GEOLOGICAL SURVEY OF CANADA

OPEN FILE 2255

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FORTRAN program using UNIRAS for plotting SPANS and EASI/PACE images

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CONTENTS (Cont.)

INTRODUCTION

During 1987, the Mathematical Applications to Geology Section (Mineral Resources Division) purchased two PC-compatible software packages for spatial data integration. One is an image analysis package called EASI/PACE (PCI, 1988); the other is a geographic information system called SPANS (TYDAC, 1988). Although equipped to plot raster images in colour on table-top plotters (such as NEC PinWriter or Tektronix 4696), these packages do not include interfaces to the large format output devices available either at the GSC Computing Science Centre (Versatec) or at Environment Canada (Optronics 4040). The Optronics 4040 is particularly useful because it produces transparencies that, in conjunction with colour separation, are suitable for colour printing.

The computer program, PLOTTER, was developed for plotting raster images from EASI/PACE or SPANS on the Versatec or Optronics. It is written in VAX FORTRAN Version 4, and uses GIMAGE subroutines from the UNIRAS plotting package. It was created on a VAX 8700 computer at the Computing Science Centre, under the VMS Version 4.4 operating system.

Image files from MORPHOLOG (Lay, 1983), an image analysis package used on the VAX, can also be plotted. MORPHOLOG files have a very simple format, which is often useful as an intermediate file structure for users with other file formats not recognized by PLOTTER.

PLOTTER can use either red, green, and blue (RGB) or cyan, magenta, and yellow (CMY) input colour schemes; raster files can have dimensions up to 4096 lines and 4096 pixels per line; images may be scaled up or down to any size and can be placed anywhere on the paper; titles and legends can be drawn and registration marks can be placed on the the hard copy output outside the image; multiple files can be used to produce a mosaic of images.

The following sections of this document describe input file formats, adding annotations, methods of handling colour palette information, and a brief user guide. The source code is included on a diskete in Appendix B, so that users can modify the program for their own applications.

INPUT FILES

The coordinate scheme used in PLOTTER for describing raster (grid) data asumes an origin in the upper left corner (of the screen or paper) with the x-direction increasing downwards and the y-direction increasing towards the right. Grid rows (lines) are parallel to the y-axis, and grid columns (pixels) are parallel to the x-axis. Maximum dimensions are defined by the number of rows or lines, and the number of columns or pixels per line (see Figure 1). These conventions are not universal and care should be exercised in using x- and y-coordinates; rows and columns are usually safer conventions.

It is recommended that the transfer of image files from the PC to the VAX should be carried out using an ETHERNET link. Crosstalk and PROCOMM have been found to be extremely slow for transferring large raster data files; it was also found that these programs insert record-control bytes into files being uploaded from PC to VAX, which render them unreadable by the PLOTTER program.

