.,KM1(K,M),EQ,1)GO TO 2095 \\
 TRP(K,M,L1)=0.0 \\
 ERP(K,M,L1)=0.0 \\
 2095 CONTINUE \\
 2096 CONTINUE \\
 C  \\
 KSAL=0 \\
 M=0 \\
 X1=-9999999.0 \\
 2103 IF (KSAL,EQ,1)GO TO 1997 \\
 M=M+1 \\
 IF (M,GT,NM)GO TO 2114
IF(MIND(M,L2),EQ,0)GO TO 1999
KSAL=1
KN=KPPL(M,L2)
GO TO 1998
1997 K=KPPR(M,L2)
KN=NK(M)
KSAL=0
GO TO 2102
1999 KN=NK(M)
1998 K=1
M1=M
2102 KK=K
X2=XG(K,M)
IF (X2.LE.X1) GO TO 2104
CALL AVG(X1,X2,L2,P1,E1)
IF (E1,NE,0,0) GO TO 2105
C
C CONDITION IN WHICH (P1,E1) IS NOT YET DEFINED
C
X1=X2
2104 K=K+1
IF (K.GT.KN) GO TO 2103
GO TO 2102
C
C CONDITION IN WHICH (P1,E1) IS DEFINED AND (P2,E2) IS TO BE SOUGHT
C
2105 KMAR=1
ERP(KK,M1,L1)=E1
TRP(KK,M1,L1)=(ERP(KK,M1,L1)-ERP(KK,M1,L1))/VVA(M1,L1)
IF (KK,EQ,1) GO TO 2106
ERP(KK-1,M1,L1)=E1
TRP(KK-1,M1,L1)=TRP(KK,M1,L1)
2106 X1=X2
2108 K=K+1
IF (K.LE.KN) GO TO 2109
IF(KSAL,EQ,0)GO TO 2119
K=KPPR(M,L2)
KN=NK(M)
KSAL=0
X1=XG(K,M)
GO TO 2102
2119 M=M+1
IF(M.GT.NM)GO TO 2113
IF(MIND(M,L2),EQ,0)GO TO 2122
KN=KPPL(M,L2)
K=1
KSAL=1
GO TO 2109
2122 KN=NK(M)
K=1
2109 X2=XG(K,M)
IF (X2.LE.X1) GO TO 2108
CALL AVG(X1,X2,L2,P2,E2)
IF (E2.EQ.0.0) GO TO 2106

2110 ERP(KK,M1,L1)=TERP(P1,E1,P2,E2,XG(KK,M1))
TRP(KK,M1,L1)=(ERP(KK,M1,L1)-ERP(KK,M1,L1))/VVA(M1,L1)
KK=KK+1
IF (M.NE,M1) GO TO 2111
IF (KK.EQ.K) GO TO 2112
GO TO 2110

2111 IF (KK,LE,NK(M1)) GO TO 2110
M1=M
KK=K
ERP(KK,M1,L1)=TERP(P1,E1,P2,E2,XG(KK,M1))
TRP(KK,M1,L1)=(ERP(KK,M1,L1)-ERP(KK,M1,L1))/VVA(M1,L1)

2112 P1=P2
E1=E2
GO TO 2106

2113 CALL AVG(X1,9999999.,L2,P2,E2)
IF (E2.EQ.0.0) GO TO 2114
ERP(KN,NM,L1)=TERP(P1,E1,P2,E2,XG(KN,NM))
TRP(KN,NM,L1)=(ERP(KN,NM,L1)-ERP(KN,NM,L1))/VVA(M1,L1)

2114 CALL FILLIN(L1)

C REPEAT IF IREP=1 OR IREP=2
C
IF (IXREP.LE.3) GO TO 2190
IREP=IREP+1
GO TO 2002

2190 L2=L2+1
IF (L2.LE.NL) RETURN 2

C END OF LAYER LOOP AT 2190

C FINAL FILTER -- TRIM-UP TIME ADJUST AT BASE OF LAYER 1
C
IF (IREP.EQ.4.OR.IXIT.LE.3) RETURN 2
I Rep=4

C
DO 2196 M=1,NM
JN=NJ(M)
KN=NK(M)
DO 2192 J=1,JN
IF (SPPT(J,M),EQ.0.0) GO TO 2192
TCOR=SPPT(J,M)/SPPT(J,M)
ERS(J,M,1)=ERS(J,M,1)-TCOR*VVA(M,1)
IF (ERS(J,M,1).GT.ESP(J,M)) ERS(J,M,1)=ESP(J,M)
CONTINUE

DO 2194 K=1,KN
IF (GPT(K,M),EQ.0.0) GO TO 2194
TCOR=GTC(K,M)/GPT(K,M)

END OF LAYER LOOP AT 2190

C FINAL FILTER -- TRIM-UP TIME ADJUST AT BASE OF LAYER 1
C
IF (IREP.EQ.4.OR.IXIT.LE.3) RETURN 2
I Rep=4

C
DO 2196 M=1,NM
JN=NJ(M)
KN=NK(M)
DO 2192 J=1,JN
IF (SPPT(J,M),EQ.0.0) GO TO 2192
TCOR=SPPT(J,M)/SPPT(J,M)
ERS(J,M,1)=ERS(J,M,1)-TCOR*VVA(M,1)
IF (ERS(J,M,1).GT.ESP(J,M)) ERS(J,M,1)=ESP(J,M)
CONTINUE

DO 2194 K=1,KN
IF (GPT(K,M),EQ.0.0) GO TO 2194
TCOR=GTC(K,M)/GPT(K,M)
ERP(K,M,1) = ERP(K,M,1) - TCOR*VVA(M,1)
IF (ERP(K,M,1).GT.EG(K,M))  ER(K,M,1) = EG(K,M)
2194 CONTINUE
2196 CONTINUE
GO TO 2000
C
9992 PRINT 9993, L1, L2
9993 FORMAT(1H0,25HVELOCITY INVERSION, LAYER,12, 10H AND LAYER,12, 19H COMPUTATION HALTED)
C
STOP
END
SUBROUTINE ADMIG(L1,M,TANU)
COMMON IBL
COMMON/BLK0/LG
1       /BLK1/NM,NJ,NK
2       /BLK2/XG,ERP
5       /BLK5/IDSPR,IDSP,D
8       /BLK8/PRG,ERG,KRG,PRS2,ERS2,KRS2
9       /BLK9/EG,ES
9       /BLK10/BLIM,ITRACE,NSWAD
9       /BLK13/NML,MIND,BL1,BL2,KPPL,KPPR,NGCED
C
C COMPUTES TAN OF AVG ANGLE OF DIP (B) OF BOTTOM OF L1 FOR SPREAD M
C BY REGRESSION OF POINTS (PRS2,ERS2) AND (PRG,ERG).
C THEN APPLIES MIGRATION TRIM-UP CORRECTION FOR AVG DIP COMPUTED.
C
DIMENSION NJ(6),NK(6),EG(24,6),LG(24,2,6),NGCED(6,5),
1 ERP(24,6,4),PRS2(6,6,4,2),ERS2(6,6,4,2),KRS2(6,6,4,2),
2 PRG(24,2,6),ERG(24,2,6),XG(24,6),ES(6,6),IDSPR(6),IDSP(6,6),
3 D(24,2,6),KRG(24,2,6),MIND(6,5),KPPL(6,5),KPPR(6,5),BL1(6,5),
4 BL2(6,5),NML(6,5)
C
KMAR1=0
KMAR=0
K1=1
JN=NJ(M)
KN=NK(M)
L2=L1+1
L0=L1-1
5 NB=0
 B=0.0
 IF(MIND(H,L2),EQ,0)GO TO 1
 IF(NSWAD,EQ,0)GO TO 1
 IF(KMAR,EQ,1)GO TO 4
KMAR=1
KN=KPPL(M,L2)
GO TO 1
4 K1=KPPR(M,L2)
KN=NK(M)
C
C COMPUTE AVERAGES
C
1 PT=0.0
 S1=0.0
 S2=0.0
 XMIN=99999999.
 XMAX=-XMIN
C
DO 16 J=1,JN
DO 14 K=K1,KN
 IF (LG(K,J,M),NE,L2.OR,ERG(K,,M),EQ,0..OR,KRG(K,J,M),NE,IBL) GO
1 TO 14
   X=PRG(K,J,M)
   S1=S1*X
   S2=S2+ERG(K,J,M)
   PT=PT+1.0
   IF (X.LT.XMIN) XMIN=X
   IF (X.GT.XMAX) XMAX=X
  14 CONTINUE
  16 CONTINUE
C
   IF (PT.LT.2.0) GO TO 99
C
   XBAR=S1/PT
   SBAR=S2/PT
C
   REGRESS TO GET TAN OF ANGLE OF DIP
C
   S1=0.0
   S2=0.0
C
   DO 26 J=1,JN
   DO 24 K=K1,KN
      IF (LG(K,J,M),NE,L2.OR.ERG(K,J,M).EQ.0..OR.KRG(K,J,M).NE.IBL) GO TO 1 TO 24
      X=PRG(K,J,M)-XBAR
      S1=S1+X*ERG(K,J,M)
      S2=S2+X*X
  24 CONTINUE
  26 CONTINUE
C
   COMPUTE TAN AND COS OF ANGLE OF DIP
C
   B=S1/S2
   NB=NB+1
   IF (B.GT.BLIM) B=BLIM
   IF (B.LT.-BLIM) B=-BLIM
   IF (NB.GE.2) GO TO 99
   COSA=1.0/SQRT(1.0+B*B)
C
   COMPUTE AVG THICKNESS
C
   S1=0.0
   PT=0.0
C
   30 DO 33 K=K1,KN
      IF (XG(K,M).LT.XMIN.OR.XG(K,M).GT.XMAX) GO TO 33
      PT=PT+1.0
      IF (L0.EQ.0.) GO TO 32
      S1=S1+ERG(K,M,L0)
      GO TO 33
  32 S1=S1+EG(K,M)
33 CONTINUE
   IF (PT GT 0,0) GO TO 36
   XMIN=XMIN-100.0
   XMAX=XMAX+100.0
   GO TO 30
C
36 ZBAR=S1/PT-EBAR
C COMPUTE AVG HORIZ MIGR DISTANCE ZTBAR
C ZTBAR=ZBAR*TANI
C FOR RAYS GOING UP AND RIGHT
C DZR=ZBAR*{(1.0+B*TANI)*COSA=1.0}
   DXR=ZTBAR-ZBAR*COSA*(TANI*B)
C FOR RAYS GOING UP AND LEFT
C DZL=ZBAR*{(1.0-B*TANI)*COSA=1.0}
   DXL=ZTBAR-ZBAR*COSA*(TANI*B)
C APPLY CORRECTIONS
C J=1
C RIGHT-GOING RAYS
C 40 CALL KENDS(L2,M,J,1,KN,K11,K22)
   IF (K11, EQ, 0) GO TO 48
   DO 47 K=K11,K22
      IF (LG(K,J,M),NE,L2, OR, ERG(K,J,M),EQ, 0.) GO TO 47
      PRG(K,J,M)=PRG(K,J,M)+DXR
      ERG(K,J,M)=ERG(K,J,M)-DZR
   47 CONTINUE
   IF (PRS2(J,M,L1,1),EQ,0.,OR,ERS2(J,M,L1,1),EQ,ES(J,M)) GO TO 48
   PRS2(J,M,L1,1)=PRS2(J,M,L1,1)-DXL
   ERS2(J,M,L1,1)=ERS2(J,M,L1,1)-DZL
48 J=J+2
   IF (J, GT, JN) GO TO 49
   GO TO 40
C LEFT-GOING RAYS
C 49 J=2
488 CALL KENDS(L2,M,J,1,KN,K11,K22)
   IF (K11, EQ, 0) GO TO 52
   DO 50 K=K11,K22
      IF (LG(K,J,M),NE,L2, OR, PRG(K,J,M),EQ, 0.) GO TO 50
      PRG(K,J,M)=PRG(K,J,M)-DXL
      ERG(K,J,M)=ERG(K,J,M)-DZL
IF (PRS2(J,M,L1,2),EQ,0.,OR,ERS2(J,M,L1,2),EQ,ES(J,M)) GO TO 52
PRS2(J,M,L1,2)=PRS2(J,M,L1,2)*DXR
ERS2(J,M,L1,2)=ERS2(J,M,L1,2)-0ZR

