Part 3 – Tutorial Manual

INCLUDES TUTORIALS:

OVERVIEW OF ADVANCED DIPS FEATURES – EXAMPLE.DIP

TOPPLING, PLANAR AND WEDGE SLIDING ANALYSIS – EXAMPPIT.DIP

ORIENTED CORE, ROCKMASS CLASSIFICATION – EXAMPBHQ.DIP

Introduction

Tutorial 1 will lead you through some of the major features of the DIPS program, and Tutorials 2 and 3 will show how DIPS can be used for various types of analyses which may not have been obvious without illustration. *Some knowledge of stereographic projection is assumed*, the aim of these tutorials is not to teach fundamentals. Further detailed information about each of the options available in DIPS is provided in the reference section (Part 2) of this manual.

NOTE:

These tutorials cannot be carried out using the BASIC version of DIPS, you must be running the ADVANCED version.

The DIPS program is initiated by typing the name of the program, *dips*, at the DOS prompt. The first time that you run DIPS, the ADVANCED version will appear on the screen. The program will automatically sense the configuration of the computer and adjust to the graphics card in use. For portable computers equipped with colour graphics cards and monochrome displays, the monochrome display is set by entering dips/m or dips/p. Further details of the DIPS graphics display options which can be accessed in the command line, are discussed in Part 1 – Getting Started. NOTE: These tutorials cannot be carried out using the BASIC version of DIPS.

Hints about the Tutorial Manual

- Follow instructions such as:

  Select: FILES ➔ LOAD DATA FILE

  to navigate the sidebar menu selections.

- Text enclosed by a box eg.:

```
> You are using the ADVANCED VERSION of DIPS. Change
(Y or N)?  Press Y
```

  indicates a prompt line message, found at the bottom of the DIPS screen. The ***italic*** text at the end of the prompt line indicates a user response. The word ***Press*** indicates that pressing the indicated letter or number will immediately carry out the action. The word ***Enter*** indicates that an alphanumeric character or string is to be typed in and entered by pressing the *Enter* key. If no ***italic*** message is indicated at the end of the prompt line, this indicates that the prompt line is displayed for information purposes, and no response is necessary.

- Text in **BOLD** (eg. **SET OPTIONS** or **Track Data**) in most cases indicates a sidebar menu item.

Example Data Files

These files are contained in the \EXAMPLES subdirectory. They indicate the wide range of problems which can be analyzed with DIPS, some of which may not have been obvious without illustration. *Suggested assignments are included at the end of most files.*

NOTE: *These sample data files are intended for use in training and education only. They should not be used as data sets for research.*

EXAMPLE.DIP

See Tutorial 1

This is the original DIPS example file. It contains bountiful comments to guide the user in setting up the data file. Users are still advised to read the first chapter (The DIPS Data File) in the reference section (Part 2) of the manual for full input detail.

EXAMPMIN.DIP

This file contains 195 data points and illustrates the minimum column and header configuration for a data file – no traverses, orientation only, no extra columns. Use this as a guide for plotting orientations only.

EXAMPPIT.DIP

See Tutorial 2

This file contains structural data from an open pit mine. It includes a PLANAR traverse for bias correction (weighted contours) and has extra columns for discontinuity spacing, length, type, shape and surface. A sample assignment problem for students is included at the end of the file.

EXAMPROS.DIP

This file contains data from an underground mine haulage tunnel and stope access drifts. There are five linear (tunnel) traverses and a total of 215 measurements. This file is ideal for illustrating the use of the ROSETTE plot option in DIPS. Several suggested exercises are given at the end of the file.

EXAMPCAV.DIP

This file contains 324 joint measurements (orientations only) measured in the backs (roofs) of pilot exavations for a power cavern. A suggested assignment contained at the end of the file deals with finding an optimum orientation for a long cavern (considering joint orientations and potential wedges).

EXAMPFLD.DIP

This file contains 175 data points collected at a road cut. The data defines a series of joints and bedding which have been folded. The sample assignment deals with determination of the fold axis and with the consequences of steepening the slope (of a high cut) for lane expansion, and with the consequences of on and off-ramp creation (variable cut orientation through the jointed rockmass).

EXAMPBHQ.DIP

See Tutorial 3

This file contains 650 measurements from 2 oriented borehole cores. In addition to relative borehole joint orientations (see manual for details), intact segment lengths and NGI JA and JR measurements are given. The sample assignment at the end of the file deals with rockmass classification for a power cavern construction as well as failure mode determination from the stereonet.

EXAMPSTR.DIP

This file contains principle stress data obtained from 20 CSIRO cells in an underground research cavern. This file is meant to illustrate alternative uses for DIPS (other than joint data) and to illustrate the variation in magnitude (Use the **Histogram** and **SET WINDOWS** options) and direction of stress data.

Template Files

Various template files are also found in your \EXAMPLES subdirectory. Remember that **template.dip** is a blank data form which can be used by a word processor or text editor to create your own DIPS files. Do not load **template.dip** as a data file unless you have placed data measurements into it. DIPS template files are also supplied for LOTUS 123 (template.wk1) and Microsoft EXCEL (template.xls).

If you or your organization would like to supply example data files for future releases, please send a disk to the address in the README file in your main DIPS directory. Please include a short description of the files contents, the data's significance, sample problems, etc. Note that submitted files become the property of the Rock Engineering Group.

Tutorial 1 – EXAMPLE.DIP Revisited

*Note the differences between the ADVANCED and BASIC versions of DIPS. Not only are many options unavailable in the BASIC version, but also, certain options common to both versions are substantially different – as an example, observe the difference in the **SET WINDOWS** option prompt lines (advanced vs. basic version)*

In the ADVANCED version of DIPS there are a large variety of options available – this tutorial uses the ADVANCED version and the file **example.dip** (the same file used for the Quick Start tutorial) to illustrate some of the more advanced features of the program.

If you have not already done so, run the program by typing *dips* at the DOS prompt. If you are running DIPS for the first time, you should be running the ADVANCED version of the program. If you are running the BASIC version of the program, then toggle back to the ADVANCED version using **SET OPTIONS->DIPS VERSION –** see Quick Start tutorial, or reference manual (Part 2) for details.

Changing Program Settings: SET OPTIONS

The **SET OPTIONS** menu of the ADVANCED version of DIPS has several options available to the user. The following steps will illustrate how to change the **PROJECTION** and **DISTRIBUTION** used for the analysis.

Changing the Projection Method

There are two methods that can be used to project three dimensional pole vectors onto a two dimensional stereonet. The default technique is EQUAL ANGLE projection. For this demonstration, we will switch to EQUAL AREA projection. See the reference section of the manual for a full description of these two projection methods.

To change the projection, select **SET OPTIONS** from the main menu and then select the **PROJECTION** option.

Select: SET OPTIONS

Select: SET OPTIONS ➔ PROJECTION

The prompt line should read:

```
> Projection is EQUAL ANGLE. Change (Y or N)?  Press Y
```

```
> Projection is EQUAL AREA.  Change (Y or N)?  Press N
```

The EQUAL AREA projection option is now toggled, and you are returned to the **OPTIONS** menu.

Changing the Distribution Method

There are two methods used to contour pole densities on a stereonet for cluster recognition. The default technique uses the FISHER distribution, which we will use in this tutorial. This technique produces smoother plots for presentation than the SCHMIDT distribution (see the reference section of the manual for a detailed description of these distribution methods). If the **DISTRIBUTION** has been toggled to SCHMIDT, toggle back to FISHER.

Select: SET OPTIONS ➔ DISTRIBUTION

If the prompt line reads:

```
> Contour distribution type is SCHMIDT: Change(Y or
N)?  Press Y to switch to Fisher
```

```
> Contour distribution type is FISHER: Change(Y or N)?
Press N to accept the Fisher distribution
```

The FISHER distribution option is now toggled, and you are returned to the **OPTIONS** menu. Select **RETURN** or hit *Esc* to return to the main menu.

Select: SET OPTIONS ➔ RETURN

Loading a File

To load a DIPS file, select **FILES** from the main menu, and **LOAD DATA FILE** from the **FILES** menu.

Select:

FILES ➔ LOAD DATA FILE.

Indicate the name of the .dip file you wish to work with: in this case ***example.dip****.*

Select: FILES

Select: FILES ➔ LOAD DATA FILE

Since the procedure is identical, see the Quick Start tutorial in Part 1 – Getting Started, for instruction on loading the **example.dip** data file.

Datafile Info

Once the file is loaded, the data file setup information will be displayed on the screen, and the cursor will automatically be positioned on the **COMPUTE** button. Inspect the data file setup information, before you select **COMPUTE**. If your data file is not behaving properly, look here for inconsistent or incorrect information, or strange non-alphanumeric characters. The listing may indicate an input error in your data file which was not detected by DIPS. Details of the major errors that DIPS will detect are provided in the DIPS Data File chapter of the reference section (Part 2) of this manual.

In the ADVANCED version of DIPS, the data file setup information can be reviewed at any time with the **Datafile Info** option of the **FILES** menu. (This option is not available in the BASIC version – the data file info is only displayed when the file is loaded.)

Select: FILES

Select: FILES ➔ Datafile Info

To view a listing of the Data File Info at any time

Select:

FILES ➔ Datafile Info

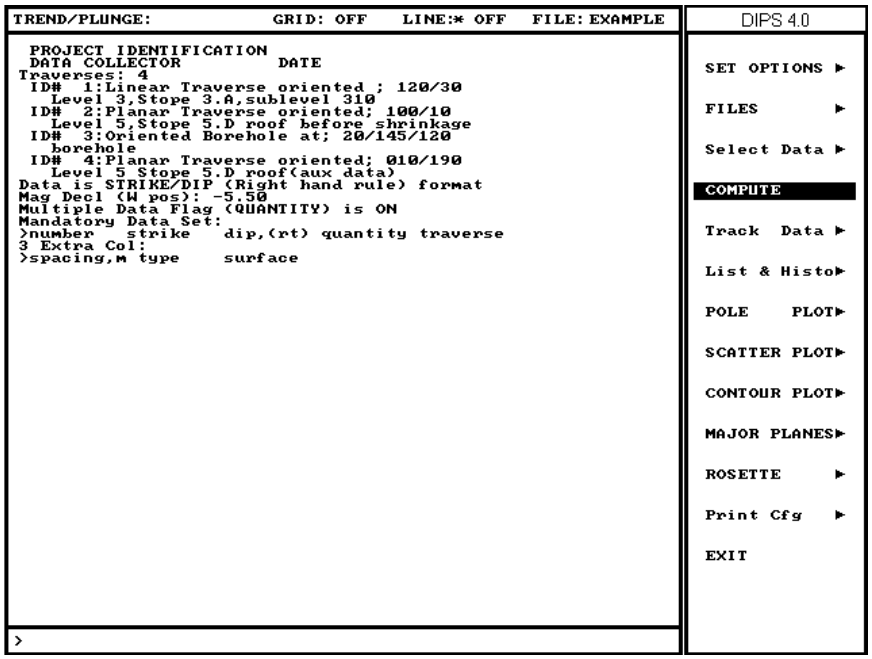


Figure T1-1: Data file info listing from DIPS.

Processing Data: COMPUTE

COMPUTE must be executed before data can be plotted and manipulated.

Select: COMPUTE

*Select **COMPUTE** from the main menu.*

The following series of prompts will be displayed as the data is loaded and processed (these may flash by too quickly too read, with the speed of the latest computers):

```
> Projecting grid points...
```

```
> Selecting and rotating data...
```

```
> 61 poles selected from 40 entries..computing: ##
```

When DIPS is finished processing the data, the amount of remaining memory in your computer will be displayed. A quantity under 5000 bytes may be cause for concern and DIPS may abort later in your session. If memory problems are experienced with large data files, use the **File Swap** option, described in the **SET OPTIONS** section of the reference manual.

The cursor will jump to **POLE PLOT** when **COMPUTE** is complete. This is the most common but not mandatory next step.

Orientation Plotting: POLE PLOT

To display a plot of pole orientations select **POLE PLOT** from the main menu.

Select: POLE PLOT

Select:

POLE PLOT ➔ FEATURE LEGEND

A plot will be generated of the pole positions for all of the data on the stereonet. To view information about the data, select **FEATURE LEGEND** from the **POLE PLOT** menu. The DIPS output that will result is shown in Figure T1-2.

Select: POLE PLOT ➔ FEATURE LEGEND

As can be seen in this figure, the only information available at this point is the orientation data. As the prompt line suggests, by using the **Track Data** option in the main menu, additional information for each pole, such as the feature type, spacing, or any other column in the data file, can be plotted with this option, using additional symbols. **Track Data** and feature attribute plotting will be discussed later in this tutorial.

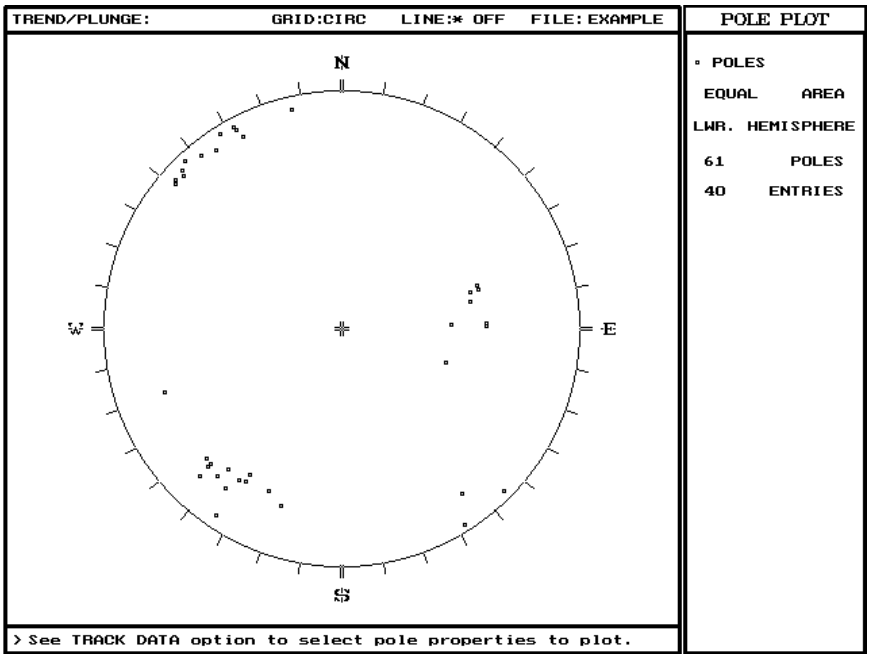


Figure T1-2: A plot of the poles from the example.dip file, with the **FEATURE LEGEND** option selected.

Press any key to return to the **POLE PLOT** menu and select **RETURN** to return to the main menu.

Select: POLE PLOT ➔ RETURN

Data Clustering: SCATTER PLOT

While the **POLE PLOT** illustrates orientation data, single pole symbols may actually represent several unit measurements of similar orientations. To better view the numerical distribution of these measurements, select **SCATTER PLOT** from the main menu.

Select: SCATTER PLOT

Select:

SCATTER PLOT ➔ SCATTER LEGEND.

A plot is generated where coincident pole and closely neighbouring pole measurements are grouped together with quantities plotted symbolically, as shown in Figure T1-3. To view the legend for the pole quantities and their representative symbols, select **SCATTER LEGEND** from the **SCATTER PLOT** menu.