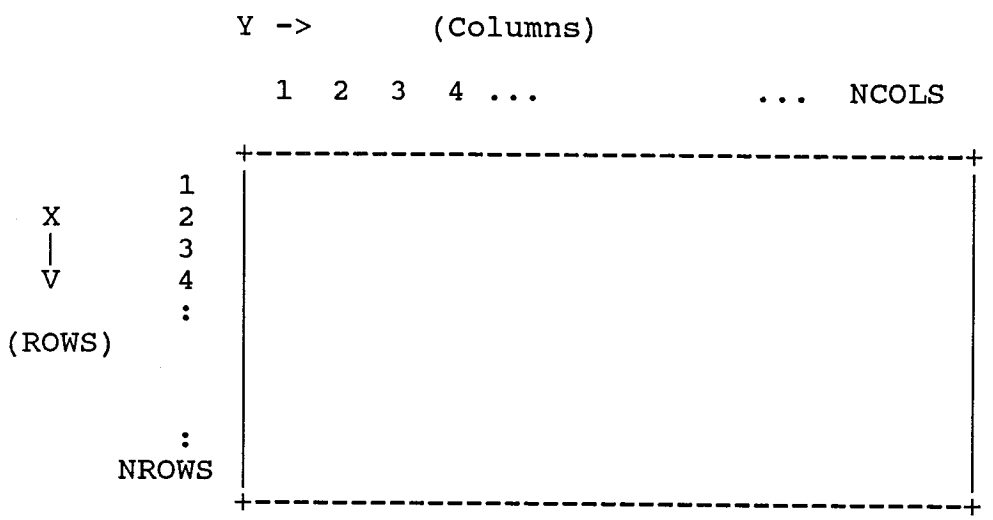

Figure 1. Grid Conventions Used in PLOTTER

MORPHOLOG Files

MORPHOLOG images used unsigned 2-byte integers to represent each pixel. The record length in bytes is the number of pixels times two. Image data is preceded by a single header record containing the number of columns (4 bytes) and the number of rows (4 bytes). Each image record corresponds to a line of image data, so that the total number of records is the number of rows plus one. The files are unformatted.

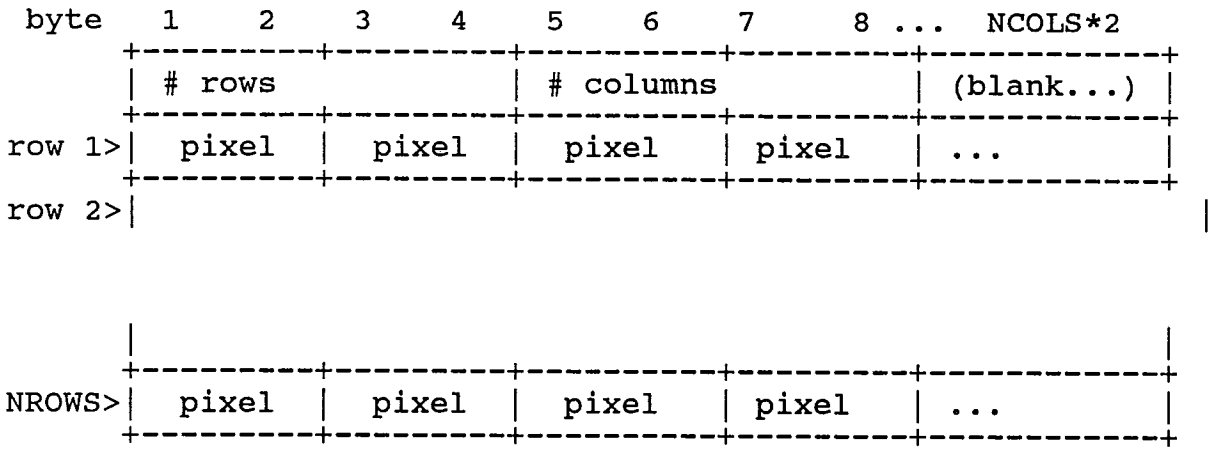

Figure 2. Morpholog Format

EASI/PACE BSQ Files

These band-sequential files, with extension .PIP, are generated on a PC from .PIX image files by using the IPPI command in EASI.

The BSQ format is very similar to the row-order MORPHOLOG format, except that the pixel data consists of one-byte unsigned integers instead of two bytes. Its record length is always 512 bytes, regardless of the number of pixels per line, and each line begins on a new 512-byte record. The 512-byte header record can contain additional information besides image size which is not used by plotter (See Table 1).

FIELD	TYPE	VALUES REQUIRED BY PLOTTER	DESCRIPTION
1	i*4	(up to 4096)	# lines in image
2	i*4	(up to 4096)	# pixels per line
3	i*4	1	# image channels
4	r*4	(any value)	pixel width in m
5	r*4	(any value)	pixel height in m
6	c*12	(any value)	ASCII creation date
7	i*4	(up to 8)	# 512B records/row
8	c*48	(any value)	ASCII file label
9	r*4	(any value)	UTM x-origin
10	r*4	(any value)	UTM y-origin
11	i*4	8	bits per pixel
12	c*412	(any value)	reserved for future
13	i*4	1	FLSO control