52  J=J+2
    IF(J,GT,JN)GO TO 1
    GO TO 488
99  IF(MIND(M,L2),EQ,0)GO TO 996
    IF(NSWAD,EQ,0)GO TO 996
    IF(KMAR1,EQ,1)GO TO 998
    KMAR1=1
    BL1(M,L2)=8
    GO TO 5
996  BL1(M,L2)=8
    BL2(M,L2)=8
    GO TO 999
998  BL2(M,L2)=8
999  RETURN
END
SUBROUTINE AVG(X1,X2,L2,PA,EA)
COMMON IBL
COMMON/BLK0/LG
COMMON/NM,LJ,NK
1 /BLK1/NM,NJ,NK
2 /BLK2/XG,ERP
8 /BLK8/PRG,ERG,KRG,PRS2,ERS2,KRS2
9 /BLK13/NML,MIND,BL1,BL2,KPPL,KPPR,NGED
C
C COMPUTES AVG COORD (PA,EA) OF ALL PTS IN ARRAYS (PRG,ERG) AND
C (PRS2,ERS2) WHOSE X POSITION IS GE X1 , AND, LT X2, AND WHOSE REFRACTOR
C IS LAYER L2, IF PTS, LE,2.AND, L2GT.2 INTERVAL IS EXPANDED BY
C DX=X2-X1 ON EACH SIDE.
C
DIMENSION LG(24,2,6),NJ(6),NK(6),PRG(24,2,6),ERG(24,2,6),
1 KRG(24,2,6),PRS2(6,6,4,2),ERS2(6,6,4,2),KRS2(6,6,4,2),
2 NML(6,5),MIND(6,5),BL1(6,5),BL2(6,5),KPPL(6,5),KPPR(6,5),NGED(6,
35),XK1(6,5),XK2(6,5),XG(24,6),ERP(24,6,4)
C
DO 21 M=1,NM
IF(MIND(M,L2),EQ,0)GO TO 21
KK1=KPPL(M,L2)
KK2=KPPR(M,L2)
XK2(M,L2)=XG(KK2,L2)
XK1(M,L2)=XG(KK1,L2)
21 CONTINUE
SUM1=0,0
SUM2=0,0
PTS=0,0
L1=L2-1
X11=X1
X12=X2
DX=0,0
C
1 DO 14 M=1,NM
JN=NJ(M)
KN=NK(M)
J1=1
3 DO 12 J=J1,JN,2
JJ=J
I=1
IF(J1.GT.1)I=2
2 IF (ERS2(J,M,L1,I),EQ,0,OR,KRS2(J,M,L1,I),NE,IBL) GO TO 5
E1=ERS2(J,M,L1,I)
P1=PRS2(J,M,L1,I)
GO TO 10
5 K1=1
6 IF (LG(K,J,M),NE,L2,OR,ERG(K,J,M),EQ,0,0,OR,KRG(K,J,M),NE,IBL) GO
1 TO 8
E1=ERG(K,J,M)
P1=PRG(K,J,M)
I=3
GO TO 10
8 K=K+1
   IF (K,GT,KN) GO TO 12
   GO TO 6
10 IF (P1,LT,X11,OR,P1,GE,X22) GO TO 11
   SUM1=SUM1*P1
   SUM2=SUM2+E1
   PTS=PTS+1,0
11 GO TO (5,5,8),I
12 CONTINUE
   IF(JJ,EQ,JN)GO TO 14
   J1=2
   GO TO 3
14 CONTINUE
   IF (PTS,EQ,0,0) GO TO 18
   IF (PTS,LE,2.,AND,L2,GT,2) GO TO 19
26 PA=SUM1/PTS
20 IF (DX,NE,0,0) PA=(X1*X2)/2,0
   EA=SUM2/PTS
16 RETURN
18 PA=0,0
   EA=0,0
   GO TO 16
19 DO 31 M=1,NM
   IF(MIND(M,L2),EQ,0)GO TO 31
   IF(X11,LT,XK2(M,L2),AND,X11,GT,XK1(M,L2))GO TO 26
   IF(X22,GT,XK1(M,L2),AND,X22,LT,XK2(M,L2))GO TO 26
31 CONTINUE
   DX=X22-X11
   X11=X11-DX
   X22=X22+DX
   GO TO 1
END
SUBROUTINE DIP(L,M,K1,K2,KK,A,B)
COMMON /BLK2/XG,ERP

COMPUTES EQUATION CONSTANTS A AND B (Y=A+B*X) FOR REGRESSION LINE FITTED TO ERP OVER GEOS K1 TO K2 WITH LINE PASSING THROUGH POINT XG(KK,M),ERP(KK,M,L)

DIMENSION XG(24,6),ERP(24,6,4)

IF (XG(K1,M),LT,XG(K2,M)) GO TO 1
6 A=ERP(KK,M,L)
B=0,0
GO TO 4
1 SUM1=0,0
SUM2=0,0
DO 2 K=K1,K2
IF (ERP(K,M,L),LE,0,0) GO TO 2
SUM1=SUM1+XG(K,M)
SUM2=SUM2+1,0
2 CONTINUE
IF (SUM2.LE,0,0) GO TO 6
XBAR=SUM1/SUM2
SUM1=0,0
SUM2=0,0
DO 3 K=K1,K2
IF (ERP(K,M,L),LE,0,0) GO TO 3
XD=XG(K,M)-XBAR
SUM1=SUM1*XD*ERP(K,M,L)
SUM2=SUM2*XD*1,0
3 CONTINUE
IF (SUM2.GT,2,0) GO TO 5
B=0,0
A=ERP(K,M,L)
GO TO 4
5 B=SUM1/SUM2
A=ERP(KK,M,L)-B*XG(KK,M)
4 RETURN
END
SUBROUTINE ELCOR(TANI, VV, HV, XSG, ESG, AD, BD, I, TC, XC, XINT, EINT)

C COMPUTES TIME CORR (TC) AND X CORR (XC) FOR SURF-TO-DATUM SLANT RAYS
C FOR LAYER 1, GIVEN X POS OF SHOT OR GEO (XSG), ELEV OF SHOT OR GEO
C (ESG), INTCPT AND SLOPE OF DATUM (AD AND BD), AND SIGN OF BOA
C (I=1 FOR PLUS, 2 FOR MINUS)

BOA=1.0/TANI
IF (I.EQ.2) BOA=-BOA
AOA=ESG-BOA*XSG
IF (ABS (BOA).GT.1.0) GO TO 2
PRINT 1, XSG
1 FORMAT (1H0,39HSLOPE OF RAY , LE, SLOPE O F DATUM AT X =,F8,0.
1 19H STOP IN SUBR ELCOR)
STOP