Select: SCATTER PLOT ➔ SCATTER LEGEND

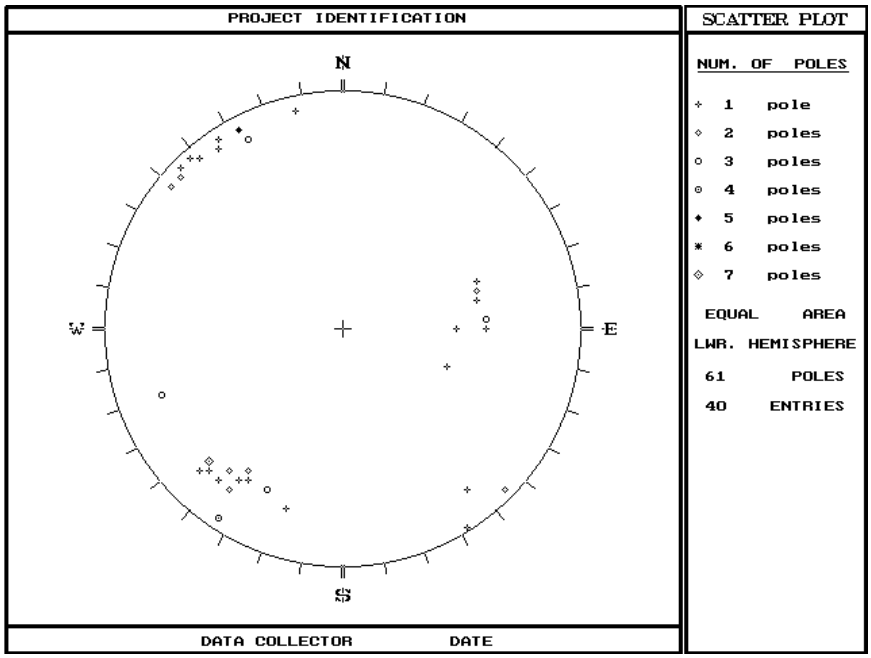


Figure T1-3: A **SCATTER PLOT** representation of the example.dip data file.

Press any key to return to the **SCATTER PLOT** menu. Select **RETURN** to return to the main menu.

Select: SCATTER PLOT ➔ RETURN

Data Concentration: CONTOUR PLOT

To view a statistical presentation of pole clustering, select **CONTOUR PLOT** from the main menu.

Select: CONTOUR PLOT

Notice that the plot is not immediately generated as were the **POLE** and **SCATTER PLOTS**. This is because there are two possible contour plots to choose from. The default option is an **UNWEIGHTED PLOT**, which plots the data directly. The **WEIGHTED PLOT** utilises the Terzaghi correction for sampling bias to modify the concentrations – **do not use this plot for applications unless you are familiar with its limitations.** See the reference section (SET OPTIONS / Bias Angle) for details.

Select:

CONTOUR PLOT ➔ UNWEIGHTED PLOT

Select:

CONTOUR PLOT ➔ CONTOUR LEGEND.

For this tutorial, select the **UNWEIGHTED PLOT** option from the menu, which will generate the following plot. Then select **CONTOUR LEGEND** to generate the sidebar legend for the contour intervals.

Select: CONTOUR PLOT ➔ UNWEIGHTED PLOT

Select: CONTOUR PLOT ➔ CONTOUR LEGEND

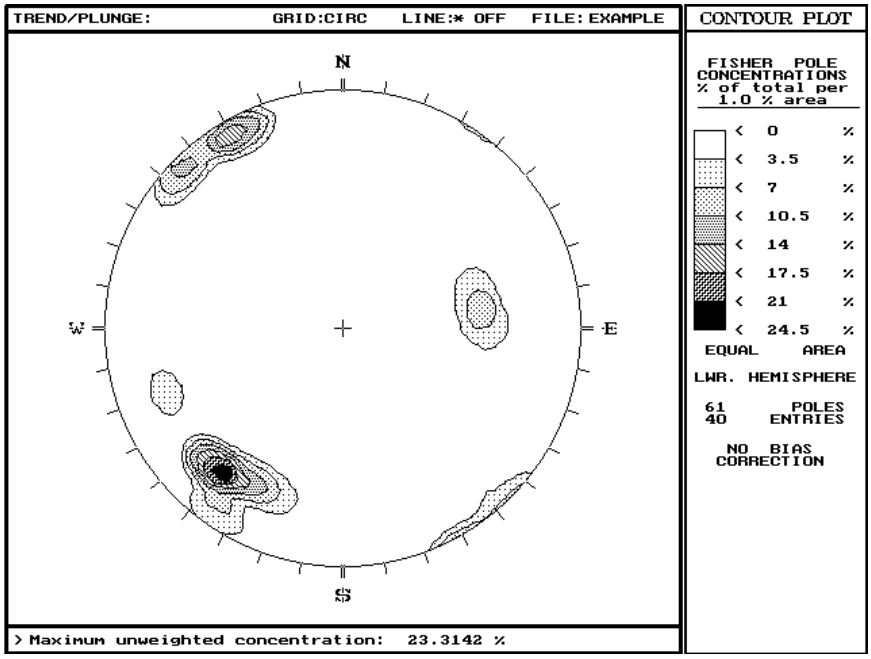


Figure T1-4: An unweighted contour plot of the example.dip data file.

Note the various plotting options within the **CONTOUR PLOT** menu: **Colour Plot**, **Line Plot** and **Stipple Plot**. The plot shown in Figure T1-4 is a Stipple Plot, which is the default in monochrome mode.

Select a different option, for instance **Line Plot,** to change the style of the contour plot.

Select: CONTOUR PLOT ➔ Line Plot

You will see the prompts:

```
> Label contour lines with LETTERS (L) or VALUES
(V) ?  Press L or V
```

```
> Use F7 in LOCATE POLES to mark labels on
contours...
```

For convenience, the cursor will automatically jump to the **UNWEIGHTED PLOT** option. *You must select this to regenerate the contour plot with the new **Line Plot** style*, as shown in Figure T1-5.

Select: CONTOUR PLOT ➔ UNWEIGHTED PLOT

The contour plot will be regenerated with the **Line Plot** style.

After selecting a new Contour Plot style (eg. ***Line Plot****), you must reselect* ***UNWEIGHTED PLOT*** *or* ***WEIGHTED PLOT*** *to regenerate the contour plot.*

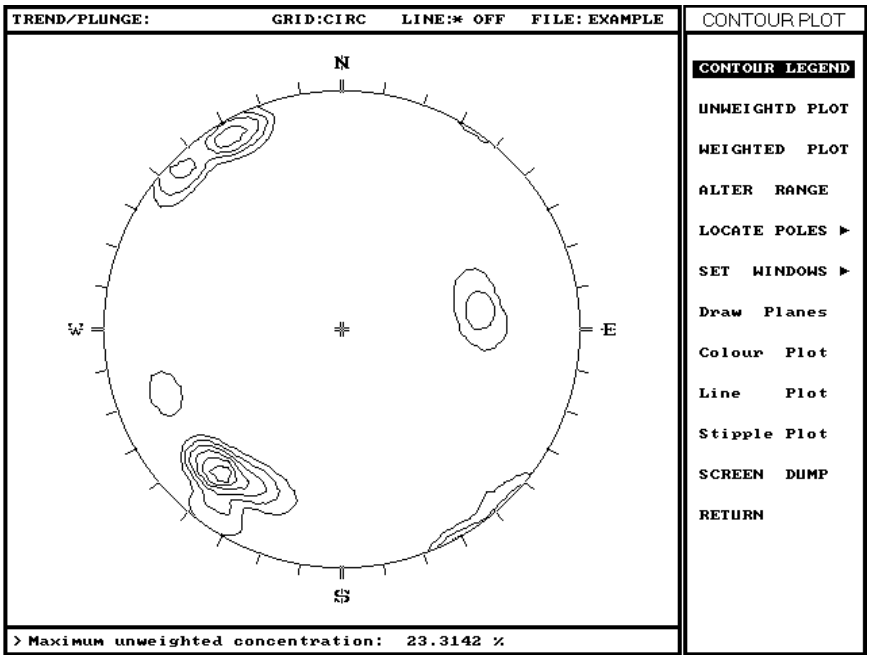


Figure T1-5: An unweighted LINE **CONTOUR PLOT**.

Altering Contour Intervals

The range of contour intervals shown in a plot is a calculated default range. To modify the contour intervals, select **ALTER RANGE** from the **CONTOUR PLOT** menu.

Select: CONTOUR PLOT ➔ ALTER RANGE

You will be prompted to change the range of the data plotted:

```
> Current range(0.000 % to 27.5362 %)..Change (Y or
N)?  Press Y
```

```
> Change to NEW RANGE,(N) or use DEFAULT RANGE,(any
key)?  Press N
```

```
> INPUT RANGE in PERCENT(from, to) %  Type in your new
range ##,## and press Enter
```

Reselect **UNWEIGHTED PLOT** to regenerate the contour plot with the new range. The default range can be restored by repeating the above procedure and pressing *any key* at the middle prompt.

Screen Preparation: SCREEN DUMP

To prepare the screen for a dump to the printer, select **SCREEN DUMP** from the **CONTOUR PLOT** menu. This will display a legend (the same legend as displayed by **CONTOUR LEGEND**) as well as titles (the first two lines of your DIPS data file) for your file.

Select: CONTOUR PLOT ➔ SCREEN DUMP

You will be asked if you wish to change the titles.

```
> Change Titles ( Y or N )?  Press Y
```

```
> Upper =  Type in a new title, or press Enter to
accept existing title
```

```
> Lower =  Type in a new title, or press Enter to
accept existing title
```

SCREEN DUMP *prepares the screen for printing, by displaying the* legend *and job* titles.

To ***print*** *the screen, press the designated "hot key" combination* ***<Ctrl P>*** *or* ***<Ctrl O>***

The legend will be automatically regenerated on the right, and the titles from your data file (or new titles which you have entered at the above prompts), will be placed at the top and bottom of the screen. *When this procedure has been completed, print the screen by pressing the hot key combination* ***<Ctrl P>*** *or* ***<Ctrl O>*** *which you have designated through the* ***Print Cfg*** *option of the main menu.*

When you press the hot key combination to print the screen, you will hear two "beeps" — one immediately, to indicate the beginning of the printing process, and one to indicate the end. When sending the image to a printer, the second "beep" may take some time, as the information is transferred from the computer to the printer. When capturing an image to a PCX file, the second beep should immediately follow the first.

When the printing of the screen is finished, *press any key* to return to the **CONTOUR PLOT** menu.

Selecting a Pole or a Plane: LOCATE POLES



The **LOCATE POLES** option exists in all of the **PLOT** menus. We will use it here in the **CONTOUR PLOT** menu.

When you select the **LOCATE POLES** option, the **CONTOUR PLOT** menu is replaced by a list of options and their associated function keys as shown in the margin. (A complete description of these auxiliary features is given in the reference section (Part 2) of this manual.)

Select: CONTOUR PLOT ➔ LOCATE POLES

We will only be concerned with selecting a pole in this example. The first prompt will read:

```
> Move cursor (mouse or arrows) to locate pole. (ALT
F10 for ID)  Position the cursor
```

Move the cursor (initially located in the bottom left corner of the plot) with the arrow keys or the mouse. (When using the arrow keys, the Left Shift and Right Shift keys will increase and decrease the cursor jumps respectively). Move the cursor to the desired location, such as the maximum pole concentration of a cluster. *As you move the cursor, you will notice that the orientation corresponding to the cursor position is displayed at the left side of the UPPER STATUS BOX,* along with the convention of the orientation data listing (ie. TREND/PLUNGE, STRIKE/DIP_R etc.) When you have positioned the cursor at the desired orientation, press *Enter* or the *Left mouse button.* You will be asked to input an identifying number for this pole by the prompt:

```
> Input Pole ID NUMBER (0 to cancel):  Enter 1
```

You may then input an optional text label for future reference, in response to the prompt:

```
> Pole Label:  For example, type POLE1 and press Enter
```

You are next asked if you wish to toggle the plane for plotting:

```
> Draw plane on diagram? (Y or N ... D to delete
  pole)?  Enter Y
```

The plane (great circle) corresponding to the normal pole represented by the cursor position will then be plotted on the stereonet, as shown in Figure T1-7. The great circle plane can then be recalled at any time using the **DRAW PLANES** option in each of the **PLOT** menus.

Select:

LOCATE POLES

to set a pole on the stereonet.

Once the cursor is in the correct position, press <Enter> or the left mouse button. Input a pole ID number. If you don't like the position of the pole, enter 0.

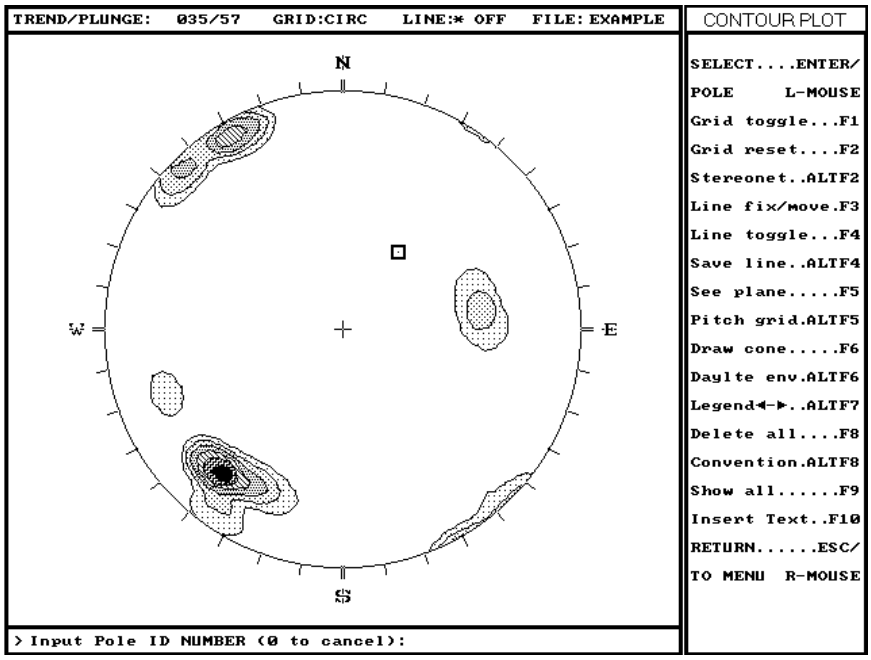


Figure T1-6: Selecting a pole with the cursor.

The default labelling of the pole / plane uses the ID# only. See **SELECT PLANES** in the **MAJOR PLANES** menu to toggle the labelling option so that the "Pole label" (i.e. POLE1) appears next to the pole or plane (see reference section of manual).

Plot the plane corresponding to the pole on the stereonet, by responding appropriately to the prompt line questions.