Table 1. BSQ File Header Format

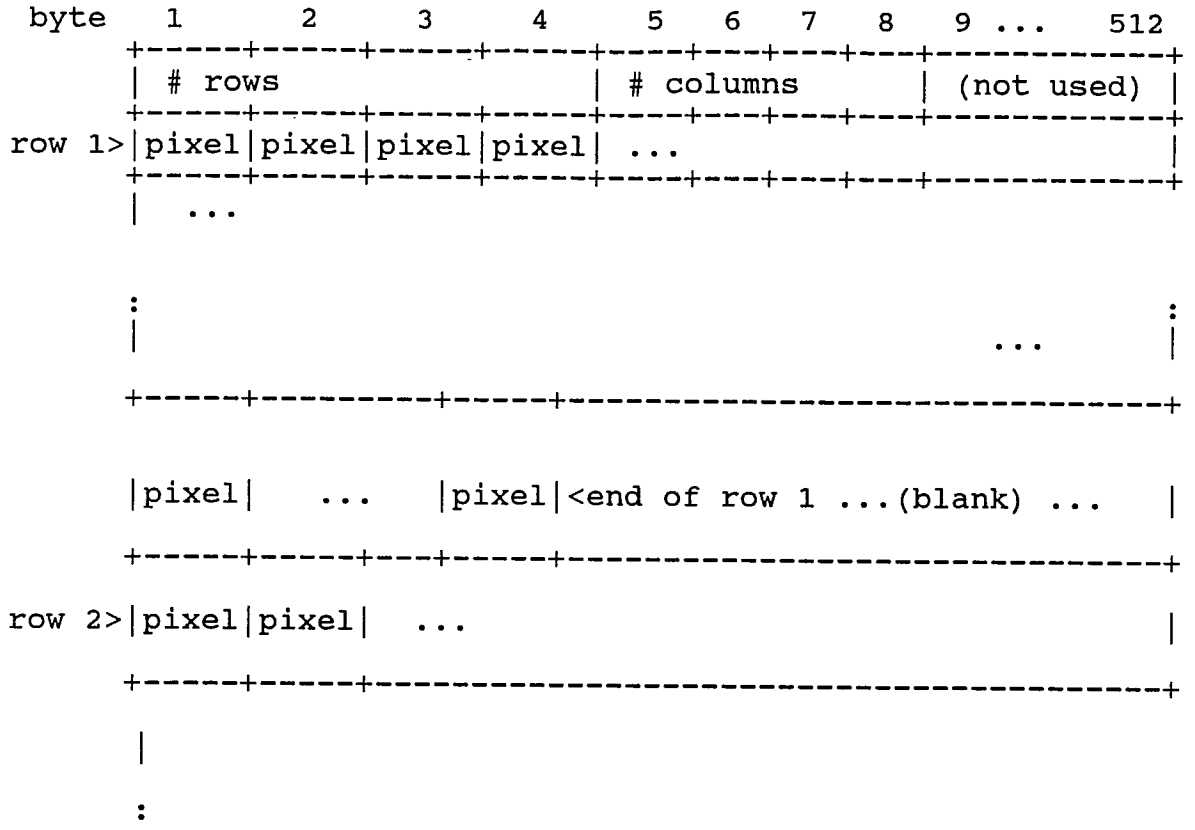

Figure 3. BSQ Format

SPANS Files

SPANS uses two file formats that can be input to PLOTTER. The first is an RGB screen dump in runlength-encoded form, called a 'browse' file. Browse files have the extension .CUT, and represent a number of lines and pixels that is determined by the graphics board being used for SPANS displays. For example, the PRO-1280 board gives .CUT files with 1280 columns by 1024 rows, whereas the Number Nine Revolution board gives 512 columns by 512 rows.

Each image pixel is treated as a pointer to an entry in a colour lookup table of RGB values. This colour table is stored in a separate file that has the extension .BIC . Every .CUT file is paired with a .BIC file in this way.

The browse (CUT/BIC) files can contain legends, titles, and annotations, as well as point and vector overlays on raster images. They require no further annotation by PLOTTER, and the colour lookup table is already defined.

The format of .CUT files is identical to that of the Media Cybernetic's CUT file format. The details of the format will not be presented here, but the interested programmer can read the FORTRAN code in the included file DECODE.FOR to find out how the

run-length encoded data is handled.

Because SPANS browse files are essentially screen dumps, they are limited in their resolution. An alternative raster format, .RNL, can also be exported from SPANS. It can have a much greater number of rows and columns, but cannot be annotated within SPANS. The .RNL files can have a number of different storage formats. The format for a particular file is recorded in a header file (extension .RNH).