2 XINT=(AD-AOA)/(BOA-BD)
EINT=AD*BD*XINT
OA=SQRT ((XSG-XINT)**2+(ESG-EINT)**2)
TC=OA/VV
XC=OA*VV/HV
IF (ESG.LE.EINT) GO TO 4
TC=-TC
XC=-XC
4 RETURN
END
SUBROUTINE EXTRP(L,M,K1,K2,A,B,V)
COMMON/BLK2/XG,ERP
6    /BLK6/TRP,JOFF
9    /BLK9/EG,ES
C COMPUTES ERP AND TRP BETWEEN GEOS K1 AND K2 USING EQUATION CONSTS A,B
C
DIMENSION XG(24,6),ERP(24,6,4),TRP(24,6,4),EG(24,6),ES(6,6)
C
DO 2 K=K1,K2
   ERP(K,M,L)=A*B*XG(K,M)
   IF (L.EQ.1) GO TO 1
   TRP(K,M,L)=(ERP(K,M,L-1)-ERP(K,M,L))/VV
   GO TO 2
1  TRP(K,M,L)=(EG(K,M)-ERP(K,M,L))/VV
2  CONTINUE
RETURN
END
SUBROUTINE FILLIN(L)
COMMON/BLK1/NM,NJ,NK
2 /BLK2/XG,ERP
4 /BLK4/VVA,VHA
6 /BLK6/TRP,JJOFF
7 /BLK7/TRS,ERS,XSP,ESP,LS
9 /BLK9/EG,ES
9 /BLK13/NML,MNO,BL1,BL2,KPPL,KPPR,NGDEO
C COMPUTES MISSING (ZERO) ELEV AND TIMES AT GEOS (ERP AND TRP) AND AT SPS (ERS AND TRS) BY INTERP OR EXTRAP OF NONZERO VALUES OF ERP AND TRP
C
DIMENSION KA(6),KB(6),NJ(6),NK(6),XG(24,6),EG(24,6),TRP(24,6,4),
ERP(24,6,4),TRS(6,6,4),ERS(6,6,4),XSP(6,6),ESP(6,6),ES(6,6),VVA(6,5),VHA(6,5),LS(6,6),NML(6,5),MNO(6,5),KPPL(6,5),
3 KPPR(6,5),BL(6,5),BL2(6,5),NGDEO(6,5)
C
C FIRST INTERP TO FILL IN GAPS WITHIN EACH SPREAD
C
L2=L+1.
DO 20 M=1,NM
KMAR1=0
KMAR=0
KN=K(M)
C SEARCH FOR 1ST NONZERO VALUE
DO 4 K=1,KN
IF (TRP(K,M,L),NE.0.0) GO TO 6
4 CONTINUE
KA(M)=0
KB(M)=0
GO TO 20.
C NONZERO VALUE FOUND -- SEARCH FOR ZERO VALUE
6 KA(M)=K
KB(M)=K
K1=K+1
8 IF(K1,GT,KN)GO TO 20
DO 10 K=K1,KN
IF (TRP(K,M,L).EQ.0.0) GO TO 12
KB(M)=K
10 CONTINUE
GO TO 20.
C ZERO VALUE FOUND -- STORE INDEX OF PRECEDING NONZERO VALUE AND SEARCH FOR NEXT NONZERO VALUE
12 K11=K-1
K1=K+1
IF (K1,GT,KN) GO TO 20
DO 14 K=K1,KN
IF (TRP(K,M,L),NE.0.0) GO TO 16
14 CONTINUE
GO TO 20

16  K22 = K
    KB(M) = K
    K1 = K11 + 1
    K2 = K22 - 1
    IF (MIND(M, L2), EQ, 0) GO TO 17
    IF (KPPL(M, L2), LT, K11) GO TO 17
    IF (KPPL(M, L2), GT, K2) GO TO 17
    IF (KPPL(M, L2), EQ, K11) GO TO 15
    KL1 = KPPL(M, L2)
    CALL DIP(L, M, 1, K11, K1, A, B)
    CALL EXTRP(L, M, K1, KL1, A, B, VVA(M, L))

15  KL2 = KPPR(M, L2)
    IF (KPPR(M, L2), EQ, K22) GO TO 1701
    CALL DIP(L, M, K22, KN, K22, A, B)
    CALL EXTRP(L, H, KL2, K2, A, B, VVA(M, L))

17  DO 18  K = K1, K2
    ERP(K, M, L) = TRP(K11, M, ERP(K11, M, L), ERP(K22, M, L), XG(K11, M), XG(K22, M),
    1  XG(K, M))
    TRP(K, M, L) = TRP(K11, M, TRP(K11, M, L), TRP(K22, M, L), XG(K11, M), XG(K22, M),
    1  XG(K, M))
18  CONTINUE
    K1 = K22 + 1
    GO TO 8

20  CONTINUE

C CONNECT PTS BETWEEN SPREADS
C
C IF (NM, NE, 1) GO TO 21
    M111 = 1
    M222 = 1
    GO TO 100

21  M = NM - 1
    DO 52  M1 = 1, M
        IPROB = 0
        KMAR2 = 0
        KN1 = NK(M1)
        M2 = M1 + 1
        KN2 = NK(M2)
        K1 = KB(M1)
        K2 = KA(M2)
        IF (K1, EQ, 0, OR, K2, EQ, 0) GO TO 52
        IF (XG(1, M2), GE, XG(KN1, M1)) GO TO 44
    C END GEOS OF THE TWO SPREADS OVERLAP
    IF (XG(K2, M2), LT, XG(K1, M1)) GO TO 30
    C END PTS WHERE ERP IS DEFINED DONT OVERLAP --- INTERPOLATE IN THIS INTVL
    K11 = K1 + 1
    KK1 = K1
    IF (K11, GT, KN1) GO TO 24
DO 22 K=K11,KN1
   IF (XG(K,M1),GT,XG(K2,M2)) GO TO 24
   ERP(K,M1,L)=TERP(XG(K1,M1),ERP(K1,M1,L),XG(K2,M2),ERP(K2,M2,L),
   1 XG(K,M1))
   TRP(K,M1,L)=TERP(XG(K1,M1),TRP(K1,M1,L),XG(K2,M2),TRP(K2,M2,L),
   1 XG(K,M1))
   KK1=K
22 CONTINUE
24 K22=K2-1
   KK2=K2
   IF (K22,LT,1) GO TO 28
   NONE=0
   DO 26 K=1,K22
      IF (XG(K,M2),LT,XG(K1,M1)) GO TO 26
      ERP(K,M2,L)=TERP(XG(K1,M1),ERP(K1,M1,L),XG(K2,M2),ERP(K2,M2,L),
      1 XG(K,M2))
      TRP(K,M2,L)=TERP(XG(K1,M1),TRP(K1,M1,L),XG(K2,M2),TRP(K2,M2,L),
      1 XG(K,M2))
      IF (NONE.EQ.1) GO TO 26
      NONE=1
      KK2=K
26 CONTINUE
23 K1=KK1
   KS(M1)=K1
   K2=KK2
   KA(M2)=K2
C NOW THE END PTS DO OVERLAP
C FIRST FILL IN SPREAD M1 GOING TO THE RIGHT
30 K11=K1+1
   IF (K11,GT,KN1,OR,K22,LT,1) GO TO 37
   DO 36 K=K11,KN1
      DO 32 KK=K2,K22
         IF (XG(K,M1),GE,XG(KK,M2),AND,XG(K,M1),LE,XG(KK+1,M2)) GO TO 34
      32 CONTINUE
      GO TO 36
34 IF (TRP(KK,M2,L),EQ.0,0,OR,TRP(KK+1,M2,L),EQ.0,0) GO TO 36
   ERP(K,M1,L)=TERP(XG(KK,M2),ERP(KK,M2,L),XG(KK+1,M2),ERP(KK+1,M2,L),
   1,XG(K,M1))
   TRP(K,M1,L)=TERP(XG(KK,M2),TRP(KK,M2,L),XG(KK+1,M2),TRP(KK+1,M2,L),
   1,XG(K,M1))
   KB(M1)=K
36 CONTINUE
C THEN FILL IN SPREAD M2 GOING TO THE LEFT
37 K11=KA(M1)+1
   K22=K2-1
   IF (K11,GT,KN1) GO TO 52
   IF (K22,LT,1) GO TO 52
   NONE=0
   DO 42 K=1,K22
      DO 38 KK=K11,K1

IF (XG(K,M2) .GE. XG(KK-1,M1) .AND. XG(K,M2) .LE. XG(KK,M1)) GO TO 40

38 CONTINUE
GO TO 42

40 IF (TRP(KK-1,M1,L) .EQ. 0.0 .OR. TRP(KK,M1,L) .EQ. 0.0) GO TO 42
ERF(K,M2,L) = TERP(XG(KK-1,M1),ERF(KK-1,M1,L),XG(KK,M1),ERF(KK,M1,L),
1, XG(K,M2))
TRP(K,M2,L) = TERP(XG(KK-1,M1),TRP(KK-1,M1,L),XG(KK,M1),TRP(KK,M1,L),
1, XG(K,M2))
IF (NONE, NE, 0) GO TO 42
NONE=1
KA(M2)=K
42 CONTINUE
GO TO 52

C END GEOS DONT OVERLAP — INTERPOLATE BETWEEN NONZERO END PTS
C FIRST GO RIGHT ON SPREAD M1

44 K11=K1+1
IF (K11 .GT. KN1) GO TO 48
DO 46 K=K11,KN1
ERF(K,M1,L) = TERP(XG(K1,M1),ERF(K1,M1,L),XG(K2,M2),ERF(K2,M2,L),
1, XG(K,M2))
TRP(K,M1,L) = TERP(XG(K1,M1),TRP(K1,M1,L),XG(K2,M2),TRP(K2,M2,L),
1, XG(K,M2))
46 CONTINUE
KB(M1)=KN1

C THEN GO LEFT ON SPREAD M2

48 K22=K2-1
IF (K22 .LT. 1) GO TO 52
DO 50 K=1,K22
ERF(K,M2,L) = TERP(XG(K1,M1),ERF(K1,M1,L),XG(K2,M2),ERF(K2,M2,L),
1, XG(K,M2))
TRP(K,M2,L) = TERP(XG(K1,M1),TRP(K1,M1,L),XG(K2,M2),TRP(K2,M2,L),
1, XG(K,M2))
50 CONTINUE
KA(M2)=1
52 CONTINUE

C FILL IN INTERMEDIATE SPREADS WITH NO DEPTH PTS DEFINED
C
DO 54 M1=1,NM
IF (KA(M1), NE, 0) GO TO 58
54 CONTINUE
PRINT 56, L
56 FORMAT (IH0,30HNO DEPTH PTS DEFINED FOR LAYER,12,
1 17H, STOP IN FILLIN)
STOP