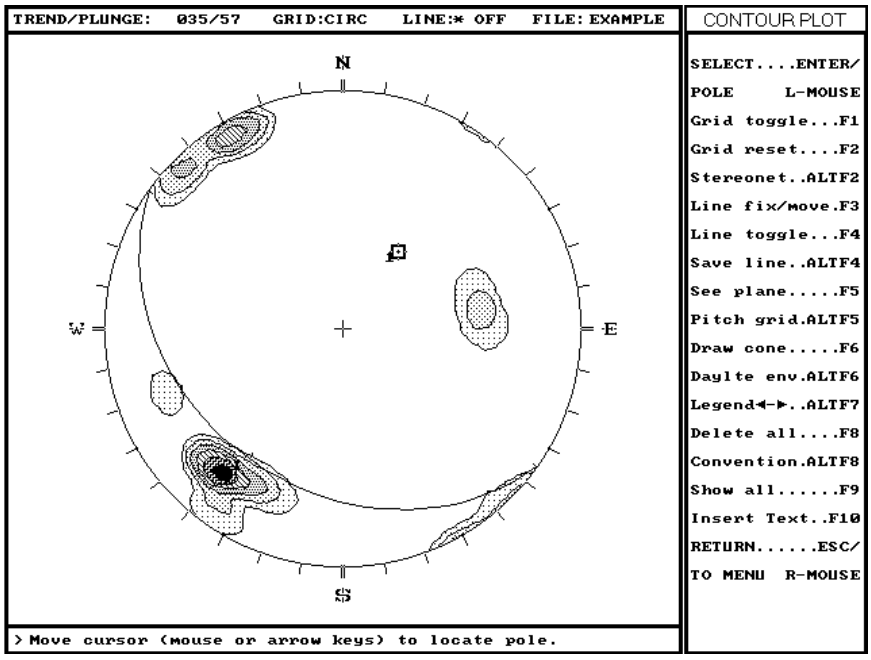


Figure T1-7: The great circle corresponding to the normal pole you have just located.

Press *Esc* or the *Right mouse button* to return to the **CONTOUR PLOT** menu.

Calculate Mean Orientations: SET WINDOWS

The **SET WINDOWS** option exists in all of the **PLOT** menus. We will use it here in the **CONTOUR PLOT** menu.

Select: CONTOUR PLOT ➔ SET WINDOWS

Select:

CONTOUR PLOT ➔ SET WINDOWS

Create a window around a data cluster as described in the Quick Start tutorial, or see the reference section of the manual.

When you select the **SET WINDOWS** option, the menu box is replaced by a list of features and their associated function keys (as seen in Figures T1-8 and T1-9) in the same manner as when **LOCATE POLES** is selected. A complete description of these auxiliary features can be found in the reference section (Part 2) of this manual.

Create a window around a data cluster as described in the Quick Start tutorial – the creation of a window is exactly the same in both the ADVANCED and BASIC versions of DIPS. Further information can also be found in the reference section of this manual. After a window has been created, the ADVANCED version requires several more prompts to be answered, as outlined below.

The ADVANCED version of DIPS requires the user to input an ID # for the set of data enclosed by the window, in response to the prompt:

```
> SET ID NUMBER (No analysis if ID = 0):  Enter 2 (for
  example)
```

The next prompts require you to specify the method of plotting for the calculated mean orientation:

```
> Mean vectors/planes will not be plotted. Change (Y
  or N)?  Press Y
```

```
> PLOT Unweighted (U), Weighted (W), Both (B), or None
  (N)?  Press U to plot the unweighted mean
```

```
> Pole Vectors (V), Planes (P), or Both (B)?..View
  with DRAW PLANES  Press B
```

The cursor will reappear, and a cross will mark the calculated mean orientation (POLE), inside the window you have created, as illustrated in Figure T1-8. *The corresponding plane is not plotted at this time – view the plane(s) using **DRAW PLANES** in any of the **PLOT** menus.* (We will do this in the next section of this tutorial.)

Now create another window, as described above. Enter an ID number (eg. 2) at the first prompt. The next prompt will now be:

```
> Unweighted mean vector & plane to be plotted. Change
  (Y or N)?  Press N
```

Since you already toggled the plot settings for the last window, you do not have to repeat them. The cursor will reappear and the prompt line will display:

```
> Select DRAW PLANES option to show mean poles and
  planes
```

Press *Esc* or the *Right mouse button* to return to the **CONTOUR PLOT** menu.

If a concentration of data appears on opposite edges of the stereonet, collect it all into one window.

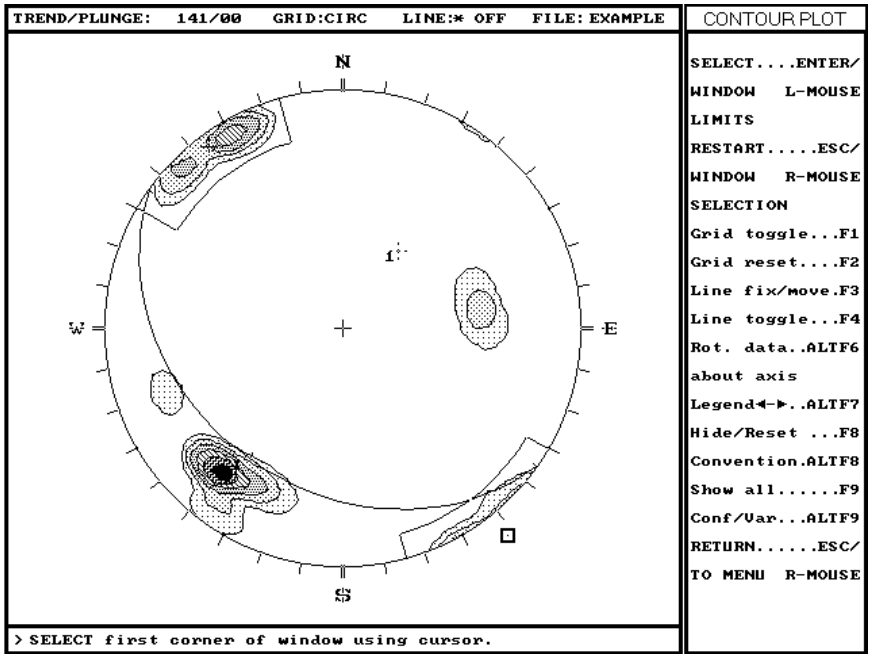


Figure T1-8: A cross marks the calculated mean orientation inside the window you have just created. The corresponding mean plane is not plotted at this time.

Note that if you get confused with the windowing procedure and 'lose control' of the window at any point, press *Esc* or the *right mouse button* to reset the cursor, and try again!

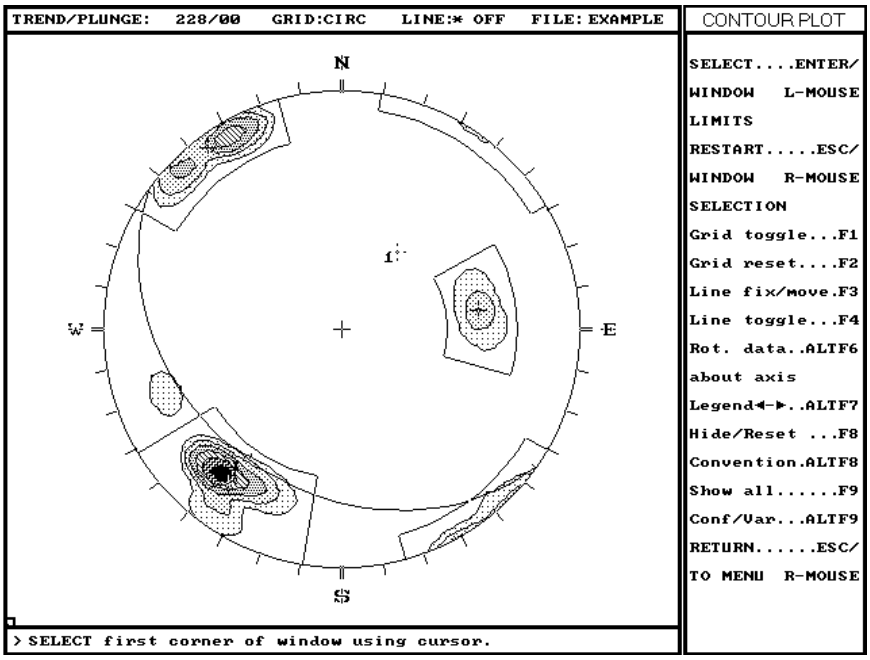


Figure T1-9: Windows drawn around the three main data clusters. The calculated mean poles are superimposed on each set. (Note: pole/plane with ID = 1 is from previous LOCATE POLES selection).

Displaying Poles and Planes: DRAW PLANES

Select:

CONTOUR PLOT ➔ DRAW PLANES

to superimpose the mean vectors and planes on the contour plot.

In order to view the planes associated with the windows you have set, select the **Draw Planes** option which appears in all of the **PLOT** menus. We will continue to use the **CONTOUR PLOT** menu for this example.

Select: CONTOUR PLOT ➔ Draw Planes

Once you have selected this option, you will be asked how you wish to *label* the plots:

```
> Label POLE VECTORS (V), PLANES (P), BOTH (B), NONE
(any key)?  Press B to select both
```

This action will cause the poles *and* planes which you toggled for plotting to be overlain on the **CONTOUR PLOT** and labelled with the ID numbers you entered, as shown in the following figure.

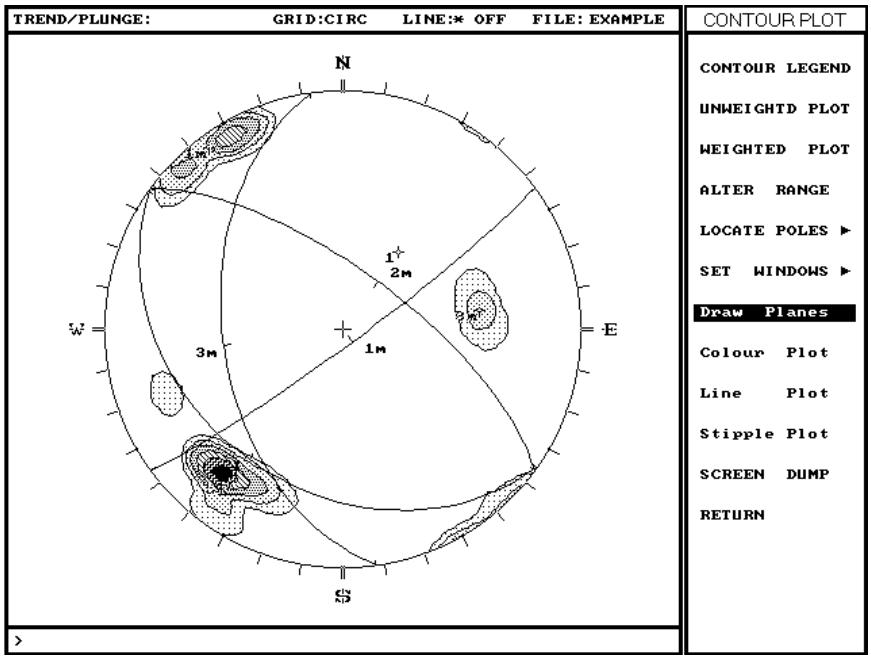


Figure T1-10: Using **Draw Planes** to overlay the mean planes and vectors on the contour plot. Note in this drawing that the pole and plane established with the LOCATE POLES option is also plotted on the drawing.

Notice that the calculated (unweighted) **mean** normals and planes are labelled with a "m" after their ID # to distinguish them from those selected with the **LOCATE POLES** option, which have no letter. (Weighted planes and poles are labelled with a "w").

To view this plot without the window limits drawn, reselect **UNWEIGHTED PLOT** and then use **Draw Planes** to redraw the planes. Select **RETURN** from the **CONTOUR PLOT** menu or press *Esc* to return to the main menu.

Select: CONTOUR PLOT ➔ RETURN

Viewing Major Planes: MAJOR PLANES

To plot the major planes on a clean stereonet, select:

MAJOR PLANES ➔ DRAW PLANES

Now that you have selected and calculated the orientations of some significant planar features, you may wish to view their corresponding great circles on a clean stereonet. Select the **MAJOR PLANES** button in the main menu, and then the **DRAW PLANES** option from the **MAJOR PLANES** menu.

Select: MAJOR PLANES

Select: MAJOR PLANES ➔ DRAW PLANES

You will be asked how you wish to *label* the features to be plotted:

```
> Label POLE VECTORS (V), PLANES (P), BOTH (B), NONE
(any key)?  Press B to select both
```

The poles and planes will be plotted on the stereonet as shown in Figure T1-11. To display a legend list of the orientations, select the **PLANES LEGEND** option.

Select: MAJOR PLANES ➔ PLANES LEGEND

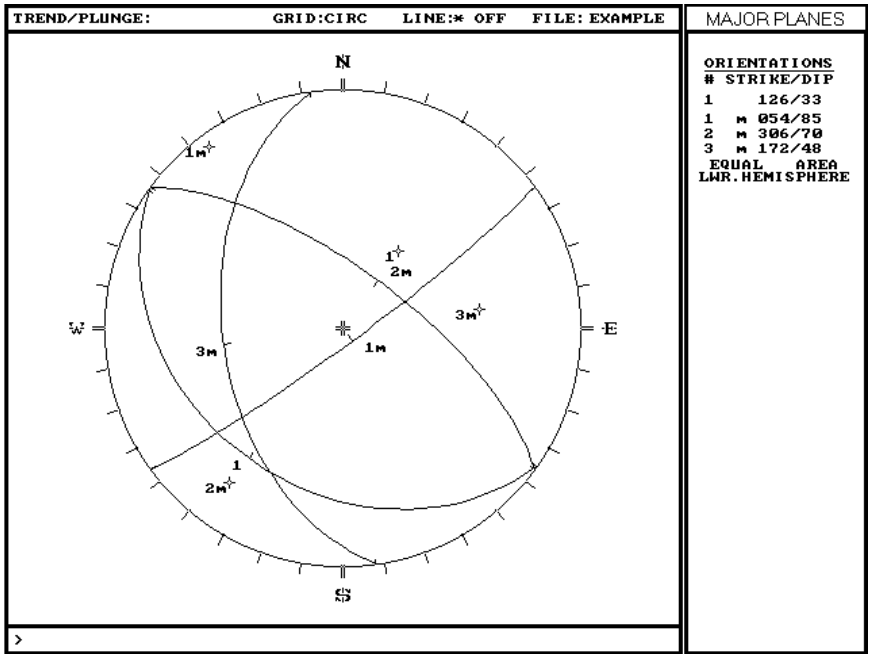


Figure T1-11: Planes and poles corresponding to the mean (**SET WINDOWS)** orientations, and selected (**LOCATE POLES**) orientations, plotted through the **DRAW PLANES** option of the **MAJOR PLANES** menu.

To view a list of planes (with additional statistical info etc), and to change plotting parameters, use the **SELECT PLANES** option (see the reference section of this manual.)

Press any key to return to the **MAJOR PLANES** menu. Select **RETURN** from the **MAJOR PLANES** menu or press *Esc* to return to the main menu.

Select: MAJOR PLANES ➔ RETURN

Processing Data Subsets: SELECT DATA

Now that you have explored some of the more fundamental features of DIPS, we will move on to several auxiliary options which are useful in a comprehensive analysis of oriented features.

The **Select Data** *option allows you to analyse a subset of a data file composed only of data units which match selection criteria which you prescribe*. This allows you to interactively separate features such as bedding, joints and shears and analyse them separately. It also allows you to specify numerical ranges for a given quantitative property, and process only data within those ranges: for example shear features longer than some minimum length. Since the DIPS file system is entirely flexible, the column entries can be whatever you wish to analyse, and all columns may be used together in a selection or screening process, eliminating the need for separate data files. The **Select Data** feature can be activated at any time by selecting this option from the main menu.