PLOTTER includes code for reading and plotting 8-bit, un-encoded release version of the program. If users choose to reinstate the code, they should note that since no colour palette is automatically generated for .RNL files, they will have to create their own (see Section 3 "Generating Colours"). They will also need to add annotations within PLOTTER (see Section 4 "Annotations").

Here are some further tips for users generating raster files in SPANS for export to PLOTTER:

1) Pixels of value 0 (background) appear black on the screen, but white on plotter paper. Areas of the image which happen to be black on the screen, and therefore hidden when surrounded by background, will become glaringly visible when plotted. Similarly, white features which are visible against the screen background may

disappear on the paper (unless they are text/annotations with colour value 255 - see below).

2) Pixels with colour value 255 (text/annotations) will always be plotted in black, no matter what colour they may have in SPANS. Therefore, pay attention to the colour of the area over which text is superimposed on the SPANS screen.

3) Due to limitations of the GIMAGE plotting routines used by PLOTTER, you are restricted to using a palette ranging from 1 to 90 colour values. Other than background pixels of value 0, or text/annotations of value 255, every pixel should therefore be in the range 0 - 90.

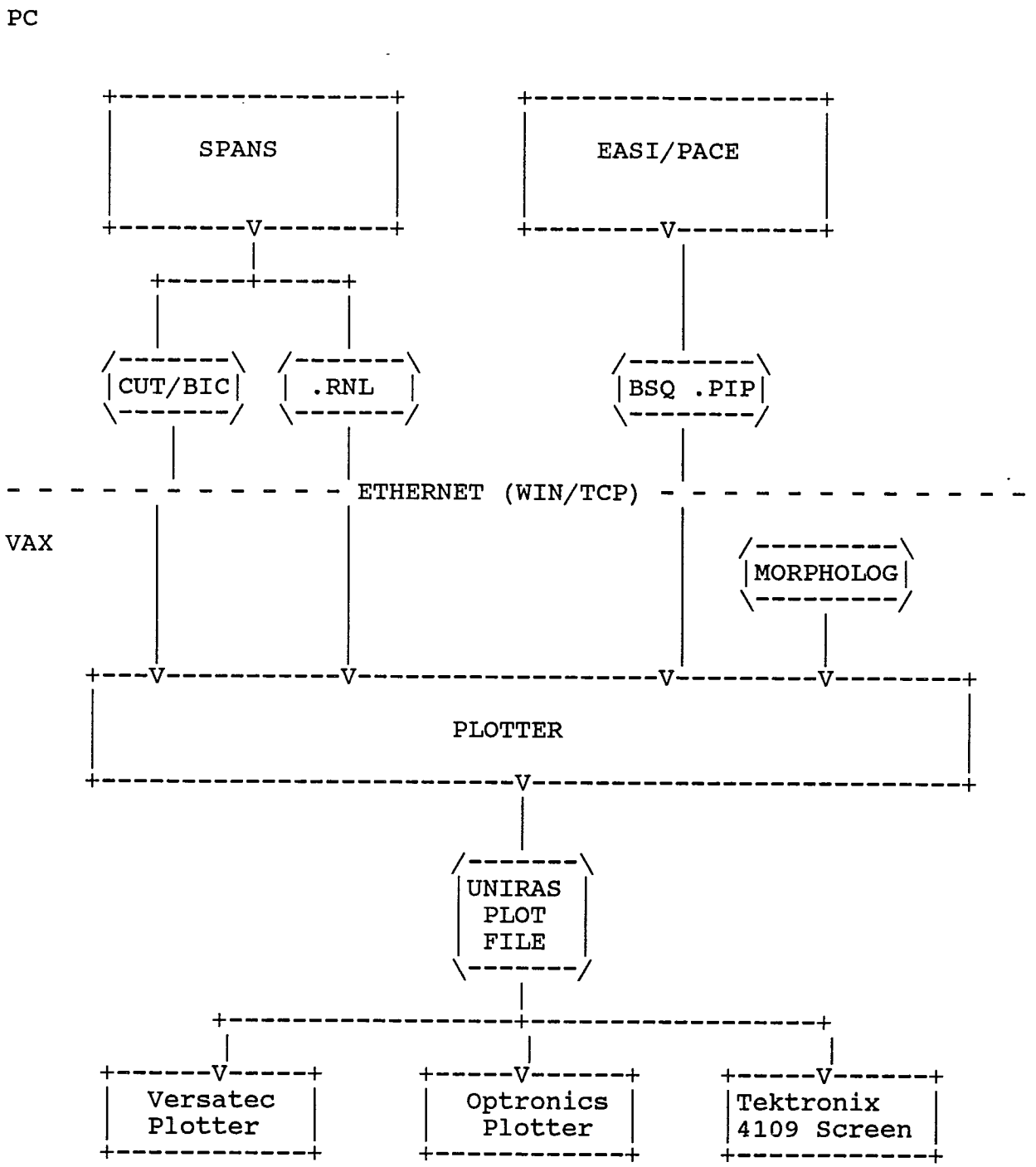

Figure 4. Schematic of PLOTTER Input/Output

GENERATING COLOUR

Colours can be plotted with your image in two different ways: (i) one to three image files can be used as direct Red-Green-Blue (RGB) or Cyan-Magenta-Yellow (CMY) channel intensity values; or, (ii) a single file's pixels can reference an RGB or CMY colour palette. Method (i) is the normal route for BSQ files, and (ii) is normally for SPANS files.

The PLOTTER program handles either RGB or CMY colour information equally well, but the user should remember that colours automatically translated from RGB to CMY by the UNIRAS routines used by PLOTTER will seldom be plotted on paper exactly as they appear on a colour monitor. Therefore, trial runs followed by slight colour adjustments will probably be necessary to get really "good-looking" plots. A colour chart in hard copy form is very useful for selecting RGB combinations that will yield good colours on output.

Three-Channel Image Files