58 M11=M1
60 M11=M1+1
IF (M11 .GE. NM) GO TO 80
DO 62 MM=M11,NM
IF (KA(MM), EQ, 0) GO TO 64
C CONTINUE
C NO SUCH SPREADS OCCUR
GO TO 80
64 MM = MM + 1
DO 66 M2 = MM, NM
IF (KA(M2), NE, 0) GO TO 68
66 CONTINUE
GO TO 80
C SUCH A SPREAD DOES OCCUR
68 K1 = KB(M1)
K2 = KA(M2)
M11 = M1 + 1
M22 = M2 - 1
DO 72 MM = M11, M22
KN = NK(MM)
DO 70 K1 = 1, KN
ERF(K, MM, L) = TERP(XG(K1, M1), ERF(K1, M1, L), XG(K2, M2), ERF(K2, M2, L),
1 XG(K, MM))
TRP(K, MM, L) = TERP(XG(K1, M1), TRP(K1, M1, L), XG(K2, M2), TRP(K2, M2, L),
1 XG(K, MM))
70 CONTINUE
KA(MM) = 1
KB(MM) = KN
72 CONTINUE
M1 = M2
GO TO 60
C FILL IN INTERMEDIATE SPREADS WITH ONLY ONE DEPTH PT DEFINED
C
C80 DO 88 M = M11, NM
KN = NK(M)
IF (KA(M), EQ, 0) GO TO 90
K1 = KA(M)
IF (K1, NE, KB(M)) GO TO 88
IF (M, EQ, M11) GO TO 84
C DO TO THE LEFT OF PT
M1 = M - 1
K1 = KB(M1)
K2 = KK - 1
IF (K2, LT, 1) GO TO 84
DO 82 K = 1, K2
ERF(K, M, L) = TERP(XG(K1, M1), ERF(K1, M1, L), XG(KK, M), ERF(KK, M, L),
1 XG(K, M))
TRP(K, M, L) = TERP(XG(K1, M1), TRP(K1, M1, L), XG(KK, M), TRP(KK, M, L),
1 XG(K, M))
82 CONTINUE
KA(M) = 1
C DO TO THE RIGHT OF PT
84 M2 = M + 1
IF (M2, GT, NM) GO TO 88
IF (KA(M2),EQ,0) GO TO 92
K1=KK+1
IF (K1,GT,KN) GO TO 88
K2=KA(M2)
DO 86 K=K1,KN
ERP(K,K,M,L)=TERP(XG(KK,M),ERP(KK,M,L),XG(K2,M2),ERP(K2,M2,L),
1 XG(K,M))
TRP(K,K,M,L)=TERP(XG(KK,M),TRP(KK,M,L),XG(K2,M2),TRP(K2,M2,L),
1 XG(K,M))
86 CONTINUE
KB(M)=KN
88 CONTINUE
M22=M
GO TO 100
90 M=M-1
92 M22=M
C EXTRAPOLATE END GEOS AND END SPREADS
100 CALL DIP(L,M111,KA(M111),KB(M111),KA(M111),A,B)
   K1=KA(M111)-1
   IF (K1.LT.1) GO TO 102
   CALL EXTRP(L,M111,l,K1,A,B,VVA(L,M111,L))
102 IF (M111,EQ.1) GO TO 106
   M11=M111=1
   DO 104 M=1,M11
   CALL EXTRP(L,M,1,NK(M),A,B,VVA(M,L))
104 CONTINUE
106 CALL DIP(L,M222,KA(M222),KB(M222),KB(M222),A,B)
   KN=NK(M222)
   K2=KB(M222)+1
   IF (K2,GT,KN) GO TO 108
   CALL EXTRP(L,M222,K2,KN,A,B,VVA(M222,L))
108 IF (M222,EQ.NM) GO TO 112
   M22=M222+1
   DO 110 M=M22,NM
   CALL EXTRP(L,M,1,NK(M),A,B,VVA(M,L))
110 CONTINUE
C INTERP-EXTRAP ELEV AND TIME AT SPS AND PREVENT CRISS-CROSS OF LAYERS
112 DO 160 M=1,NM
   J1=1
   J2=NJ(M)
   KN=NK(M)
   DO 146 J=J1,J2,2
   MM=M
   KNM=NK(M)
   IF (TRS(J,M,L),NE,0,0) GO TO 142
   IF (XSP(J,M),GE,XG(J1,MM)) GO TO 118
117 IF (MM,EQ.1) GO TO 128
MM=MM-1
KNM=NK(MM)
IF (XSP(J,M),LT,XG(1,MM)) GO TO 117
GO TO 122
118 IF (XSP(J,M),LE,XG(KNM,MM)) GC TO 122
119 IF (MM,EQ,NM) GO TO 126
MM=MM+1
KNM=NK(MM)
IF (XSP(J,M),GT,XG(KNM,MM)) GC TO 119
C
122 DO 124 K=2,KNM
IF (Xg(K,MM),GE,XSP(J,M)) GO TO 134
124 CONTINUE
C
126 CALL DIP(L,MM,1,NK(MM),NK(MM),A,B)
ERS(J,M,L)=A*B*XSP(J,M)
GO TO 142
C
128 CALL DIP(L,1,1,NK(1),1,A,B)
ERS(J,M,L)=A*B*XSP(J,M)
GO TO 142
C
134 K1=K-1
K2=K
C
ERS(J,M,L)=TERP(XG(K1,MM),ERP(K1,MM,L),XG(K2,MM),ERP(K2,MM,L),
1 XSP(J,M))
C
142 IF (L,LE,1) GO TO 144
IF (ERS(J,M,L),LE,ERS(J,M,L-1)) GO TO 143
ERS(J,M,L)=ERS(J,M,L-1)
TRS(J,M,L)=0.0
GO TO 146
143 TRS(J,M,L)=(ERS(J,M,L-1)-ERS(J,M,L))/VVA(M,L)
GO TO 146
144 IF (ERS(J,M,L),LE,ERS(J,M)) GO TO 145
LS(J,M)=2
TRS(J,M,L)=0.00001
IF (ERS(J,M,L),GT,ERS(J,M)) ERS(J,M,L)=ERS(J,M)
GO TO 146
145 TRS(J,M,L)=(ERS(J,M)-ERS(J,M,1))/VVA(M,L)
C
146 CONTINUE
C
IF(J1,LE,2)GO TO 147
J1=J1+1
GO TO 113
147 IF (L,LE,1) GO TO 150
DO 148 K=1,KN
IF (ERP(K,M,L-1)-ERP(K,M,L),GE,0.00001) GO TO 148
ERP(K,M,L)=ERP(K,M,L-1)-0.00001
TRP(K,M,L)=0.00001
148 CONTINUE
GO TO 160
C
150 DO 152 K=1,KN
IF (EG(K,M)-ERP(K,M,L),GE.0.00001) GO TO 152
TRP(K,M,L)=0.00001
ERP(K,M,L)=EG(K,M)-0.00001
152 CONTINUE
C
160 CONTINUE
C
RETURN
END
SUBROUTINE HOBV(L,NIXIT)
COMMON/BLK0/LG
1 /BLK1/NM,NJ,NK
3 /BLK3/TA,DSG
5 /BLK5/IDSPR,IDSP,D
9 /BLK12/VHOB,PHOB,IARR
9 /BLK13/NML,MIND,BL1,BL2,KPPL,KPPR,NGEDE
9 /BLK14/LGC
C COMPUTES HORIZ VEL OF LAYER L BY HOBS0N-OVERTON METHOD
C
DIMENSION EP(24),DX(24),DT(24),NJ(6),NK(6),IDSPR(6),LG(24,2,6),
1 TA(24,2,6),IDSP(6,6),VHOB(5),PHOB(5),D(24,2,6),NGEDE(6,5),
2 DSG(24),IARR(25),NML(6,5),LGC(24,2,6),MIND(6,5),BL1(6,5),
3 BL2(6,5),KPPL(6,5),KPPR(6,5)
IP (NIXIT,EQ,0) PRINT 2, L
2 FORMAT (1H0,5HLAYER,12,43H VELOCITY COMPUTED BY HOBS0N-OVERTON MET
1HOD)
SUM2=0,0
PTS2=0,0
DO 22 M=1,NM
IF(NML(M,L),EQ,0)GO TO 22
NONE=0
NJ=NJ(M)
KN=NK(M)
SUM3=0,0
PTS3=0,0
J2=NJ-1
DO 18 J=1,J2,2
CALL KENDS(L,M,J,1,KN,KR1,KR2)
IF (KR1,EQ,0) GO TO 13
DO 16 JJ=2,JN,2
CALL KENDS(L,M,JJ,1,KN,KL1,KL2)
K1=MAX0(KR1,KL1)
K2=MIN0(KR2,KL2)
IF (K1,EQ,0.OR.(K2=K1).LE,0) GO TO 16
C BEGIN HOBS0N-OVERTON ROUTINE
C
SDX=0,0
SDX2=0,0
SDT=0,0
SDTDX=0,0
SEEPEP=0,0
PT=3,0
DO 3 K=1,24
EP(K)=0,0
CONTINUE
DO 4 K=K1,K2
MALOS=LGC(K,J,M)*LGC(K,JJ,M)
IF (LGC(K,J,M),NE,L.OR,LGC(K,JJ,M),NE,L.OR,MALOS,GT,0) GO TO 4
DX(K)=D(K,J,M)-D(K,JJ,M)
SDX=SDX+DX(K)
SDX2=SDX2+DX(K)**2
DT(K)=TA(K,J,M)-TA(K,JJ,M).
SDT=SDT+DT(K)
SDTDX=SDTDX+DX(K)*DT(K)
PT=PT+1.0
4 CONTINUE
IF (PT.LE.1.0) GO TO 8
V=(SDX2-SDX**2/PT)/(SDTDX-(SDX*SDT)/PT)
TDSQ=(SDT-SDX/V)/PT
DO 6 K=K1,K2
MALOS=LGC(K,J,M)*LGC(K,JJ,M)
IF (LGC(K,J,M),NE,L.OR,LGC(K,JJ,M),NE,L.OR,MALOS,GT,0) GO TO 6
EP(K)=DT(K)-DX(K)/V-TDSQ
SEEP=SEEP+EP(K)**2
6 CONTINUE
SEEP=SEEP (SEEP/PT)
GO TO 10
8 V=0.0
PT=0.0
END HOBSON-OVERTON ROUTINE
C END HOBSON-OVERTON ROUTINE
C IF (PT.EQ.0.0) GO TO 16
SUM3=SUM3*V/PT
PTS3=PTS3+PT
IF (NIXIT.EQ.1) GO TO 16
IF (NONE,NE.0) GO TO 12
NONE=1
PRINT 11, IDSPR(M),(IARR(I),I=1,24)
11 FORMAT (1H0, 8H SPREAD, A1,50X, 29HERRO FIT AT EACH GEOPHONE/1H, 6X,
1 31HVEL SPGE US GEOS TDSQ SE EP ,12(12, ' ',12,2X)/1H, 4X,11H--
2--- 2X,11H------ ------13(7H --------)
12 PRINT 13, V, IDSP(J,M), IDSP(JJ,M), K1,K2,TDSQ,SEEP, (EP(K), K=1,KN)
13 FORMAT (1H ,3PF10.0,2X, A1,1X,A1,1X,213,0PF6.1,13F7.3/T36,12F7.3)
16 CONTINUE
18 CONTINUE
SUM2=SUM2+SUM3
PTS2=PTS2+PTS3
IF (PTS3,EQ.0,0) GO TO 22
SUM3=SUM3/PTS3
IF (NIXIT,EQ.0) PRINT 20, SUM3,PTS3
20 FORMAT (1H0,3HAVG,3PF7.0,4H FOR,0PF4.0,7H POINTS)
22 CONTINUE
IF (PTS2, EQ, 0, 0) GO TO 26
SUM2=SUM2/PTS2
IF (NM, EQ, 1, OR, NIXIT, EQ, 1) GO TO 26
PRINT 24
24 FORMAT (1H0, 4X, 2(8H--++)
PRINT 20, SUM2, PTS2
C
26 VHOB(L)=SUM2
PHOB(L)=PTS2
C
RETURN
END
SUBROUTINE HTIME (01,X1,X2,P1,E1,P2,E2,HV,TH)
C