Select: Select Data

Select: Select Data ➔ SELECT SUBSET

Return to the main menu, and choose:

Select Data ➔ SELECT SUBSET

*Pick the "Type" heading title from the list that appears in the menu box. Press 2 to indicate QUALITATIVE data, enter two data labels – **joint** and **shear** – and check the results on the screen display.*

A list of column titles will now appear in the right hand menu box (see Figure T1-12). These are the titles which you used in your data file. Move the cursor to select one of the titles, such as Type, which is a column containing discontinuity descriptions, in the **example.dip** file. DIPS needs to know if the entries in this column are QUANTITATIVE or QUALITATIVE. Since the "Type" column entries are character labels, such as Joint, Shear etc., indicate that the data type is QUALITATIVE in response to the following prompt:

```
> Data is 1. QUANTITATIVE or 2. QUALITATIVE (1 OR 2)?
Press 2
```

```
> NUMBER of selection LABELS for this data column =
Enter 2
```

This is the number of data labels you wish to use for the analysis. You will now be prompted for the actual labels:

```
> INPUT DATA LABEL string for range 1 =  Enter: Joint
```

```
> INPUT DATA LABEL string for range 2 =  Enter: Shear
```

Note that these are simply two of the labels in the "Type" column in the example file. (The column title and the labels – or values if QUANTITATIVE – in this column can be anything you wish to use in your file.)

A summary of your criteria for this column will be displayed next, and you will be asked to confirm your selection, as shown in the following figure.

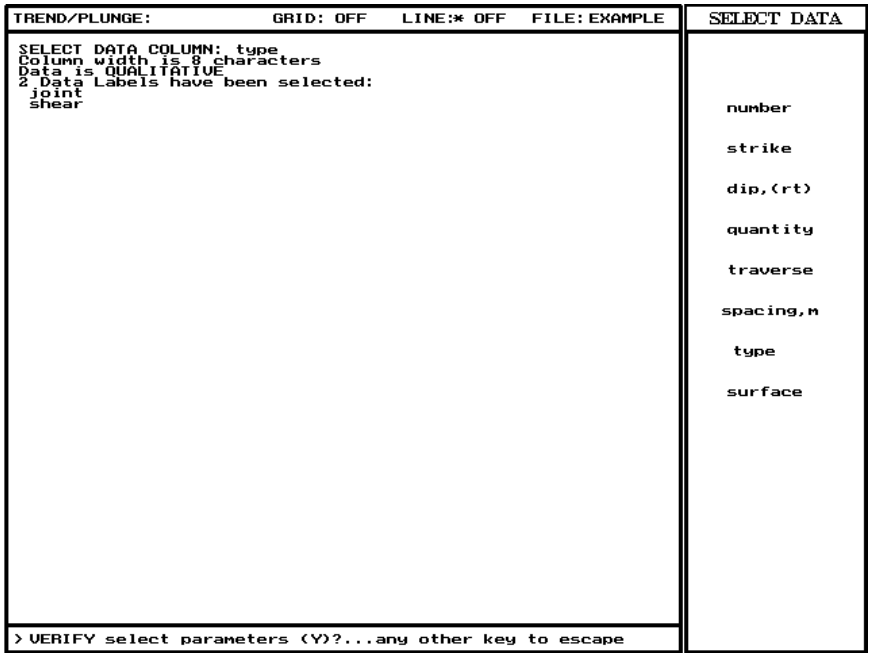


Figure T1-12: The screen display of the data you have selected for the SUBSET. Check the data and then either verify your selection, or *Esc*ape from the option.

After verifying your SUBSET selection, the column title (TYPE in this example) will be capitalised in the list, to indicate its use in the selection criteria.

If you are happy with the data subset displayed on the screen, press *Y* or the *left mouse button*. The column title "Type" will be capitalised in the list to indicate its use in the selection criteria. You may now select another column and repeat this procedure if you wish. *Any or all of the columns can be used together in the selection process*. Note that only data matching **all** of the selection criteria being used will be processed. For this example, however, use only Type, and press *Esc* to return to the **Select Data** menu.

(Note the **Reset** option in the **Select Data** menu. Use this option to cancel any selection criteria which you have used. Do not select this at this time.) Now toggle **RETURN** to return to the main menu.

The cursor will jump to the **COMPUTE** option in the main menu, indicating that you must execute **COMPUTE** before proceeding. This must be done so that this new SUBSET of the main data file can be processed. If you then use one of the **PLOT** options, you will notice that the number of data points has been reduced, since data units not satisfying your selection criteria are ignored.

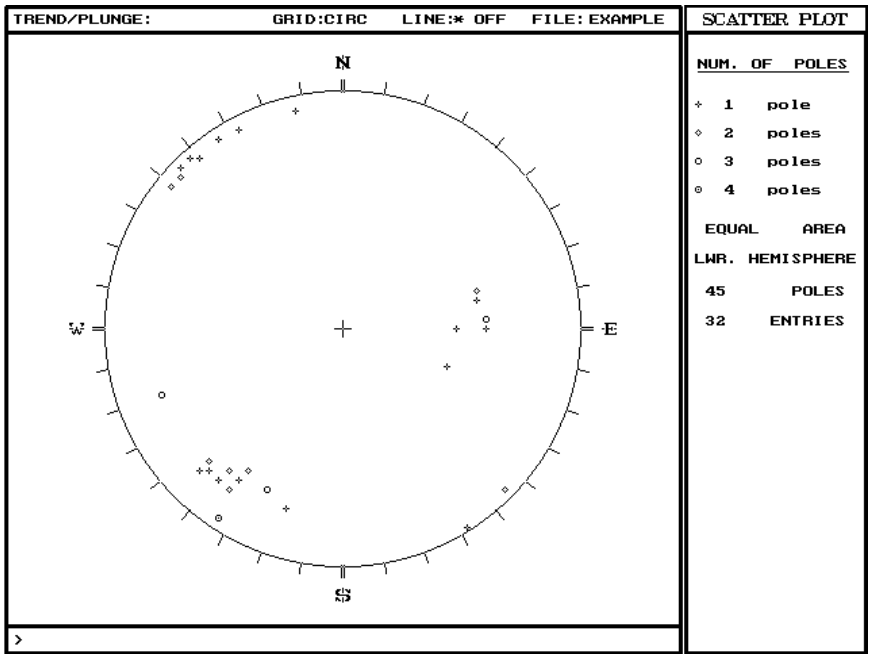


Figure T1-13: **SCATTER PLOT** of the data set consisting of the "joint" and "shear" types of data. These subsets were selected for analysis using the **Select Data** option.

Plotting Data Attributes: TRACK DATA

*Select **Track Data** from the main menu. Enter the **SELECT COLUMN** option, and pick a column heading to track. For this example, choose the "Spacing" column, and indicate that this is QUANTITATIVE data.*

In addition to analysing the orientation of a number of features, you may wish to interactively analyse other attributes of your data. This can be done through a symbolic **POLE PLOT** or a **HISTOGRAM**. The particular attribute to be analysed must first be selected via the **Track Data** option.

Select: Track Data

Once you have selected the **Track Data** option, choose a particular data column to analyse, by choosing the **SELECT COLUMN** option. All of the column titles will now be listed in the right side menu box. Select one of the columns to be "tracked". Note that only one column may be selected for "tracking" at one time. The word "TYPE" is capitalised, since it has been used to define a subset selection in **Select Data** (assuming you followed the instructions in the previous section of this tutorial). You may choose to track this column as well, but for this example select "Spacing" as the column to be tracked. DIPS needs to know how to treat the data in this column. Since "Spacing" is QUANTITATIVE, press 1 in response to the prompt:

```
> Data is 1. QUANTITATIVE or 2. QUALITATIVE (1 or 2)?
Press 1
```

You will be returned to the **Track Data** menu, and the prompt line will confirm your selection:

```
> Data column 6 has been selected for TRACKing
```

Select **RETURN** to return to the main menu. If you now perform a **POLE PLOT** and select the **FEATURE LEGEND** option, you will obtain a symbolic plot with symbols representing ranges of spacing for the data, as shown in Figure T1-14.

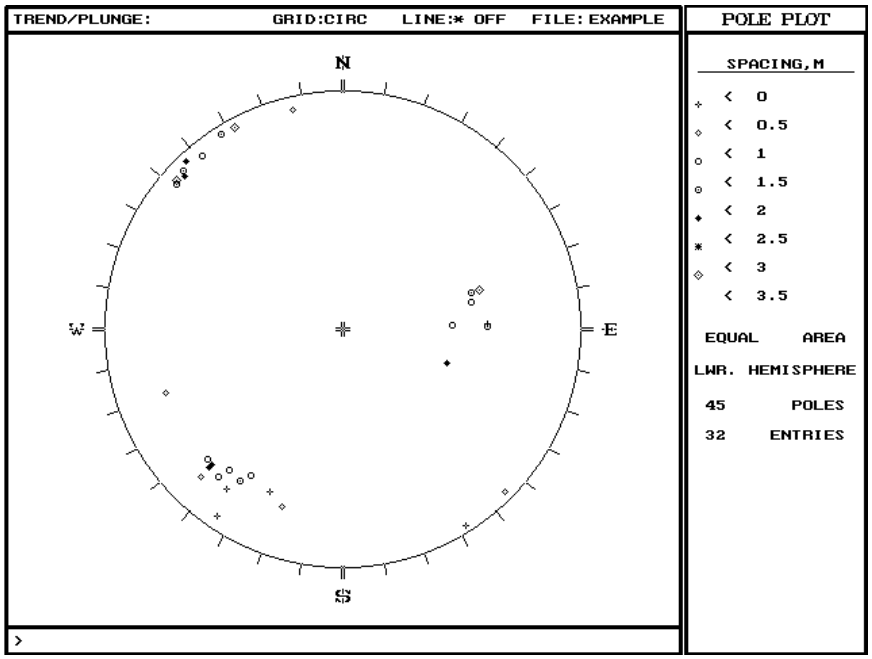


Figure T1-14: A POLE PLOT showing the SPACING of the data subset consisting of the **joint** and **shear** TYPE of features.

You may change the column being tracked at any time. This does not require **COMPUTE** to be reexecuted. Please note that you must remember whether a particular column contains QUALITATIVE or QUANTITATIVE data. If you track a column as quantitative and the values all plot as 0, then the column was probably qualitative. You may wish to include a flag in your column name to indicate the type (eg. Spacing (1) or Type (2).)

Altering the Range of Data Plotted in POLE PLOT

After you have selected a column with **Track Data**, you may wish to alter the QUANTITATIVE intervals used to generate the pole plot, to highlight a specific range. (You may also alter a QUALITATIVE legend – for further details refer to the reference section of this manual.) Select the **Alter Legend** option from the **POLE PLOT** menu.

Select: POLE PLOT ➔ Alter Legend

Select:

POLE PLOT ➔ Alter Legend

You may choose to alter the legend TITLE, and / or the RANGE of values used. Follow the steps below, to alter the RANGE:

```
> Change TITLE (T) or RANGE (any key)?  Press any key
```

```
> Current range (0.000 to 3.5000)...CHANGE(Y or N)?
Press Y
```

```
> Use DEFAULT(D), LOG SCALE(L) or LINEAR RANGE(any
key)?  Press any key, for a linear range
```

```
> INPUT LINEAR RANGE (from,to) =  Enter:  0 , 2
```

DIPS will divide this range into 8 intervals and assign a symbol to each interval. If you then select the **REDRAW PLOT** and **FEATURE LEGEND** options, you may view the effect of this new range.

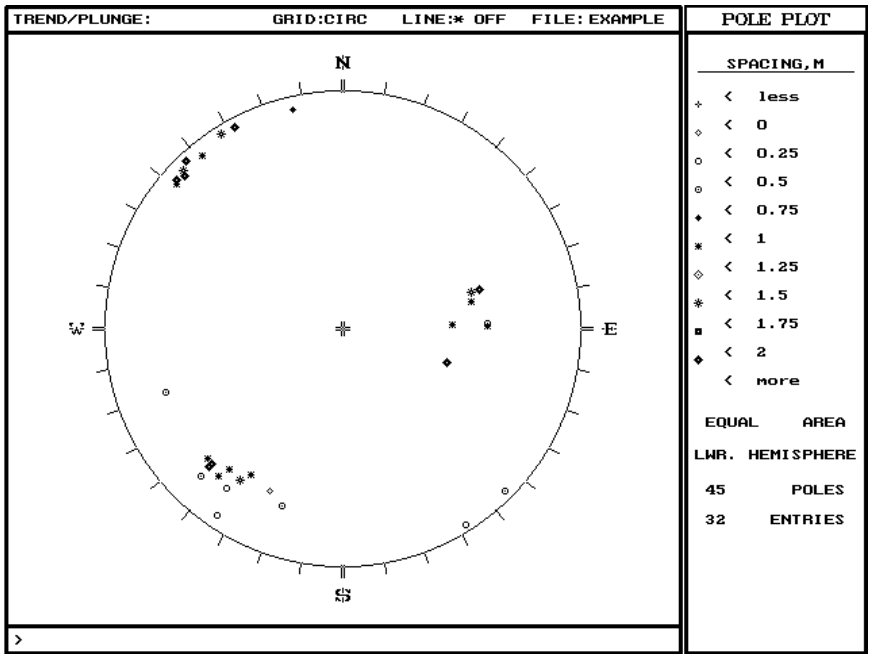


Figure T1-15: The pole plot with an altered range for the plotting of the quantitative data selected for tracking.

Detailed Attribute Analysis: LIST & HISTO

Return to the main menu.

Select:

List & Histo ➔
Data Histogram

In addition to the visual analysis afforded by a symbolic **POLE PLOT**, a more detailed analysis of the feature attributes may be required. The **List & Histo** menu allows you to perform this analysis. For this example, select the **Data Histogram** option from the **List & Histo** menu. This allows you to plot a histogram of the data in the column currently being tracked. Both QUALITATIVE and QUANTITATIVE data may be analysed in this way.

Select: List & Histo

Select: List & Histo ➔ Data Histogram

If you have selected any data sets using the **SET WINDOWS** option, you will be asked to identify the SET # to be analysed. Input 0 to analyse all of the data. In this tutorial, however, because you reexecuted **COMPUTE** since you last selected your windows, the window records have been erased. Therefore, you will not see this prompt, and a histogram for the complete data subset will be plotted automatically, as shown here.

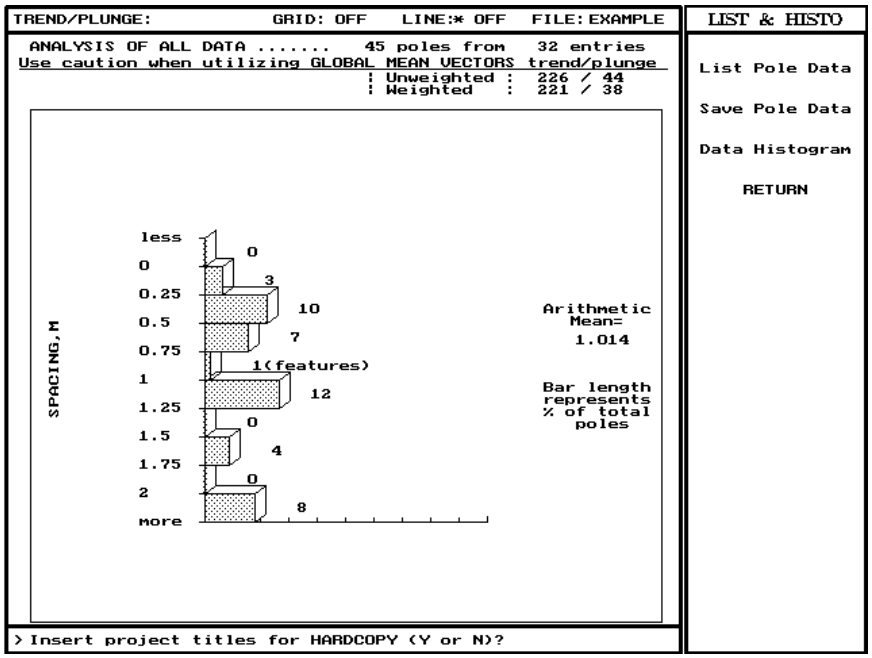


Figure T1-16: Data histogram for the spacing of the joints and shears "type" data subset.