This can be used for remotely sensed data where three image channels are assigned to three colour colour channels (eg. red, green, and blue) to produce a colour image. The pixel values from each one of the three files are treated as intensities for one colour channel. The pixel intensities must be between 0 and 255, where 0 denotes the lack of a colour and 255 means it will be plotted at full strength. UNIRAS approximates colour intensities over the full 0-255 input range by using various dithering patterns.

Typically, the channels have been enhanced prior to uploading, so that a 1:1 ratio of pixel value to colour intensity is assumed. However, lookup tables (in the form of palette files) can also be generated (see below).

Using this colour option, if only one image file is used, it will be copied by PLOTTER into all three channels automatically. A black-and-white image of a single file can therefore be produced. This can also be accomplished before the fact by producing three identical files and treating them as separate channel files in PLOTTER.

Colour Palettes for Single Channel Files

The colour lookup table used when plotting a single data file can come from either of these sources:

(i) Table is loaded by reading a palette file of type .PAL as described below;

(ii) Table is loaded by reading a SPANS BIC file. A .PAL file is created by PLOTTER at the same time, which can be used for subsequent plots of the same data file.

When using a colour lookup table, only the values 1 to 90 are used by the GIMAGE routines called by PLOTTER. Other than background pixels (colour number 0), and text/annotations (colour number 255), every pixel value should have a value (colour number) in that range. In SPANS, this can be accomplished by creating palettes which do not use more than 90 classes.

Format of .PAL Files

PAL files, which are read by PLOTTER to obtain colour lookup table values, are ASCII, and can therefore be readily edited, whereas BIC files are binary.

SPANS keeps all of its internal palettes in a file called PALET.DAT, from which it creates .BIC files whenever .CUT files are created. There is a program, called GETPALET, which can extract colour information from PALET.DAT and create .PAL files on a PC (see Appendix C "Other Programs"). While not normally used, it may be useful for plotting .RNL files or for using an alternate palette to the .BIC corresponding to a particular .CUT browse file.

PAL files have the following format:

Colour number Red Green Blue

or else,

Colour number Cyan Magenta Yellow

where all numbers are integers. The colour number values should be in increasing order from 1, and the colour values themselves should be from 0 to 255. Colour value numbers greater than 90 in a .PAL file will be ignored.