C COMPUTES THE HORIZONTAL TRAVEL TIME TH ALONG THE REFRACTOR HORIZON
C
COMMON/BLK10/BLIM,ITRACE,NWAC
DE=E2-E1
DX=X2-X1
DP=P2-P1
DP=SIGN(DP,DX*DP)
IF (DX.EQ.0.,OR.DP.EQ.0.) GO TO 10
IF (ABS(DE/DP).GT.BLIM) DE=BLIM*DP
TH=SIGN(D1+SQRT(DP**2+DE**2)/DX,DP)/HV RETURN
10 DH=D1-ABS(P1-X1)-ABS(P2-X2)
TH = SIGN(SQRT(DH**2+DE**2),DH)/HV
RETURN
END
SUBROUTINE KENDS(L, M, J, K1, K2, K11, K22)
COMMON/BLK0/LG
C
C FINDS INDEX OF LEFTMOST (K11) AND RIGHTMOST (K22) GEO REPRESENTING
C LAYER L FOR SP J, SPREAD M, K1 AND K2 ARE END PTS OF RANGE TO BE
C TESTED, AND ARE INPUT VALUES, K11 AND K22 ARE END PTS FOUND (OUTPUT),
C BOTH K11 AND K22 SET TO ZERO IF NO PTS FOUND
C
DIMENSION LG(24,2,6)
K11=0
K22=0
IF (K1.EQ.0 .OR. K2.EQ.0) GO TO 2
DO 1 K=K1,K2
IF (LG(K,J,M),NE.L) GO TO 1
IF (K11.EQ.0) K11=K
K22=K
1 CONTINUE
2 RETURN
END
SUBROUTINE PLOTT(II)
C
C PLOTS ALL THE T-D GRAPHS AND CROSS-SECTION OF THE MODEL
C INTERPRETATION. IT MAY CALCULATE ITS OWN SCALES, IT SET OUT 12
C INCHES ON THE X-AXIS PER SPREAD FOR T-D GRAPH WITH
C 4 INCHES BETWEEN SPREADS, PROVIDES 12 INCHES ON THE X-AXIS
C PER SPREAD FOR THE CROSS-SECTION MODEL. IF TSSCALE AND ESSCALE
C ARE DIFFERENT TO ZERO THEN PLOT-SCALES ARE SET UP ACCORDING
C THESE VALUES,
C
C UNLABELED COMMON
C COMMON IBL, NL, IQUES, ITWO, KM1, IFLAG, IREP, LN,
1 IDENT
C
C LABELED COMMON
C COMMON/BLK1/NM, NJ, NK
2 /BLK2/XG, ERP
3 /BLK3/TA, DSG
5 /BLK5/IDSPR, IDSP, D
9 /BLK9/EG, ES
9 /BLK13/NML, MIND, BL1, BL2, KPP1, KPPR, NGCDE
9 /BLK16/TSCL, ESCALE
C
DIMENSION NJ(6), NK(6), XG(24, 6), ERP(24, 6), TA(24, 6), EG(24, 6),
1 DSG(24), ES(6, 6), NML(6, 5), MIND(6, 5), BL1(6, 5), BL2(6, 5), KPP1(6, 5),
2 KPPR(6, 5), NGCDE(6, 5), IDSPR(6), IDSP(6, 6), D(24, 6), YTD(14), XXD(26)
3, YYT(26), IDENT(14)
C
L=IPL0T(1)
IF(L.NE.0) STOP
CALL SETHIN(84, 11.)
CALL PLOT(4, 1, -3)
CALL FACTOR(6, 5)
LL=NEWPEN(2)
IF(II.EQ.2) GO TO 100
C
C PLOTS T-D GRAPHS
C
DO 1 M=1, NM
KN=NK(M)
JN=NJ(M)
J1=JN-1
C
C CALCULATING SCALES TO PLOT EACH T-D GRAPH,
C
SMADI=XG(KN, M)-XG(1, M)
FACOH=12./SMADI
ZEROX=FACOH*XG(1, M)
COHFA=1./FACOH
IF(TSCALE.EQ.0, 0) GO TO 2
SMATA=TSCL + FLOAT(NM) * 15.
GO TO 4
2 SMATA=-1.0*37
SMINT=0.0
DO 3 J=J1,JN
DO 3 K=1,KN
SMATA=AMAX1(TA(K,J,M),SMATA)
3 CONTINUE
4 FACOV=9.5/SMATA
COVFA=1./FACOV
C DRAWING TITLE OF THE JOB,
CALL SYMBOL(1,,9,,15,IDENT,0,,70)
DO 5 K=1,KN
XXD(K)=XG(K,M)
5 CONTINUE
XXD(KN+1)=XG(1,M)
XXD(KN+2)=COVFA
C SETTING THE AXIS FOR THE T-D GRAPHS.
CALL AXIS(0,0,0,'TIME IN MSECS',14,9.5,90.0,SMINT,COVFA)
CALL AXIS(0,0,0,'DISTANCE IN FEET',16,12.,0,XXD(KN+1),XXD(KN+2))
CALL AXIS(12.,0,'TIME IN MSECS',14,9.5,90.,SMINT,COVFA)
ISB=1
J1=1
SJN=FLOAT(JN)
GKN=FLOAT(KN)
8 DO 6 J=J1,JN,2
DO 7 K=1,KN
YYT(K)=TA(K,J,M)
7 CONTINUE
YYT(KN+1)=SMINT
YYT(KN+2)=COVFA
CALL LINE(XXD,YYT,KN,-1,ISB,0.)
6 CONTINUE
IF(J1.EQ.2)GO TO 9
J1=2
ISB=3
GO TO 8
9 CALL SYMBOL(5,,2,5,,25,'SPREAD',0,,6)
CALL SYMBOL(6,75,2.5,,25,SPR(M),0,,1)
CALL SYMBOL(4,45,2.20,,15,'OF SHOT POINTS',0,,16)
CALL NUMBER(7,2,2.20,,20,SN,2,,1,10)
CALL SYMBOL(3,6,1.9,,15,'# OF GEOPHONES ON SPREAD',0,,24)
CALL NUMBER(7,5,1.9,,20,GKN,0,,1,10)
CALL SYMBOL(3,5,1.5,,10,'OFFSET OF LEFT SHOT POINTS (FEET)',0,,331)
DOWN=1,75
DO 11 J=1,JN,2
OFFSET=0(D1,J,M)
DOWN=DOWN-.25
CALL NUMBER(7,0,DOWN,,15,OFFSET,0,,1,10)
11 CONTINUE
DOWN=DOWN-.25
CALL SYMBOL(3,5,DOWN,10,'OFFSET OF RIGHT SHOT POINTS (FEET)'),0,
134
DO 12 J=2,JN,2
OFFSET=0(KN,J,M)
CALL NUMBER(7,0,DOWN,15,OFFSET,0,,1,10)
DOWN=DOWN-.25
12 CONTINUE
FACOH=1./XXD(KN+2)
DO 13 K=1,KN
XXD=FACOH*XG(K,M)-.05-ZEROX
CALL NUMBER(XXD,.05,.10,FLOAT(K),0,,-1,10)
13 CONTINUE
CALL PLOT(16,0,-3)
1 CONTINUE
XFIN=12,
GO TO 9999
100 CONTINUE
C PLOTS CROSS-SECTION MODEL.
C CALL PLOT(0,0.5,-3)
C DRAWING TITLE OF THE JOB,
C CALL SYMBOL(1,8,5,15,IDENT,0,7)
KCONK=0
SMAUP=-1.0E+37
SMIND=1.0E+37
C CALCULATING THE SCALES TO PLOT THE CROSS-SECTION MODEL.
C DO 20 M=1,NM
KN=NK(M)
DO 20 K=1,KN
SMAUP=AMAX1(EG(K,M),SMAUP)
SMIND=AMIN1(ERP(K,M,NL-1),SMIND)
20 CONTINUE
SMADI=XG(KN,NM)-XG(1,1)
XAXSC=FLOAT(NM)+12.0
FACOH=XAXSC/SMADI
COHFA=1./FACOH
IF(ESCALE,GT.,0,0)SMIND=ESCALE
SMADE=SMAUP-SMIND
FACOV=8.4/SMADE
COVFA=1./FACOV
VETEXG=0.7*FACOV/FACOH
CALL AXIS(0,0,'DISTANCE IN FEET','-16,XAXSC,0,XG(1,1),COHFA)
DO 14 M=1,NM
DYD=0.,05
IF(MOD(M+1,2),EQ,0)DYD=0.,15
KN=NK(M)
ZEROX=FACOH*XG(1,1)
DO 15 K=1,KN
DXD = FACOH * XG(K, M) - 0.05 - ZEROX
CALL NUMBER(DXD, DYD, 10, FLOAT(K), 3, = 1.10)
15 CONTINUE
KMED = KN / 2
OMED = FACOH * XG(KMED, M)
DME = OMED + 1.4
CALL SYMBOL(OMED, 5, 20, 'SPREAD', 0, 6)
CALL SYMBOL(OMED1, 5, 20, IDSPR(M), 0, 1)
14 CONTINUE
ZEROY = FACOV * SMIND
CALL AXIS(XAXSC, 0, 'ELEVATION IN FEET', 17, 8, 90, SMIND, COVFA)
CALL AXIS(0, 0, 'ELEVATION IN FEET', 17, 8, 90, SMIND, COVFA)
CALL SYMBOL(1, 2, 1, 20, 'VERTICAL EXAGGERATION :1', 0, 29)
CALL NUMBER(5, 5, 2, 1, 0, 20, VETEXG, 0, 2, 10)
YYY = 2.0
DO 16 I = 1, 4
CALL DASHLN(0, 0, YYY, XAXSC, YYY, 15)
YYY = YYY + 2.
16 CONTINUE
DXD = FACOH * XG(1, 1) - ZEROX
DYD = FACOV * ERP(1, 1, L) - ZEROY
CALL PLOT(DXD, DYD, 3)
CALL PLOT(DXD, DYD, 2)
DO 18 M = 1, NM
KN = NK(M)
DO 18 K = 1, KN
DO 25 L = 1, NL1
L2 = L + 1
SMB = FLOAT(L)
DXD = FACOH * XG(1, 1) - ZEROX
DYD = FACOV * ERP(1, 1, L) - ZEROY
CALL PLOT(DXD, DYD, 3)
CALL PLOT(DXD, DYD, 2)
DO 26 M = 1, NM
K1 = 1
KN = NK(M)
IF(MIND(M, L2), EQ, 0) GO TO 50
KMAR = 1
KN = KPPL(M, L2)
GO TO 50
31 K1 = KPPL(M, L2)
KN=NK(M)
28 DXD=FACOH*XG(K1,M)-ZEROX
      DYD=FACOV*ERP(K1,M,L)-ZEROY
      CALL PLOT(DXD,DYD,3)
      CALL PLOT(DXD,DYD,2)
50 DO 27 K=K1,KN
       KCONK=KCONK+1
       DXD=FACOH*XG(K,M)-ZEROX
       DYD=FACOV*ERP(K,M,L)-ZEROY
       CALL PLOT(DXD,DYD,0)
       CALL SYMBOL(DXD,DYD,.05,.1,.2,.2,.2)
       IF(KCONK.GE.5)GO TO 32
       GO TO 27
32 DYD1=DYD+0.05
     CALL NUMBER(DXD,DYD1,2,SMB,0.0,-1,10)
     CALL PLOT(DXD,DYD,3)
     CALL PLOT(DXD,DYD,2)
     KCONK=0
     CONTINUE
IIF(KMAR.EQ.0)GO TO 26
     KMAR=0
     GO TO 31
26 CONTINUE
25 CONTINUE
     XFIN=XAXSC+2.
9999 CALL PLOT(XFIN,1,3)
     CALL PLOT(XFIN,Y,999)
     RETURN
END
SUBROUTINE RAYCOR(X1, X2, E1, E2, VV, HV, TCOR)