Notice that the prompt line under this plot is asking if you would like to insert titles for a hard copy output. If you respond with a *Y*, you will prepare the screen for a screen dump in a similar fashion to the **SCREEN DUMP** option discussed previously. Press any key to return to the **List & Histo** menu.

To view individual data units as processed by **COMPUTE**, select **List Pole Data** from the **List & Histo** menu.

Select: List & Histo ➔ List Pole Data

Select:

List & Histo ➔
List Pole Data

This will display a list of all of the data after processing (i.e. after appropriate rotations, weighting, declination addition and, if performed, set designation).

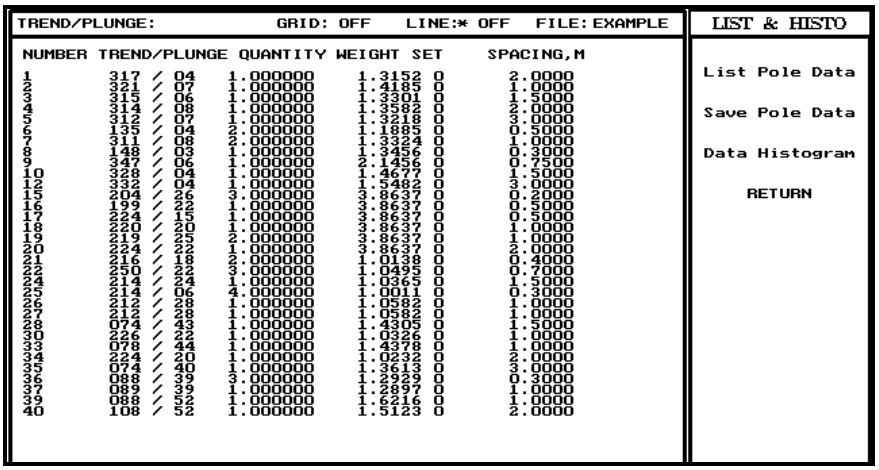


Figure T1-17: A list of the pole data for the subset of the example data file.

Note that since your windows were reset when you reexecuted **COMPUTE**, all of the **SET** numbers are 0. Use Page Up and Page Down to browse through the list.

Press *Esc* to return to the **List & Histo** menu. Press *Esc* again to return to the main menu.

Exiting the Program

That brings to a close this tutorial. Now that you are familiar with some of the tools available in the DIPS package, the best way to find out more about the program is to experiment with the options discussed in this tutorial and with the other tools that are also available in the various menus. A complete description of all the features of DIPS is found in the the reference section (Part 2) of this manual.

You are also advised to read the first chapter of the reference section, in which setting up your own data file is discussed.

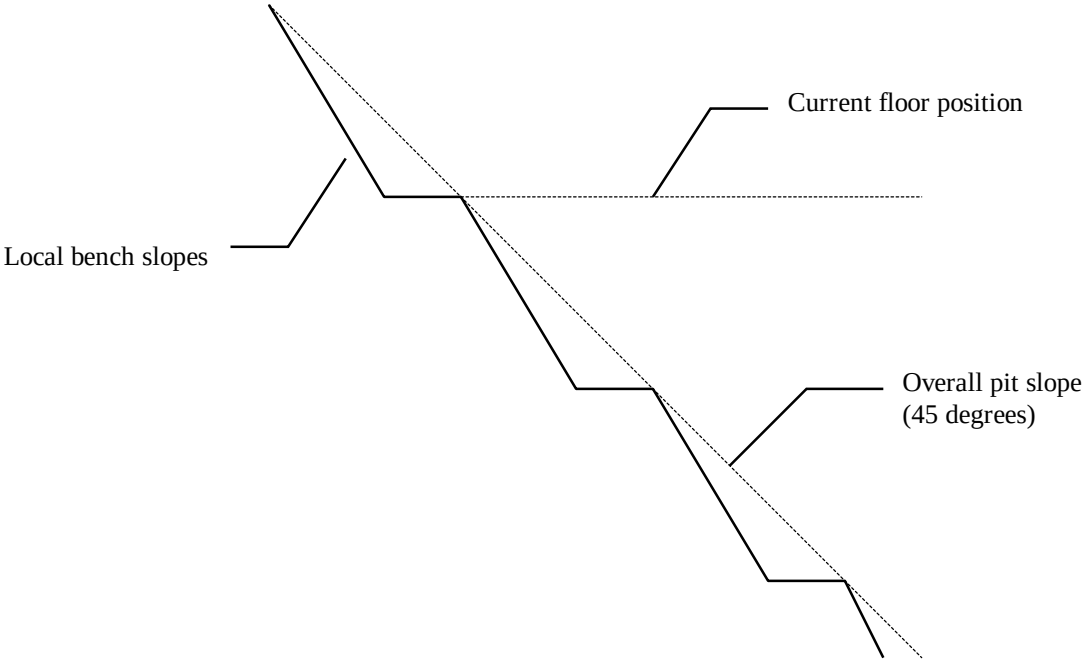
To exit the program, select **EXIT** in the main menu (or use the hot key combination <***Alt X***>), and press *Y* at the confirmation prompt.

Tutorial 2 – Toppling, Planar Sliding, Wedge Sliding

The data for this tutorial is contained in the example file **EXAMPPIT.DIP**, which can be found in your \EXAMPLES subdirectory.

The data has been collected by a geologist working on a single rock face above the 1st bench in a young open pit mine.

The rock face above the current floor of the existing pit has a dip of 45 degrees and a dip direction of 135 degrees.



The current plan is to extend the pit down at an **overall** angle of 45 degrees. This will require a steepening of the **local** bench slopes, as indicated in the figure above. The local benches are to be separated by an updip distance of 16m. The bench roadways are 4m wide.

EXAMPPIT.DIP Data File

The EXAMPPIT.DIP data file header is as follows:

```
Surface Structure Survey -  #3 Pit Slope - B.F.O.P. MINE
M.Diederichs:11/07/92  Surveyed on bench plane at 45/135
1 traverses used in bias correction calculations:
1;PLANAR;45;135;SECTOR N-45-W-200, face above survey bench
DIP/DIPDIRECTION
```

```
7.5 Mag Decl
NO QUANTITY
5 Extra Data Columns:       (Quant)    (Quant)   (Qual)     (Qual)    (Qual)
NUMBER;DIP;DIPDIR;TRAVERSE;SPACING(m);LENGTH(m);  TYPE   ;  SHAPE  ; SURFACE  ;
     1  77    322        1          3        14   joint    planar    rough
     2  68     80        1        1.3         7   joint    undulate  v.rough
     3  39    136        1        1.6        22   bedding  planar    smooth
     .
     .
     .
   303  88      1        1        1.5         7    joint    planar    rough
-1
```

Referring to the data header above, and to the DIPS DATA FILE chapter of the REFERENCE section of the manual:

Lines 1& 2 are title lines containing a description of the site and other information.

Line 3 indicates that all data has been collected on a single traverse.

Line 4 contains a description of the survey traverse:

Traverse 1 is PLANAR with a DIP of 45 degrees and a DIP DIRECTION of 135 degrees (NOTE: orientation input correpsonds to GLOBAL ORIENTATION FLAG).

Line 5 is the GLOBAL ORIENTATION FLAG and is set to DIP/DIPDIRECTION.

Line 6 indictates that 7.5 degrees will be added to the dip direction to correct for magnetic declination.

Line 7 indicates that NO QUANTITY column is present (individual measurements only).

Line 8 indicates that 5 extra columns are present to describe the structural features.

Line 9 is the data header line and is self explanatory.

Note the form of the data itself. ALL DATA FALLING UNDER A HEADER MUST LIE WITHIN THE APPROPRIATE DATA FIELD. See the DIPS DATA FILE chapter in the REFERENCE section (Part 2) of this manual for further information.

Set Options

To view raw data run DIPS.

Check that the **SET OPTIONS** selections are as outlined below. If not, toggle the following options as per the previous tutorial.

DIP VERSION – ADVANCED

PROJECTION – EQUAL ANGLE

DISTRIBUTION – FISHER

CONVENTION – PLANE

COUNT CIRCLE – 1 %

GRID SIZE – 4 %

BIAS ANGLE – 15 %

If you wish to use these settings again remember to **SAVE OPTIONS**.

Select: SET OPTIONS ➔ SAVE OPTIONS

RETURN to the main menu.

Track Data

If you have not already done so, load the **examppit.dip** data file.

Select: FILES ➔ LOAD DATA FILE

If necessary, use **New Directory** in the **FILES** menu to switch to the \EXAMPLES subdirectory, where you should find the **examppit.dip** file.

Now use the **Track Data** option to plot the data according to the discontinuity Type.

Select: TRACK DATA ➔ SELECT COLUMN ➔ Select TYPE from the list of column titles which will appear in the menu box area

The prompt line will ask:

```
> Data is 1. Quantitative or 2. Qualitative (1 or 2)?
Press 2 since Type is a Qualitative data column
```

Pole Plot

Now select **COMPUTE**, and then **POLE PLOT**, to plot the data with symbols representing the different discontinuity types, in this case **joint**, **bedding** and **shear** types. Select **FEATURE LEGEND** from the **POLE PLOT** menu to display a legend for the symbolic pole plot, as illustrated in Figure T2-1.

Select: COMPUTE

Select: POLE PLOT

Select: POLE PLOT ➔ FEATURE LEGEND

*Track the data TYPE, and observe the clustering of the **joint**, **bedding** and **shear** features on a POLE PLOT.*

Look closely at the data clustering and the data TYPE. Note the clustering of bedding features and the two clusters of shear features. These may behave very differently from similarly oriented joints or extension fractures and should be considered separately.

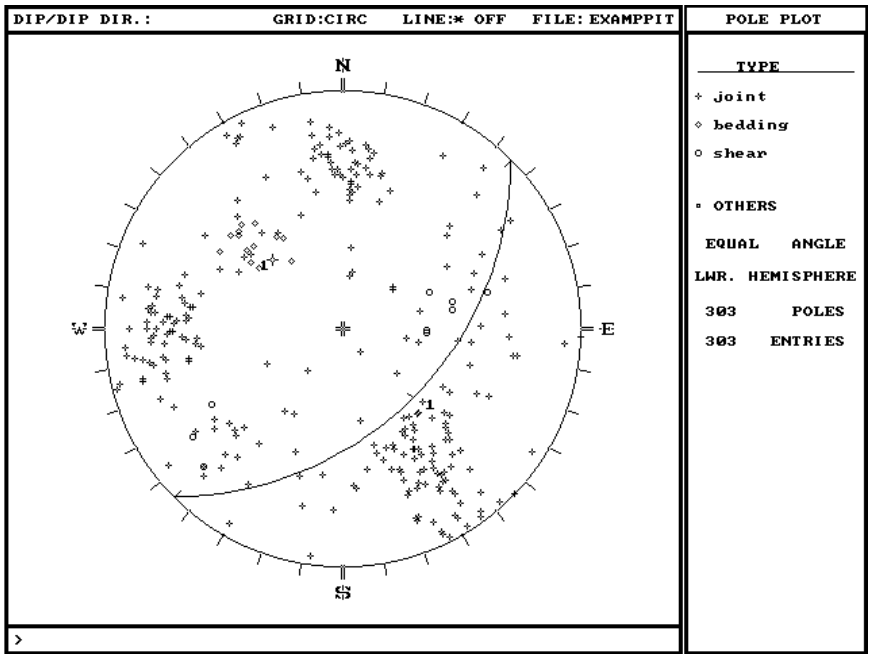


Figure T2-1: Pole plot with legend for discontinuity type, and great circle representing the pit slope.

*Use LOCATE POLES to draw a great circle representing the **pit slope** on the stereonet.*

Note that Figure T2-1 also displays a great circle corresponding to the current pit slope. This was placed on the stereonet using the **LOCATE POLES** option within **POLE PLOT**, as follows.

Select: POLEPLOT ➔ LOCATE POLES

```
> Move cursor(mouse or arrows) to locate pole.(ALT F10
for ID) Place cursor outside the stereonet, and press
Enter.
```

Because we know the exact orientation of the pit *we will enter it by hand instead of using the cursor*. Place the cursor *outside* the stereonet and press the *left mouse button* or *Enter*. You will see the following series of prompts. Answer them as indicated below:

```
> Input Pole ID NUMBER (0 to cancel):  Enter 1
```

```
> INPUT ORIENTATION ( DIP , DIP DIRECTION ):  Enter 45
, 135
```

```
> Pole Label:   Type in Pit Slope
```

```
> Draw Plane on diagram?? (Y or N ... D to delete
pole)  Press Y
```

The plane (great circle) representing the overall pit slope should appear on the stereonet as shown in Figure T2-1.

Contour Plot

Now view the contoured data using **CONTOUR PLOT->UNWEIGHTED PLOT**. View the **CONTOUR LEGEND** and use **Draw Planes** to overlay the pit face on the data, as illustrated in Figure T2-2.

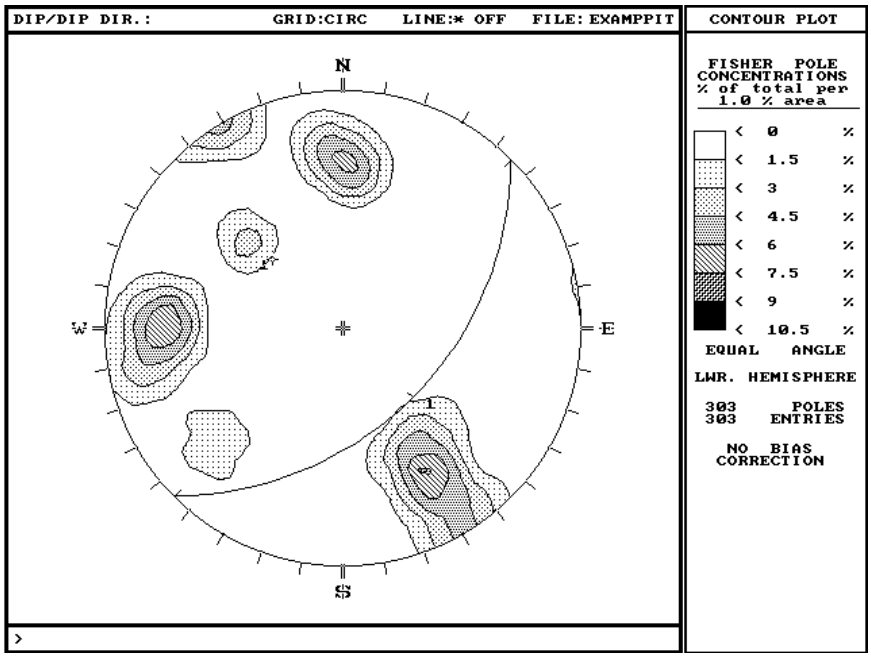
Select: CONTOUR PLOT ➔ UNWEIGHTED PLOT

Select: CONTOUR PLOT ➔ Draw Planes

Select: CONTOUR PLOT ➔ CONTOUR LEGEND

A useful rule of thumb is that any cluster with a maximum concentration of greater than 6 % is very significant. 4-6 % represents a marginally significant cluster. Less than 4 % should be regarded with suspicion unless the overall quantity of data is very high (several hundreds of poles). Rock mechanics texts give more rigorous rules for statistical analysis of data.

Now plot the **WEIGHTED PLOT** and view the legend, as outlined above for the unweighted plot option. Note the change in adjusted concentration for the set nearly parallel to the mapping face, as shown in Figure T2-3.



Plot the UNWEIGHTED and WEIGHTED contour plots. Observe the effect of bias correction on the bedding plane joint set in particular.

Figure T2-2: UNWEIGHTED contour plot with legend. Draw planes option was used to display great circle corresponding to pit slope.

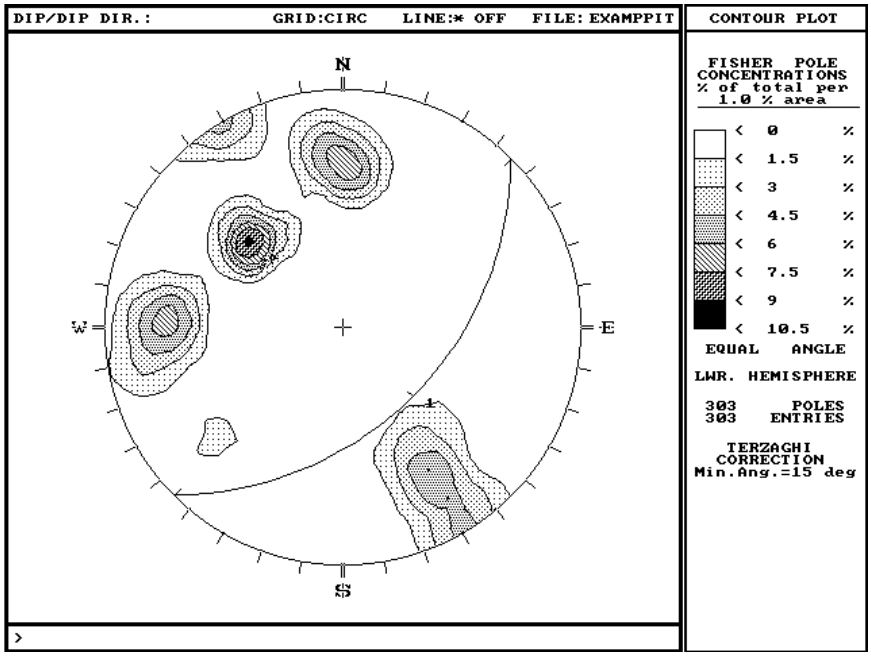


Figure T2-3: WEIGHTED contour plot with legend. Note the change in adjusted concentration for the set nearly parallel to the mapping face, as compared with the previous figure.

Now **RETURN** to **POLE PLOT** in the main menu and select **Contour Plot** from the **POLE PLOT** menu to overlay line contours of density on top of the raw data. If desired **Draw Planes** again to see the pit slope.

Select: POLE PLOT ➔ Contour Plot

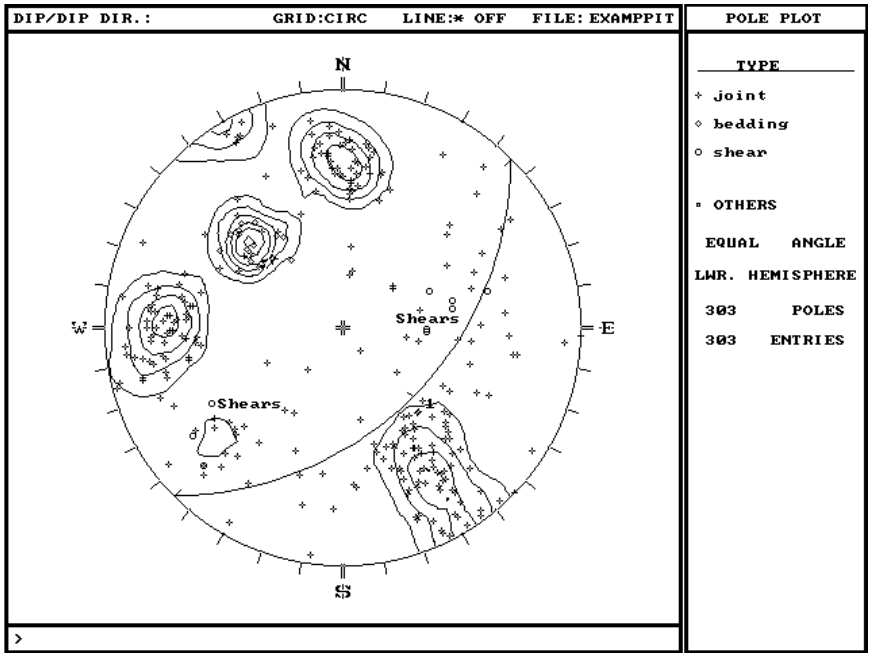


Figure T2-4: Pole plot with overlayed line contour plot. (Note inserted text added with F10 option in LOCATE POLES)

Select:

POLE PLOT ➔ Contour Plot

to overlay a line contour plot on top of the pole plot.

Then use SET WINDOWS to create windowed data sets around the four major data clusters.

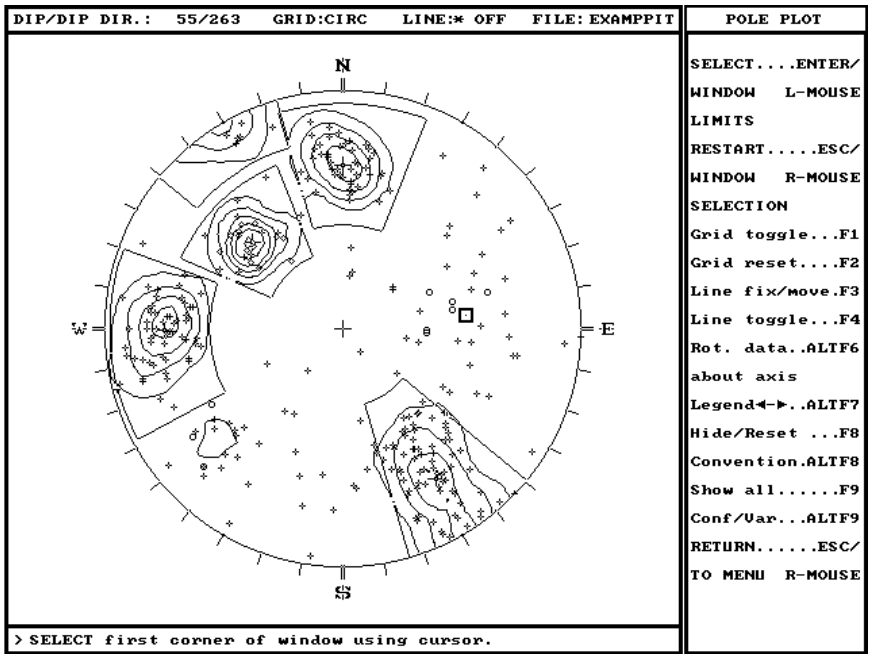


Figure T2-5: Windows formed around the four principal joint sets, using the SET WINDOWS option.

NOTE:

Although the SHEARS are not numerous enough to be represented in the contours, they may have a dominating influence on stability due to low friction angles and inherent persistance.

Notice that the **shears** (see Figure T2-4) in this example are not represented in the contours. This is because the number of mapped shears is small. However, due to the low friction angle and inherent persistance, the shear features may have a dominating influence on stability. It is always important to look beyond mere orientations and densities when analysing structural data.

Next use **SET WINDOWS** to delineate the joint contours. You can do this in the **CONTOUR PLOT** menu or in the **POLE** or **SCATTER PLOT** menus using the **CONTOUR** overlay option. Detailed information on use of the SET WINDOWS option can be found in the previous tutorial, and also in the reference section of the manual.

View the planes using **MAJOR PLANES** option in the main menu. View parameters can be modified at any time using the **SELECT PLANES** sub-option of the **MAJOR PLANES** menu.

FAILURE MODES

Surface Condition

For stability analysis it will be necessary to assume a value for friction angle on the joint surfaces. Use **Track Data** again, this time selecting SURFACE instead of TYPE (also check SHAPE).

Select: TRACK DATA ➔ SELECT COLUMN ➔ Select SURFACE from the list of column titles which will appear in the menu box area

The prompt line will show:

```
> Data is 1. Quantitative or 2. Qualitative (1 or 2)?
Press 2 since Surface is a Qualitative data column
```

*Now use **Track Data** and **List & Histo** to view the SURFACE properties of the joint sets.*

Now use **List & Histo->Data Histogram** to view the surface properties for any or all of the joint sets.

Select: List & Histo ➔ Data Histogram

Since you have created four windows, the prompt line will ask you for the ID number of the window you wish to analyse:

```
> ID number of window to view (0 for all) =  Enter the
ID number which you entered for the joint set at the
lower right of the stereonet (= 4 in this example)
```

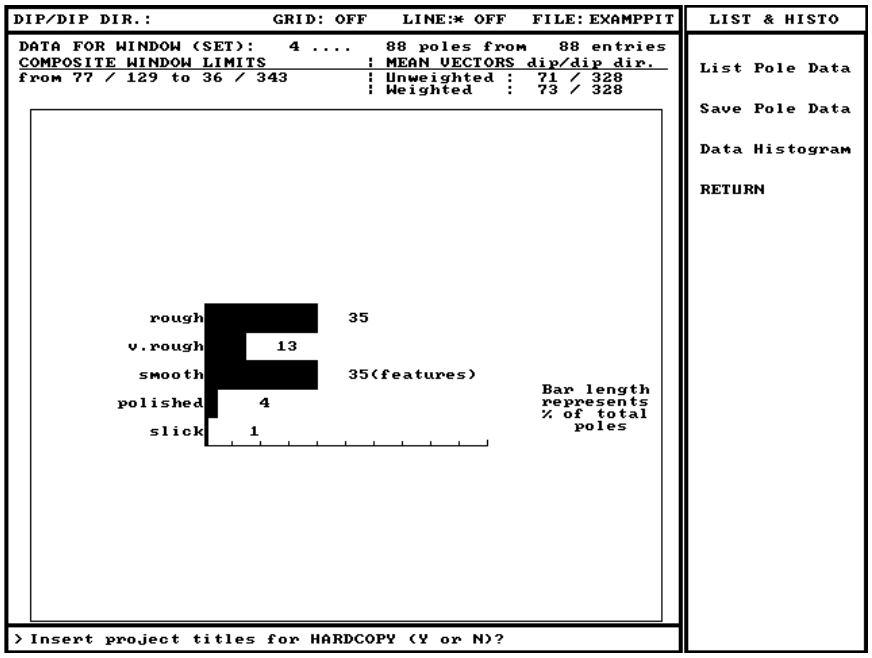


Figure T2-6: Data histogram of SURFACE properties for joint set 4.

The joint set illustrated above is predominantly rough and so a friction angle of 35-40 degrees (a conservative estimate) will be used.

Statistical Info

To add some statistical information to the pole plot at this stage enter **POLE PLOT**->**SET WINDOWS**, and using the ALT-F9 option place VARIABILITY cones around the mean orientations (remember that the shears will be considered separately where appropriate).

Select:

POLE PLOT ➔
SET WINDOWS ➔
ALT F9

*to place variability cones of **one** and **two** standard deviations around the joint sets.*

Select: POLE PLOT ➔ SET WINDOWS ➔ ALT F9 (Conf / Var)

Answer the prompts as follows:

```
> Input ID # of set to analyse: (0 for all)  Enter 0
```

```
> Compute CONFIDENCE ON MEAN(C) or VARIABILITY ABOUT
MEAN (V) ?  Press V
```

```
> CHANGE OVERALL VARIABILITY LIMIT (Y or N)?  Press Y
```

```
> Enter new LIMIT in percent (1-99)  Enter 68.27 (one
standard deviation)
```

```
> Draw Weighted(W) or Unweighted(U) or Both(B)?  Press
W
```

Now repeat the above procedure but use 95 degrees (two standard deviations) at the fourth prompt.

You now have variability cones representing **one** and **two** standard deviations of orientation uncertainty centered on the calculated means. This is illustrated in Figure T2-7 below. The above procedure can be repeated at any time to restore the cones on the plot. The default variability limit is the last one selected.

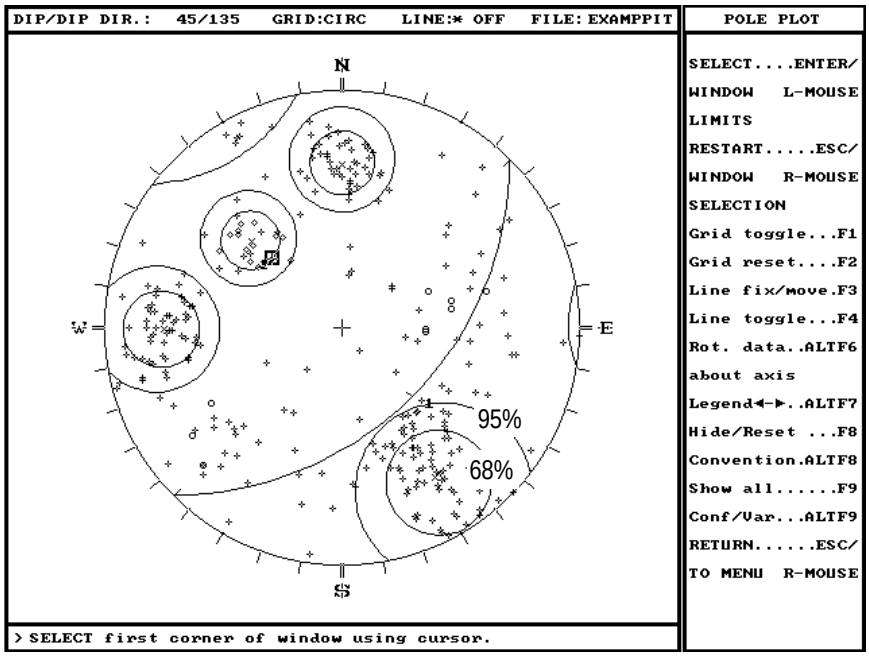


Figure T2-7: VARIABILITY cones representing one and two standard deviations from the calculated (weighted) means for each joint set.

TOPPLING

A TOPPLING ANALYSIS using stereonets is based on:

1) Variability cones indicating the extent of the joint set population

2) A slip limit based on the joint friction angle and pit slope

3) Kinematic considerations

(The following analysis is based on Goodman 1980. See the reference at the end of this tutorial).

Using the variability cones generated above, proceed with a toppling analysis. Assume a friction angle of 35 degrees, based on the surface condition of the joints (see Figure T2-6).

Planes cannot topple if they cannot slide with respect to one another. Place a second plane on the plot using **LOCATE POLES**. As before, place the cursor outside of the stereonet and press *Enter*. At the prompt:

```
> INPUT ORIENTATION ( DIP , DIP DIRECTION ):  Enter 10
, 135
```

Use a DIP of **45** minus **35** equal to **10** degrees — pit slope angle equals 45 degrees and friction angle is 35 degrees. Use a DIP DIRECTION equal to that of the face (135 degrees). Goodman states that for slip to occur, the bedding normal must be inclined less steeply than a line inclined at an angle equivalent to the friction angle above the slope.

Next, use the SMALL CONE angle to place kinematic bounds on the plot. When specifying cone angles, remember that the angle is measured from the cone axis.

Place cursor outside the net and press F6 from within LOCATE POLES.