C ADJUSTS COORDINATES OF BOTTOM END POINT OF RAY ENTERING OR LEAVING THE
C REFRACTING HORIZON SO THAT TOTAL TIME OF COMPUTER-TRADED RAY AGREES
C WITH TOTAL OBSERVED TIME,

C
DX=X1-X2
DE=E1-E2
DENOM=SQR(DX**2+DE**2)/VV/ABS(DX)/HV

IF (DENOM.LT.0.1) DENOM=0.1
FCTR=TCOR/DENOM
X2=X2+DX*FCTR
E2=E2+DE*FCTR

RETURN
END
SUBROUTINE RAYUP(L, LL, L0, M, I, X0, E0, XLL, ELL, TL, TL, XL, EL, T)
COMMON/BLK1/NM, NJ, NK
2 /BLK2/XG, ERP
4 /BLK4/VVA, VHA
9 /BLK10/BLIM, ITRACE, NSWAD
9 /BLK13/NML, MIND, BL1, BL2, KPPL, KPPR, NGDED

C TRACES RAY FROM STARTING POINT ON TOP OF LAYER L OR LL TO ENDING POINT
C (X0,E0) WITHIN OR ON THE UPPER BOUNDARY OF LAYER L0. Refracting Horiz
C IS THE TOP OF LAYER L. COMPUTES AND RETURNS CORRECTED COORD OF START
C POINT AND TOTAL TRAVEL TIME, FOR IREP=1, LL=L-1, AND RAY START POINT
C IS TAKEN AS (XLL, ELL) ON TOP OF LAYER LL. FOR IREP=2 OR 3, LL=L, AND
C START POINT IS TAKEN AS (XL, EL) ON TOP OF LAYER L. ALSO FOR IREP=2 OR
C 3, RAY INTERSECTION WITH TOP OF LAYER L-1 IS OUTPUTTED AS (XLL, ELL)
C AND TIME FROM THIS POINT AS TLL. INPUT PARAMETER BLL IS PRECOMPUTED
C AS AVG DIP OF REFRACTOR OVER ENTIRE SPREAD. IF BLL IS NONZERO ON INPUT
C IT IS USED IN PLACE OF INTERVAL DIP BETWEEN GEO PAIRS WHICH IS
C RAYS GOING UP AND RIGHT, 2 FOR RAYS GOING UP AND LEFT.

DIMENSION NK(6), XG(24, 6), ERP(24, 6, 4), VVA(6, 5), VHA(6, 5), NJ(6)
DIMENSION MIND(6, 5), BL1(6, 5), BL2(6, 5), KPPL(6, 5), KPPR(6, 5)
DIMENSION NML(6, 5), NGEDES(6, 5)

C INITIALIZE

KTEST=0
NONE=0
XL=LL
TLL=TL
XLS=XL
TLS=TL
IF (L.EQ.LL) XLL=XL
2 IBLSW=0
3 XREFL=XLL
XREFLL=XLL
TLL=0, 0
TL=0, 0
M1=M
L2=LL
L1=L2-1

C COMPUTE SLOPE OF RAY FROM STARTING POINT
INVAL=0

C FIRST FIND K OF GEOS BOUNDING XLL
4 KN=NK(M1)
K3=KN-1
K1=1
K2=2
IF (XLL.LT.XG(1, M1)) GO TO 8
K1=KN-1
K2=KN
IF (XLL.GT.XG(KN, M1)) GO TO 12
DO 6 K1=1,K3
K2=K1+1
IF (XLL.LE.XG(K2,M1)) GO TO 13
6 CONTINUE
GO TO 14
C CASE OF XLL LEFT OF SPREAD M1
8 IF (M1.EQ.1.OR.INVAL.GT.0) GO TO 13
INVAL=-1
M1=M1-1
GO TO 4
C CASE OF XLL RIGHT OF SPREAD M1
12 IF (M1.EQ.NM.OR.INVAL.LT.0) GO TO 13
M1=M1+1
GO TO 4
14 K1=KN-1
K2=KN
C K1, K2, AND M1 NOW KNOWN, COMPUTE ELL AND BL FOR LAYER L1 AT (XLL,ELL)
13 IF(MIND(M1,L2).EQ.0)GO TO 15
9 IF(K1.LT.KPPL(M1,L2))GO TO 15
IF(K1.GE.KPPR(M1,L2))GO TO 15
GO TO 79
15 ELL=TERM(XG(K1,M1),ERP(K1,M1,L1),XG(K2,M1),ERP(K2,M1,L1),XLL)
16 EL=ELL
EREFL=ELL
EREFLL=ELL
IF (NONE.NE.0) GO TO 17
ELLS=ELL
ELS=ELL
IF(M1.NE.M)GO TO 18
IF(K1.GT.KPPL(M1,L2)) GO TO 18
GO TO 16
17 IF (BL1(M1,L2).LE.0.D0001.OR.K1.GT.KPPL(M1,L2)) GO TO 18
BL=BL1(M1,L2)
GO TO 19
18 IF (BL2(M1,L2).LE.0.D0001.OR.K1.LT.KPPL(M1,L2)) GO TO 18
BL=BL2(M1,L2)
GO TO 19
18 IF (IBLSW.NE.0) GO TO 19
IF(ERP(K2,M1,L1).LE.0.0.OR.ERP(K1,M1,L1).LE.0.0)
1 GO TO 70
BL=(ERP(K2,M1,L1)-ERP(K1,M1,L1))/(XG(K2,M1)-XG(K1,M1))
IF (BL.GT.BLIM) BL=BLIM
IF (BL.LT.-BLIM) BL=-BLIM
19 BLREF=BL
TANI=VVA(M1,L1)/SQR(VHA(M1,L)**2-VVA(M1,L1)**2)
C COMPUTE SLOPE OF RAY EMERGING FROM L2
IF (I.EQ.2) TANI=TANI
C ENTRY PT FOR RAYS AFTER 1ST ONE
20 DENOM=TANI-BL
C DECREMENT L1 IN PREPARATION FOR FINDING INTERSECTION W/ HORIZON ABOVE
L1=L1-1
L2=L2-1
C VERTICAL RAY TEST
IF (ABS(DENOM).LT.0.000001) GO TO 39
C NONVERTICAL RAY
BRAY=(TAN1*BL+1.0)/DENOM
ARAY=ELL-BRAY*XLL
C TEST FOR UPPERMOST RAY -- IF SO COMPUTE XL1, TLL, TL, AND THEN EXIT
IF (L2.GT.L0) GO TO 23
XL1=(E0-ARAY)/BRAY
IF(L2.LE.0)GO TO 211
IF(MIND(M1,L2).EQ.0)GO TO 211
KK1=KPPL(M1,L2)
KK2=KPPR(M1,L2)
IF(XL1.LE.XG(KK1,M1))GO TO 211
IF(XL1.GE.XG(KK2,M1))GO TO 211
GO TO 70
211 T=SQRT((XL1-XLL)**2+(E0-ELL)**2)/VVA(M1,L2)
IF (E0.GT.ELL) GO To 22
T=-T
21 L3=L2+1
T=T/VVA(M1,L2)/VVA(M1,L3)
22 TLL=TLL*T
TL=TL*T
GO TO 46
C NOT UPPERMOST RAY -- COMPUTE TENTATIVE INTERSECTION W/ HORIZON ABOVE
23 INVAL=0
IF(ERP(K2,M1,L1).LE.0,0,0,0.OR.ERP(K1,M1,L1).LE.0,0) GO TO 70
24 BL=(ERP(K2,M1,L1)-ERP(K1,M1,L1))/(XG(K2,M1)-XG(K1,M1))
AL=ERP(K1,M1,L1)-BL*XG(K1,M1)
C TEST FOR RAY PARALLEL WITH HORIZON ABOVE
DENOM=BRAY-BL
IF (ABS (DENOM).GE.0.000001) GO TO 28
IF (BRAY) 32,25,36
26 GO TO (36,32), 1
C TEST FOR VALID INTERSECTION
28 XL1=(AL-ARAY)/DENOM
IF (XL1,LT,XG(K1,M1)) GO TO 32
IF (XL1,GT,XG(K2,M1)) GO TO 36
IF(L2.LE.0)GO TO 30
IF(MIND(M1,L2).EQ.0)GO TO 30
KK1=KPPL(M1,L2)
KK2=KPPR(M1,L2)
IF(XL1.LE.XG(KK1,M1))GO TO 30
IF(XL1,GE,XG(KK2,M1))GO TO 30
GO TO 70
C VALID INTERSECTION FOUND
30 EL1=AL-BL*XL1
IF (ABS (BRAY).LT.0.000001) BRAY=0.000001
IF (BRAY) 32,25,36
IF (BL,LT,-BLIM) BL=-BLIM
TANR=BL+1.0/BRAY
T = SQRT ((XL1 - XLL) * (E1 - ELL)) / VVA(M1, L2)

31 TL = TL + T

C TEST FOR CASE WHERE TLL STARTS ACCUMULATING AT L-1, NOT L
IF (LL.EQ.1 AND L2.EQ.(L-1)) GO TO 43
TLL = TLL + T
GO TO 44

C INTERSECTION NOT VALID -- SEARCH TO LEFT
32 IF (INVAL.GT.0) GO TO 30
IF (K1.EQ.1) GO TO 34
K2 = K1
K1 = K1 - 1
IVAL = -1
GO TO 24

33 IF (M1.EQ.1) GO TO 37
M1 = M1 - 1
KN = NK(M1)
K2 = KN
K1 = K2 + 1
IVAL = 1
GO TO 24

34 IF (M1.EQ.NM) GO TO 33
M1 = M1 + 1
KN = NK(M1)
K1 = 1
K2 = 2
IVAL = 1
GO TO 24

C INTERSECTION NOT VALID -- SEARCH TO RIGHT
35 IF (INVAL.LT.0) GO TO 30
IF (K2.EQ.KN) GO TO 38
K1 = X2
K2 = K2 + 1
IVAL = 1
GO TO 24

36 IF (M1.EQ.NM) GO TO 33
M1 = M1 + 1
KN = NK(M1)
K1 = 1
K2 = 2
IVAL = 1
GO TO 24

C VERTICAL RAY -- TEST IF UPPERMOST -- IF SO COMPUTE TL, TLL AND EXIT.
39 XL1 = XLL
IF (L2.GT.L0) GO TO 40
T = (E0 - ELL) / VVA(M1, L2)
IF (T.LE.0.0) GO TO 21
GO TO 22

C VERTICAL RAY -- NOT UPPERMOST ONE
40 IF (XG(K1, M1).EQ.XG(K2, M1)) GO TO 41
IF (ERP(K2, M1, L1).LE.0.0.OR.ERP(K1, M1, L1).LE.0.0) GO TO 70
BL = (ERP(K2, M1, L1) - ERP(K1, M1, L1)) / (XG(K2, M1) - XG(K1, M1))

41 IF (BL.GT.BLIM) BL = BLIM
IF (BL.LT.-BLIM) BL = -BLIM
AL = ERP(K1, M1, L1) - BL * XG(K1, M1)

42 EL1 = AL + BL * XL1
TANR = BL
T = (EL1 - ELL) / VVA(M1, L2)
GO TO 31
C

43 XREFLL=XL1
    EREFLL=EL1
    ELLS=EL1
C PREPARE TO CONTINUE TRACING RAY UPWARD
44 XLL=XL1
    ELL=EL1
    SINI=VVA(M1,L1)*TANR/(SQRT(1,0*TANR**2)*VHA(M1,L1))
    TANI=SINI/SQRT(1.0-SINI**2)
    GO TO 20
C EXIT FROM RAY TRACING ROUTINE -- PREPARE TO TRACE MORE RAYS IF NECESSARY
46 IF (NONE,GT,0) GO TO 50
C FIRST RAY TRACED -- STORE RESULTS
    NONE=NONE+1
    XS1=X0-XL1
    XRL1=XREFLL
    XRL1=XREFLL
    ERL1=EREFL
    ERL1=EREFL
    TL1=TL
    TLL1=TLL
    BLREF1=BLREF
    EPSS=ABS(XS1)
    IF (ITRACE,NE,0) PRINT 47, XL1,XREFLL,EREFL,TLL,XREFL,EREFL,TL,
    1 XS1,NONE
47 FORMAT (1H,25X,F10.1,9X,6F9.1,F15.1,F5)
    IF (ABS(XS1),LT,1,0) GO TO 67
49 XLL=XREFL*XS1
    GO TO 2
C SECOND RAY TRACED -- STORE RESULTS
50 NONE=NONE+1
    XS2=X0-XL1
    XRL2=XREFL
    XRL2=XREFLL
    ERL2=EREFL
    ERL2=EREFL
    TL2=TL
    TLL2=TLL
    BLREF2=BLREF
    IF (ABS(XS2),GE,EPSS) GO TO 51
    EPSS=ABS(XS2)
    XLLS=XREFLL
    ELLS=EREFL
    TLLS=TLL
    XLS=XREFL
    ELS=EREFL
    TLS=TL
51 IF (ITRACE,NE,0) PRINT 47, XL1,XREFLL,EREFL,TLL,XREFL,EREFL,TL,
    1 XS2,NONE
C MAKE TESTS FOR ACCEPTING FIRST TWO RAYS TRACED
    IF (XS1,XS2,LT,0,0) GO TO 53
C THE TWO RAYS ARE ON SAME SIDE OF SP OR GEO

IF (ABS (XS2), LT, ABS (XS1)) GO TO 54

C THE 2ND RAY IS NOT CLOSER TO SP OR GEO THAN 1ST RAY

IF (NONE, GT, 4) GO TO 52

XLL = XREFL * XS1
GO TO 56

C GIVE UP AND RESORT TO USING SAVED INPUT VALUES, THEN RETURN

52 XLL = XLLS

ELL = ELLS

TLL = TLLS

XL = XLS

EL = ELS

TL = TLS

GO TO 62

C TEST IF 2ND RAY COMES WITHIN 10 FT OF OBJECTIVE

53 IF (ABS (XS2), LE, 10.0) GO TO 58

C NOT WITHIN 10 FT, IF 4 OR LESS RAYS TRACED TRY ONCE MORE AFTER

C INTERPOLATING BL, IF MORE THAN 4 RAYS TRACED, ACCEPT LAST PAIR

IF (NONE, GT, 4) GO TO 52

8LSW = 1

XLL = (XRL1 * XS2 - XRL2 * XS1) / (XS2 - XS1)

BL = TERP (XRL1, BLREF1, XRL2, BLREF2, XLL)

XRL1 = XRL2

XRL1 = XRL2

ERL1 = ERL2

ERL1 = ERL2

TL1 = TL2

TLL1 = TLL2

XS1 = XS2

GO TO 58

C TEST IF EXTRAPOLATION IS PERMISSIBLE

54 IF (ABS (XS2), LE, ABS (XS1 - XS2)) GO TO 57

IF (NONE, GT, 4) GO TO 52

C READJUST STARTING POINT AND THEN RETRACE 2ND RAY

55 XLL = TERP (XS1, XRL1, XS2, XRL2, 0, 2)

56 XRL1 = XRL2

XRL1 = XRL2

ERL1 = ERL2

ERL1 = ERL2

TL1 = TL2

TLL1 = TLL2

XS1 = XS2

BLREF1 = BLREF2

GO TO 57

C TEST IF 2ND RAY WITHIN 10 FT OF OBJECTIVE

57 IF (ABS (XS2), LE, 10.0) GO TO 58

C NOT WITHIN 10 FT, IF 4 OR LESS RAYS TRACED TRY ONCE MORE, OTHERWISE

C ACCEPT THE LAST PAIR TRACED

IF (NONE, GT, 4) GO TO 58

GO TO 55

C INTERPOLATE OR EXTRAPOLATE TO OBTAIN XLL, ELL, TLL, XL, EL, TL, THEN RETURN
58 XL = TERP(XS1, XRL1, XS2, XRL2, 0, 0)
    XLL = TERP(XS1, XRL1, XS2, XRL2, 0, 0)
    ELL = TERP(XRL1, ERL1, XRL2, ERL2, XLL)
    EL = TERP(XRL1, ERL1, XRL2, ERL2, XL)
    TLL = TERP(XRL1, TLL1, XRL2, TLL2, XLL)
    TL = TERP(XRL1, TLL1, XRL2, TLL2, XL)
   IF (TL LT TLL) GO TO 52
62 IF (L NE 2) GO TO 63
    XL = X0
    ELL = E0
    TLL = 0, 0
63 IF (ITRACE NE 0) PRINT 65, XLL, ELL, TLL, XL, EL, TL
65 FORMAT (1H, 44X, 6F9.1)
RETURN
C VERY CLOSE APPROXIMATION — NO FURTHER RAY TRACING NEEDED
67 XLL = XREFLL
    XL = XREFL
    ELL = EREFLL
    EL = EREFL
GO TO 62
C TO BE NO TAKE INTO ACCOUNT
70 XLL = 0, 0
    XL = 0, 0
    ELL = 0, 0
    EL = 0, 0
    TLL = 0, 0
    TL = 0, 0
GO TO 63
END
FUNCTION TERP(X1,Y1,X2,Y2,X)
C COMPUTES INTERPOLATED VALUE OF Y CORRESPONDING TO X, GIVEN THE 2 PTS C (X1,Y1) AND (X2,Y2)
C
   IF (ABS (X2-X1).LT.0.1) GO TO 2
   TERP=((X-X1)*(Y2-Y1))/(X2-X1)*Y1
1  RETURN
2  TERP=(Y1+Y2)/2.0
   GO TO 1
END
SUBROUTINE REGRES(K1,K2,J,M,L,V,PT)
COMMON/BLK3/LG
3 /BLK3/TA,D
4 /BLK4/VVA,VHA
9 /BLK14/LGC