Select: POLE PLOT ➔ LOCATE POLES ➔ F6 (Draw Cone)

Use a TREND equal to the DIP DIRECTION of the face plus 90 degrees. (135+90=225). Use a PLUNGE of 0. Use a CONE ANGLE of 60 degrees. This will place two limits plus/minus 30 degrees with respect to the face dip direction as suggested by Goodman — planes must be within 30 degrees of parallel to a cut slope to topple. An earlier 15 degree limit proposed by Goodman was found to be too small.

```
> INPUT CONE AXIS (TREND , PLUNGE):  Enter 225 , 0
```

```
> Input small circle cone angle:  Enter 60
```

The zone outlined in Figure T2-8 is the toppling region. Any POLES plotting within this region indicate a toppling risk.

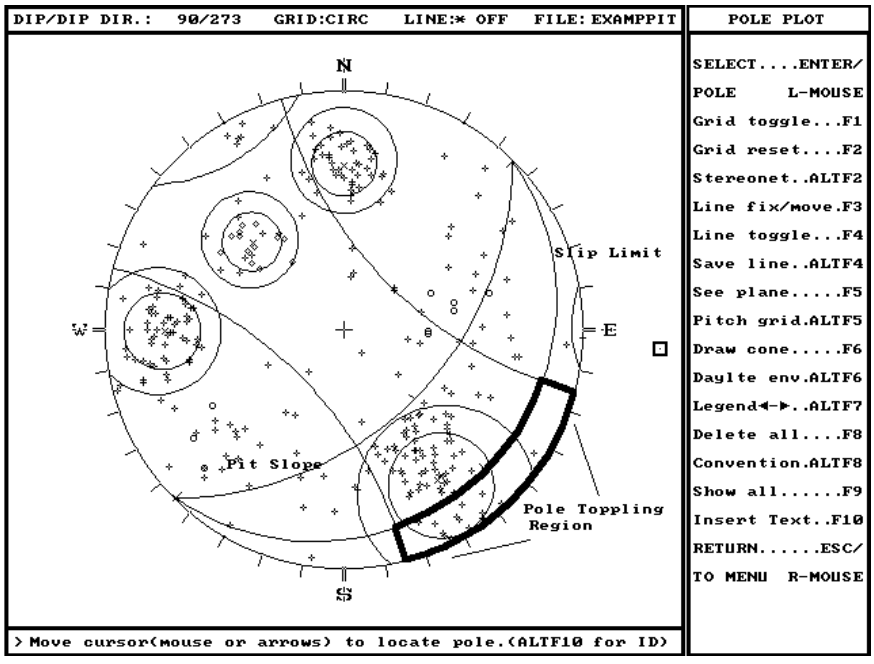


Figure T2-8: Toppling risk is indicated by the relative number of poles within joint set which fall within the outlined pole toppling region. Visual estimate indicates about 25-30% toppling risk for joint set 4, based on the 95% variability cone.

The zone which is bounded by these new curves and which is outlined in Figure T2-8 is the toppling region. Any POLES plotting within this region indicate a toppling risk. Remember that a near horizontal pole represents a near vertical plane.

The two variability cones give a statistical estimate of the toppling risk for the joint set in question. A visual estimate indicates that 25-30 % of the theoretical population of joint set 4 falls within the toppling zone. It could be said that, ignoring variability in the friction angle, there is an approximate toppling risk of 30%. Frictional variability could be introduced by overlaying additional slip limits coresponding to say 30 and 40 degrees.

PLANAR SLIDING

From within **POLE PLOT** select **REDRAW PLOT**. Regenerate the variability cones for 68 and 95 % limits, as described earlier in this tutorial (use SET WINDOWS -> ALTF9).

Select: POLE PLOT ➔ REDRAW PLOT

Select: POLE PLOT ➔ SET WINDOWS ➔ ALT F9 (Conf / Var)

From within **LOCATE POLES**, place a POLE FRICTION CONE at the center of the stereonet using F6 (Place cursor outside of net and press F6).

*A PLANAR SLIDING analysis can be performed using the Draw Cone and Daylight Envelope options in SET WINDOWS along with the Variability cones, to test for combined **frictional** and **kinematic** possibility of planar sliding.*

Select: POLE PLOT ➔ LOCATE POLES ➔ F6 (Draw Cone)

Select a TREND of 0 and a PLUNGE of 90. Select a CONE ANGLE equal to the friction estimate of 35 degrees.

```
> INPUT CONE AXIS (TREND , PLUNGE):  Enter 0 , 90
```

```
> Input small circle cone angle:  Enter 35
```

Any POLE falling within this circle represents a plane which could slide if kinematically possible.

To test for kinematics (i.e. a rock slab must have somewhere to slide into – free space), place a DAYLIGHT ENVELOPE for PLANE 1 (the pit slope in this example) using ALT F6 in **LOCATE POLES**.

Select: POLE PLOT ➔ LOCATE POLES ➔ ALT F6 (Daylight Envelope)

Any pole falling within this envelope is kinematically free to slide if frictionally unstable.

The **cresent** shaped zone formed by the daylight envelope and the pole friction circle encloses the region of planar sliding. Any poles in this region represent planes which can and will slide.

*Note that a POLE friction cone angle is measured from the **center** of the stereonet.*

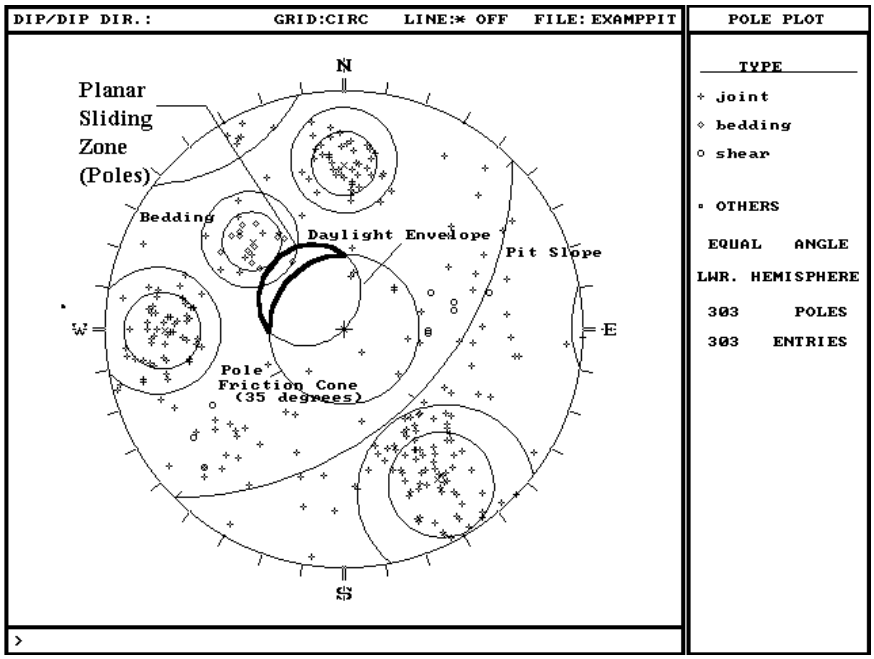


Figure T2-9: Planar sliding zone is represented by crescent shaped region. Only a small area overlaps the bedding joint set, therefore the risk of planar sliding is minimal.

***NOTE**:*

We have been using the EQUAL ANGLE projection option throughout this analysis.

When making visual estimates of clusters and variabilities it is actually more appropriate to use EQUAL AREA projection to reduce areal distortion and improve visual estimates.

Again, the variability cones give a statistical estimate of failure probability. Only a small percentage (< 5%) of the bedding joint set falls within this zone.

Planar sliding is unlikely to be a problem.

NOTE: We are using an EQUAL ANGLE projection for this analysis. When making visual estimates of clusters and variabilities it is actually more appropriate to use an EQUAL AREA projection to reduce areal distortion and improve visual estimates.

WEDGE SLIDING

It has been shown that a sliding failure along any of the joint planes is unlikely. However, multiple joints can form **wedges** which can slide along the intersection line between two planes. To analyse for sliding along intersections, use **MAJOR PLANES->DRAW PLANES** to plot all of the planes (pit slope plus all calculated planes from the windowed data sets).

Select: MAJOR PLANES ➔ DRAW PLANES

If not all appropriate planes have been toggled for plotting (see Figure T2-10) then use **SELECT PLANES** to toggle on (or off) the appropriate selections. See reference section of manual for a description of the **SELECT PLANES** option.

Select: MAJOR PLANES ➔ SELECT PLANES

On top of this plot use **LOCATE POLES**->F6 to place a friction cone about the center of the net.

WEDGE SLIDING may occur if the mean joint set orientation intersections fall within the zone defined by the friction cone and pit slope.

Select: MAJOR PLANES ➔ LOCATE POLES ➔ F6 (Draw Cone)

As before, select a TREND of 0 and a PLUNGE of 90. NOTE: This time we are not dealing with poles but an actual sliding surface or line so the friction angle (35 degrees) is taken from the *equator* of the stereonet and *not from the center* as before, therefore enter **90 - 35 = 55** degrees when prompted for the small circle cone angle.

```
> INPUT CONE AXIS (TREND , PLUNGE):  Enter 0 , 90
```

```
> Input small circle cone angle:  Enter 55
```

The zone OUTSIDE the pit slope but enclosed by the friction cone represents the zone of wedge (intersection) sliding. Any plane intersections (highlighted by black dots in Figure T2-10) which fall within this zone will be unstable. This is not the case in this example, therefore wedge sliding should not be a problem.

*Note that a PLANE friction cone angle is measured from the **perimeter** (equator) of the stereonet.*

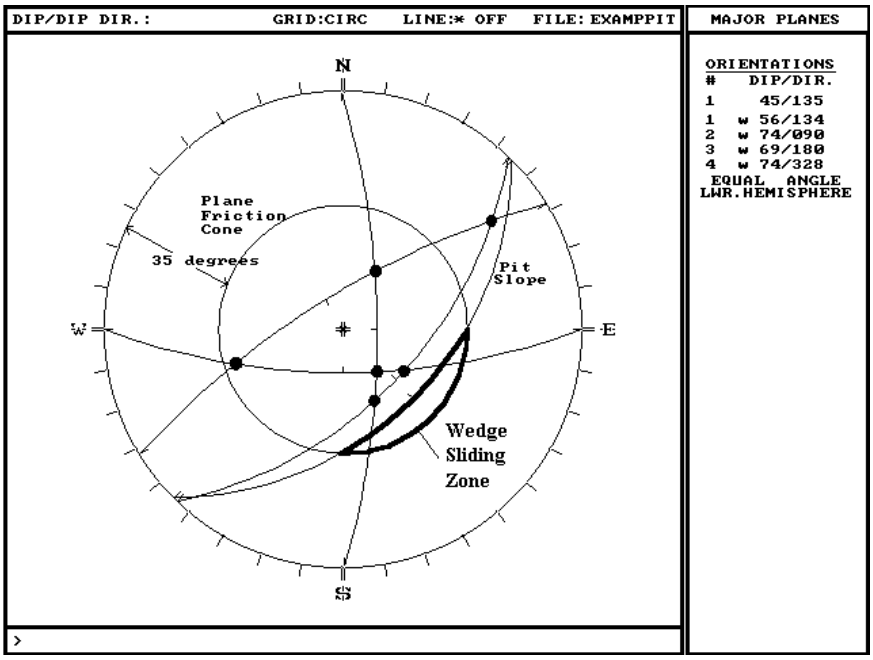


Figure T2-10: Wedge sliding zone is represented by crescent shaped region. Since no plane intersections fall within this region, wedge sliding failure should not be a concern.

DISCRETE STRUCTURES

Finally you should analyse the shear zones mentioned before. If these shears occur in proximity to one another they may interact to create local instability.

Perform an analysis similar to the one above using discrete combinations of shear planes (individually selected using **LOCATE POLES**). It can be seen in this example that for this pit slope configuration the risk of wedge failure along the shear planes is low.

Using the procedure described for a wedge analysis (above), the stability of discrete combinations of shear planes, or of shear planes with the mean joint orientations, may be analysed.

It is left as an exercise then to determine whether the shears will interact with any of the joint sets to create an unstable wedge. For this exercise, plot the calculated mean planes and the pit slope using **POLE PLOT-> DRAW PLANES** (use **MAJOR PLANES->SELECT PLANES** if needed to toggle planes on or off). In **LOCATE POLES** create an outer wedge friction cone as in the previous analysis (35 degrees from the OUTSIDE of the net) and then press F5. This will produce a rubber-plane which will follow the cursor. Use this rubber plane to test each shear for interactions with the joints. Place the cursor over each shear pole and the rubber plane will indicate the shear plane.

Increased Local Pit Slope

Repeat these analyses for steeper local slopes. If the overall slope is to be maintained at 45 degrees (see the first page of this tutorial), the local bench slope will have to be increased to accomodate the roadways. What is the critical local slope ?

Examine the stability of other pit slope orientations.

Assume that the joint sets are consistent throughout the mine property, and perform the analyses described in this tutorial using 45 degree increments of dip direction around the pit wall.

Other Pit Orientations

Assume that the joint sets are consistent throughout the mine property. Are there any slope orientations that are more unstable than others? Examine slope dip directions in 45 degree increments around the pit wall.

HINT: if you have AutoCAD, output pole or contour plots with mean planes and the selected pit slope orientation. These can be imported into a plan of the pit and placed in their appropriate orientations for quick reference.

Reference for Tutorial 2

Goodman, R.E. 1980. Introduction to Rock Mechanics (Chapter 8), Toronto: John Wiley, pp 254-287.

TUTORIAL 3 – Oriented Core and Rockmass Classification

This tutorial uses the example file **EXAMPBHQ.DIP**, which can be found in your \EXAMPLES subdirectory. A brief description of this file can be found in the Example Data Files chapter at the beginning of this tutorial manual.

This tutorial assumes some familiarity with DIPS. For a review of the basics, see the Quick Start tutorial in Part 1 – Getting Started, or consult the Reference Section (Part 2) of the manual.

EXAMPBHQ.DIP Data File

The EXAMPBHQ.DIP data file header is as follows:

```
MAIN CAVERN: STRUCTURAL SURVEY & ROCKMASS CLASSIFICATION
TERAWATT POWER CORP.    ORIENTED CORE SURVEY.   13/06/93
2 (traverses are oriented core boreholes)
* Reference line is bottom of core
* Two holes: (see DIPS manual for definition  borehole orientations)
1;BOREHOLE;180;135;040;BH# TPC1a, 40 E, Plunge 45, Length 70m
2;BOREHOLE;180;160;135;BH# TPC2a, 45 E, Plunge 70, Length 82m
* Data in file is in local borehole angles: alpha & beta
* Global flag below indicates which global orientation convention
* will be used to represent processed data in DIPS plot and output files
DIP/DIPDIRECTION
0 (no declination - can be used to correct borehole orientations)
NO QUANTITY
4 Extra Columns:
* Traverse = Borehole number
* CORE POSIT = distance from collar of borehole
* INTCT LNTH = length  of intact core from measured joint to next joint
* NGI-JA = NGI Q Classification: Alteration Index
* NGI-JR = NGI Q Classification: Roughness Index
NUMBER;BH-alpha;BH- beta;TRAVERSE;CORE POSIT(m);INTCT LNTH(m);NGI-JA;NGI-JR;
     1       72       19        1         35.10          0.10      1    1.5
     2        3      234        1         35.36          0.26      3      1
     3        6       37        1         35.45          0.09      1      3
     4        6       37        1         35.50          0.05      2      3
     .
     .
   650       57      290        2         80.95          0.21      2      2
    -1   end of file flag
```

Borehole Traverse Lines

First note the two (borehole) traverse lines in this file (lines 4 and 5 ignoring comments).

See the DIPS DATA FILE chapter in the REFERENCE section (Part 2) of this manual for detailed illustration of the borehole orientation requirements for DIPS input.