C COMPUTES VELOCITY V BY REGRESSION OF TIME PTS (TA) AT DISTANCES C FROM
C SP J TO GEOS BETWEEN INDICES K1 AND K2 FOR LAYER L, SPREAD M,
C ONLY NONZERO TA FOR WHICH LG=L ARE USED IN REGRESSION,
C HALF INTERCEPT TIME AT SP J IS GIVEN BY T, NUM OF REGRESSED PTS IS PT.
C
DIMENSION D(24),TA(24,2,6),LG(24,2,6),VHA(6,5),VVA(6,5),
2 LGC(24,2,6)

S1=0,0
S2=0,0
PT=0,0
T=0,0
V=0,0
DO 5 K=K1,K2
IF (LG(K,J,M),NE.L,OR,LGC(K,J,M),EQ.1) GO TO 5
S1=S1+D(K)
S2=S2*TA(K,J,M)
PT=PT+1,0
5 CONTINUE

IF (PT,LE,1,0) GO TO 15
XBAR=S1/PT
TBAR=S2/PT
S1=0,0
S2=0,0
DO 10 K=K1,K2
IF (LG(K,J,M),NE.L,OR,LGC(K,J,M),EQ.1) GO TO 10
X0=D(K)-XBAR
S1=S1+X0*TA(K,J,M)
S2=S2+X0**2
10 CONTINUE
V=ABS (S2/S1)
T=(TBAR-XBAR*S1/S2)/2,0
12 RETURN

15 IF (PT,EQ.0,0) GO TO 12
V=VHA(M,L)
IF (V,LE,0,0) GO TO 12
T=(S2-S1/V)/2,0
GO TO 12
END
SUBROUTINE REGV(L,NIXIT)
COMMON/BLK0/LG
/BLK1/NM,NJ,NK
/BLK3/TA,DSG
/BLK5/IDSP,IDSP,D
/BLK11/VREG,PREG
/BLK17/NTVE
C Computes and prints regression velocities and intercept t for layer l
C Dipping-layer may be taken into account or not according ntve
C
DIMENSION NJ(6),NK(6),D(24,2,6),IDSP(6),
1 IDSP(6,6),VREG(5),PREG(5),LG(24,2,6),TA(24,2,6),DSG(24),
2 AANG(5),BANG(5),DIP(5),ALL(5),BLI(5),APA(5),BPA(5)
C
IF (NIXIT,EO,0) PRINT 1, L
1 FORMAT (1H0.5HLAYER,i2.52H VELOCITY AND TIME INTERCEPTS COMPUTED B
1Y REGRESSION)
KMARK=0
KMAR1=0
SUMR=0,0
PTSR=0,0
SUML=0,0
DO 50 M=1,NM
NONE=0
JN=NJ(M)
KN=NK(M)
J1=1

4 SUM2=0,0
PTS2=0,0
DO 40 J=J1,JN,2
JJ=J
CALL KENDS(L,M,J,1,KN,KL1,KL2)
IF (KL1,EQ,0) GO TO 10
DO 5 K=KL1,KL2
DSG(K)=D(K,J,M)
5 CONTINUE
CALL REGRES(KL1,KL2,J,M,L,VL,TL,PT)
IF (PT.LE,1,0) GO TO 10
TL=TL+TL
SUM3=PT/VL
PTS3=PT
GO TO 23
10 VL=0,0
TL=0,0
SUM3=0,0
PTS3=0,0
23 SUM2=SUM2+SUM3
PTS2=PTS2+PTS3
C
IF (PTS3,EQ,0,0) GO TO 40
IF (NONE,NE,0) GO TO 27
NONE=1
IF (NIXIT,EQ,0) PRINT 25, IDSPR(M)
25 FORMAT (1H0,6H SPREAD, A1,3X,22HVEL TIME GEOS SP, 8X,
1 19HAVG V AVG T PTS/1H, 10X,6H------,2X,4H------,2X,5H-------,
2 3X,3H-----,6X,6H------,3X,5H------,3X,3H-----)
27 SUM3=PTS3/SUM3
IF (NIXIT,EQ,1) GO TO 40
PRINT 31, VL, TL, KL1, KL2, IDSP(J, M), SUM3, AVG T, PTS3
31 FORMAT (1H , 10X, 3PF6.0, 0PF6.1, 2X, 12X, 4PF6.0, 0PF6.1
1, 2PF6.0)
40 CONTINUE
C
IF (JJ, EQ, JN) GO TO 39
SUM3=SUML+SUM2
PTS2=PTS2+PTS2
38 IF (NONE, EQ,0) GO TO 50
SUM2=PTS2/SUM2
IF (NIXIT, EQ, 1) GO TO 50
PRINT 41, SUM2, PTS2
41 FORMAT (1H0, 42X, 10H AVE OF ALL 3PF7.0, 0PF14.0)
IF (JJ, EQ, JN) GO TO 50
J1=2
GO TO 4
39 SUMR=SUMR+SUM2
PTS2=PTS2+PTS2
GO TO 38
C
50 CONTINUE
C
IF (NTVE, EQ, 1) GO TO 111
IF (PTS3, LE,0.1) GO TO 56
IF (PTS2, LE,0.1) GO TO 59
PREG(L)=PTS2+PTS3
VRR=PTS2/SUMR
VLL=PTS3/SUML
ALL(1)=ASIN(VREG(1)/VRR)
BL2(1)=ASIN(VREG(1)/VLL)
IF (L=3) S1,52,52
51 AANG(1)=(ALL(1)+BL2(L))=0,5
DIP(L)=(ALL(1)-BL2(L))=0,5
VREG(2)=VREG(1)/SIN(AANG(1))
GO TO 550
52 K=1
AANG(1)=ALL(1)-DIP(2)
BANG(1)=BL2(1)+DIP(2)
53 K=K+1
VVL=VREG(K)/VREG(K-1)
PE01=VVL*SIN(AANG(K-1))
PE02=VVL*SIN(BANG(K-1))
WRITE (10,999)PE01,PE02,BANG(K-1),AANG(K-1), VVL
999 FORMAT(5F12.6)
  IF(ABS(PE01).GT.1) PE01=1.0
  IF(ABS(PE02).GT.1) PE02=1.0
  APA(K)=ASIN(PE01)
  BPA(K)=ASIN(PE02)
  IF(K+1=L)54,55,55
54  AANG(K)=APA(K)-DIP(K+1)+DIP(K)
  BANG(K)=BPA(K)+DIP(K+1)-DIP(K)
  ALL(K)=AANG(K)+DIP(K+1)
  BLL(K)=BANG(K)-DIP(K+1)
  GO TO 53
55  AANG(K)=(APA(K)+BPA(K))=0.5
  BANG(K)=AANG(K)
  DIP(K+1)=DIP(K)+(APA(K)-BPA(K))=0.5
  ALL(K)=AANG(K)+DIP(K+1)
  BLL(K)=BANG(K)-DIP(K+1)
  VREG(K+1)=VREG(K)/SIN(AANG(K))
550 IF(NM.EQ.1.OR.NIXIT.EQ.1) GO TO 60
58  FORMAT(1H0,63X,7H--s^--.13X,=3H--»-i
  PRINT 41, VREG(L)
  GO TO 60
56  VREG(L)=PTSL/SUML
  PREG(L)=PTSL
  GO TO 61
59  VREG(L)=PTSR/SUMR
  PREG(L)=PTSR
  GO TO 61
111 SUMT=SUMR*SUMU
  PREG(L)=PTSR*PTSL
  VREG(L)=PREG(L)/SUMT
C
61 IF(NIXIT.EQ.0) PRINT 57
57  FORMAT(/ / / //1H0,8H--NONE--)
C
60 RETURN
END
SUBROUTINE TIE(L2, M, J, JJ, K11, K22, KT1, KT2, KN, TR, D)
COMMON/BLK0/LG
1  /BLK3/TA, DSG
C
C MAKES TIE CORRECTION FOR OUTLYING SHOTPOINTS
C
DIMENSION LG(24,2,6), TA(24,2,6), DSG(24), TR(24,2,6), D(24,2,6)
C
CALL KENDS(L2, M, J, KT1, KT2, K11, K22)
IF (KT11, EQ, 0) GO TO 99
DO 10 K=1, KN
DSG(K)=D(K, J, M)
TA(K, J, M)=TR(K, J, M)
10 CONTINUE
CALL REGRES(KT11, KT22, J, M, L2, V, T, PT)
IF (PT, EQ, 0) GO TO 99
ATA=T*T
BTA=1./V
SUM1=0.
PTSl=0.
K11=MAX0(K11, K11)
K22=MIN0(K22, K22)
IF (K22, GE, K11) GO TO 20
K11=K11
K22=K22
20 DO 30 K=K11, K22
IF (LG(K, JJ, M), NE, L2) GO TO 32
SUM1=SUM1+TR(K, JJ, M)-(ATA*BTA+DSG(K))
PTSl=PTSl+1.
30 CONTINUE
IF (PTSl, EQ, 0) GO TO 99
SUM1=SUM1/PTSl
DO 40 K=K11, K22
IF (LG(K, JJ, M), EQ, L2) TR(K, JJ, M)=TR(K, JJ, M)-SUM1
40 CONTINUE
C
99 RETURN
END