Traverse 1 indicates borehole core data. The first traverse orientation (180) denotes a reference line that is 180 degrees from the top of the core (i.e. at the bottom of the core as it would be in situ). The second orientation (135) indicates that the borehole was drilled at 135 degrees from the vertical or with a plunge of 45 degrees. The third orientation indicates that the downhole direction has an azimuth (CW angle from compass north) of 40 degrees. Traverse 2 also has a bottom of core reference mark and is drilled at 160 degrees from vertical at an azimuth of 135 degrees. *See the Dips Data File chapter in the Reference section (Part 2) of this manual for detailed illustration of the borehole orientation requirements for DIPS input.*

Declination

Note that in this file there is no declination. Declination would, if present, be applied to the borehole trends (azimuths).

Global Orientation Flag

The orientation flag indicates that the borehole data will be converted to DIP and DIP DIRECTION with respect to the global system.

Extra Columns

Four extra columns are present including:

1) core position from collar,

2) intact length (calculated in a spreadsheet from position or recorded directly) between adjacent joints,

3) JA

4) JR.

The latter measurements are qualitative indices of roughness and alteration taken from the Q Classification by Barton and can be quickly recorded during core logging. Consult any modern rock enginneering text for a definition of these terms.

Borehole Orientation Pairs – Alpha and Beta

The orientations alpha and beta are core joint angles and are measured from the **core axis** and from the **core reference line** respectively. See the Dips Data File chapter in the Reference section (Part 2) of the manual for detailed illustrations.

Rock Tunneling Quality Index – Q

The rock tunneling quality index Q is defined as:

$$Q = (RQD/JN)(JR/JA)(JW/SRF)$$

The purpose of this tutorial is not to discuss rock mass rating systems. Consult any modern rock engineering text (see the references at the end of this tutorial) for more information if required.

Set water parameter JW = 1 (dry) and stress reduction factor SRF = 1 (moderate confinement - no stress problems) for this example.

Determination of RQD

Use a spreadsheet and the INTACT LENGTH extra data column to determine a value for RQD

Using the intact lengths, RQD (Rock Quality Designation) can be calculated using a spreadsheet. RQD is taken as the:

$$\frac{\text{cumulative length of core pieces greater than 10cm}}{\text{total length of core.}} \times 100$$

Determination of JN

JN is the joint number. To obtain a value for this parameter, **LOAD** the data file into DIPS and **COMPUTE**. Use the **CONTOUR PLOT-> WEIGHTED PLOT** to determine the number of (well) defined joint sets. This is shown in Figure T3-1. DIPS will automatically convert the alpha and beta values to dips and dip direction based on the traverse (borehole) orientation data.

Select: FILES ➔ LOAD DATA FILE

Select: COMPUTE

Select: CONTOUR PLOT ➔ WEIGHTED PLOT

Select: CONTOUR PLOT ➔ CONTOUR LEGEND

NOTE: use the **SET OPTIONS** settings outlined in the previous tutorial. It may be necessary to toggle some of these settings if you have previously been using different ones.

Create a WEIGHTED contour plot of the data.

The three well defined joint sets result in a Barton JN value = 9

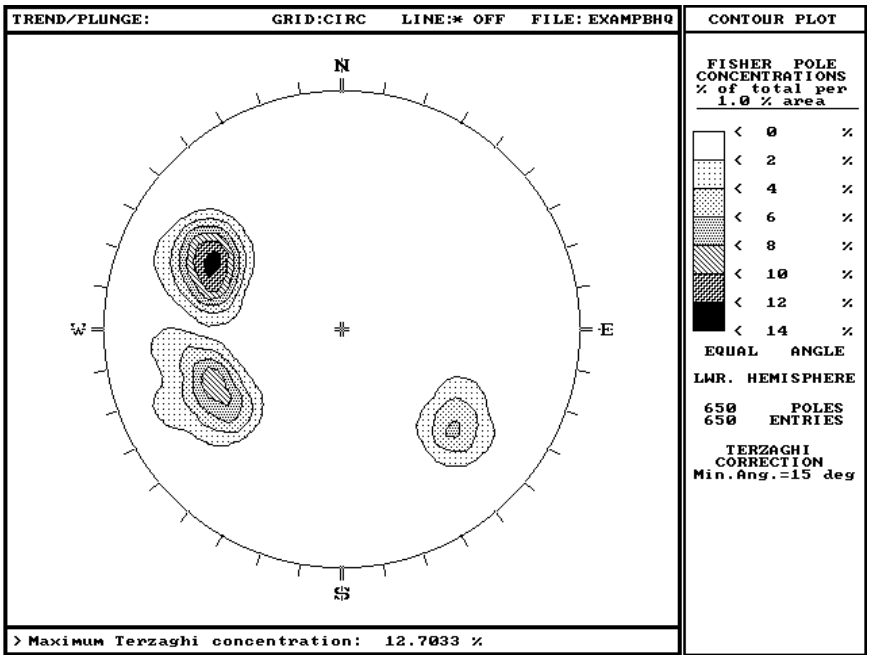


Figure T3-1: Contour plot of combined borehole data, converted to global orientations. Note 3 well defined joint sets resulting in Barton's JN of 9.

Use **SET WINDOWS** and **DRAW PLANES** to plot the mean joint planes. (See Reference manual (Part 2) or Quick Start tutorial (Part 1) for instructions). Use F4 and ALT F4 in SET WINDOWS to place a proposed tunnel axis on the figure (asssume a tunnel trend of 20 degrees).

*Superimpose the **tunnel axis** on the **mean joint planes** to judge the critical joint set for Q classification.*

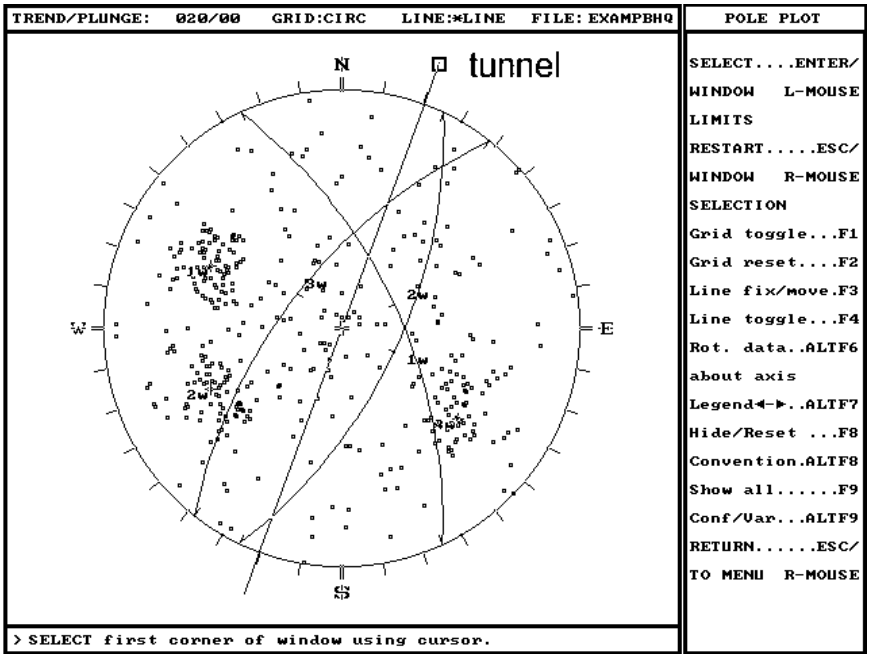


Figure T3-2: Mean planes with superimposed tunnel axis.

It is not immediately obvious which is the critical joint in this case. However, it can be shown that joint set 1 is most likely to prevent any development of tension in the roof and therefore will reduce the self supporting nature of the tunnel roof. Let us use this then as the critical joint set for Q classification. Note the sliding wedge (closed triangle in the above plot formed by the three joint sets) which appears in the roof of the tunnel.

Estimation of JR and JA

The next step then is to use **Track Data** to look at JR and JA. These indices can be viewed as either qualitative or quantitative. Quantitative analysis allows a mean calculation and so is prefered. Select JR first and then repeat the procedure with JA.

Select: TRACK DATA ➔ SELECT COLUMN ➔(select JR column to track as QUANTITATIVE data)

Go to the **List & Histo** option and select **Data Histogram**. When prompted select joint set 1 for plotting for this example.

Select: List & Histo ➔ Data Histogram ➔(enter Joint Set 1 at prompt line)

Use Track Data to track the JR column as QUANTITATIVE data. Then use List & Histo ➔ Data Histogram to estimate a mean JR value for the critical joint set.

Repeat the procedure for the JA data column.

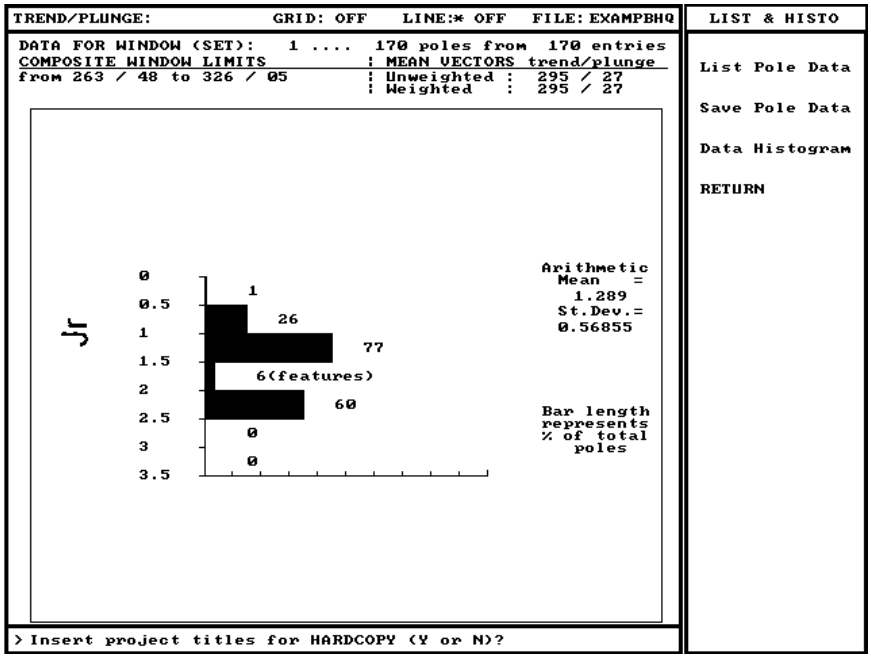


Figure T3-3: Joint Roughness, JR, plot for joint set 1.

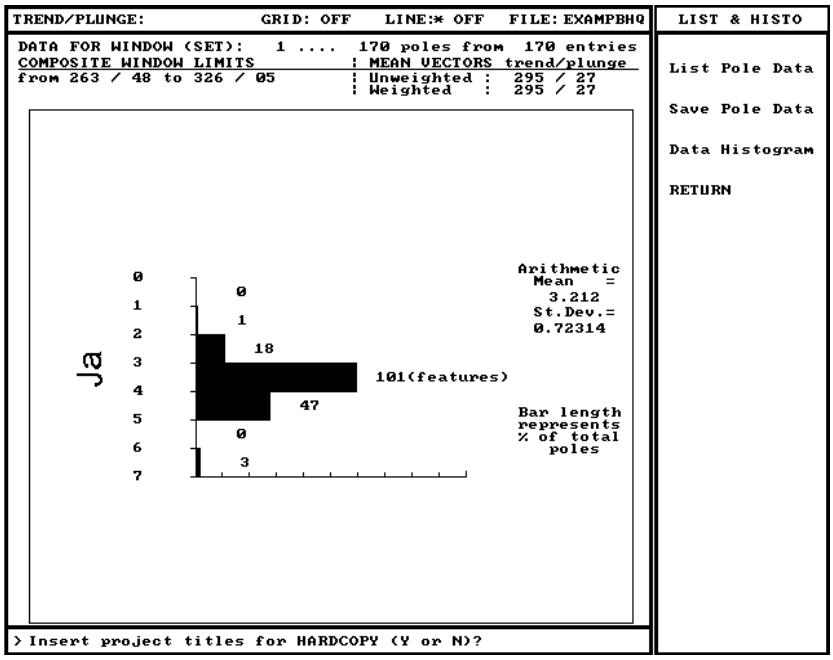


Figure T3-4: Joint Alteration, JA, for joint set 1.

For the purposes of classification, a JR of 1 to 1.5 and a JA of 3 to 4 would be adequate in this example.

Calculation of Q Values

RQD, as calculated in the spreadsheet was 60 %. Using the JN value of 9 and the upper and lower limits for JR and JA (see above), gives:

- a lower Q of (60 / 9)(1 / 4)(1 / 1) = 1.7
- an upper Q of (60 / 9)(1.5 / 3)(1 / 1) = 3.3

This range of values can now be used for further empirical support design according to Barton's design charts – see Figure T3-5. Real values for JW may be evaluated qualitatively from borehole inflow notes. SRF can be determined from the depth of the proposed excavation according to Barton.

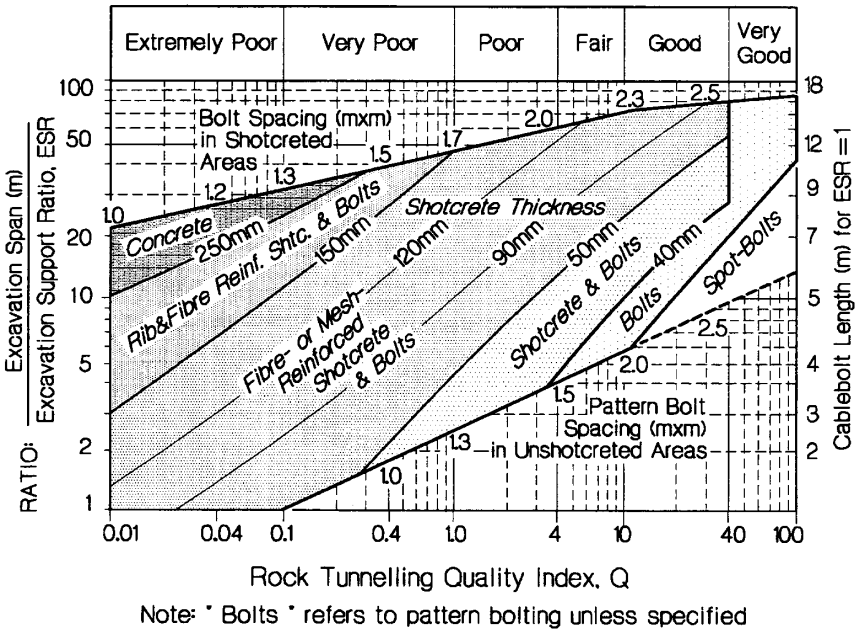


Figure T3-5: Tunneling support guidelines, based on the tunneling quality index Q (bolt lengths modified for cablebolting). Ref. 1, after original Ref. 3 (see below).

References and Further Reading for Tutorial 3

1. Hutchinson, D.J. and Diederichs, M. 1996. Cablebolting in Underground Mines, Vancouver: Bitech. 400 pp.

2. Hoek, E., Kaiser, P.K. and Bawden, W.F. 1995. Support of Underground Excavations in Hard Rock. Rotterdam: Balkema.

3. Grimstad, E. and Barton, N. 1993. Updating the Q-System for NMT. *Proc. int. symp. on sprayed concrete - modern use of wet mix sprayed concrete for underground support*, Fagernes, (eds Kompen, Opsahl and Berg). Oslo: Norwegian Concrete Assn.

Index