Here is a sample fragment of a .PAL file:

```
1       0      0    255
2       0    255    255
3      80    255      0
4     100    100    100
5     255    100      0
6     255      0      0
            .
            .
            .
```

PAL files cannot skip a particular colour, for example, by defining only odd colour numbers, but there may be less than 90 colours defined. In the latter case, it is up to the PLOTTER user to ensure that image files do not reference colour values that are beyond the range of the colour table as loaded.

PLOT ANNOTATION

Any of the following can be added to your plotted image: titles centered at the bottom; a legend to the upper right; comments at the lower right; and registration marks at all four corners. See Figure 5.1 below for a schematic diagram of the annotations. See Appendix A "Sample Plots" for actual PLOTTER output of annotations.

Titles

This consists of a primary title centered just below the image, in large text, with a slightly smaller secondary title beneath.

Legend

This is located at the upper right of your image, taking up to four-fifths of the image height. It contains an underlined legend title, up to 12 colour theme boxes with descriptive titles, an optional arrow showing the bearing of true north, and an optional map scale.

Comments

Up to five lines of comments can be plotted in small print at the lower right of your image.

Registration Marks

These are to assist in recombining the four colour separations produced by an Optronics plotter. They appear outside each corner of the image.

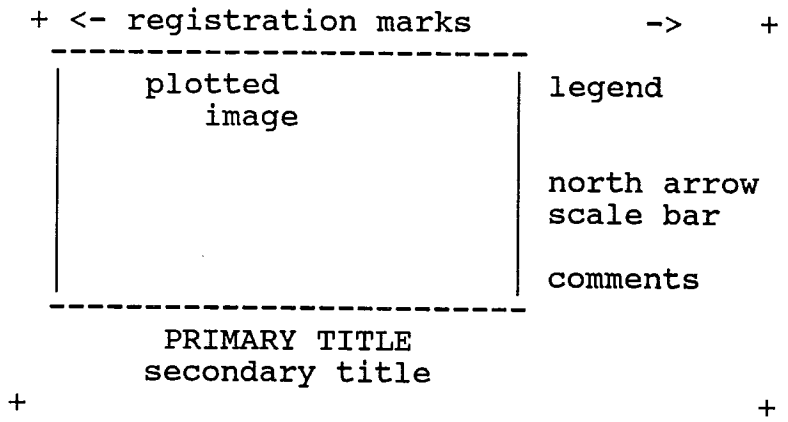

Figure 5. Plot Annotations

PLOTTING DEVICES

Versatec

When the Versatec option is selected, the PLOTTER program generates a plot file with the logical name UNIRAST. After PLOTTER has finished, you must send UNIRAST to the plotter itself. This must be done with a UNIRAS device driver program, for example DVERC. At the Geological Survey of Canada, an improved version of DVERC was developped by D. Ellwood called QVERC.

Versatec plots are limited to a maximum width of 860 mm (= 34 in.), but can have any height, since the paper comes off the machine in a roll.

Optronics

The Optronics plotter produces four colour separations on transparencies, which can then be recombined by colour printing to produce illustrations suitable for publishing. This option also produces a plot file called UNIRAST. At the Geological Survey of Canada, the UNIRAST file is converted to four plot files (cyan, magenta, yellow, and black) by running OPTPLOT.COM, which creates a plot tape. The tape can then be physically transported to the Canada Lands Data Systems (CLDS) plotter in Hull (see Appendix C "Other Programs").

The maximum size of an Optronics plot is approximately 1m x 1m (= 40 inches x 40 inches). Because of the separate black, cyan, magenta, and yellow plots that are produced, it is recommended to select the registration-mark option when running PLOTTER. This will allow the separations to be accurately recombined later.

The PLOTTER program assumes that an Optronics plot will use the 100 micron dot size. This should be indicated to the plotter operator.

Tektronix 4109

This screen display option is intended as a debugging, testing, and preview facility for the PLOTTER program. It should work on the entire 41** family, including 4106 and 4107. PLOTTER must be run from the same terminal on which the image is to appear. PLOTTER handles all of the switches between text and graphics mode, but you should type in the sequence

<SETUP>code edit<ENTER><SETUP><ENTER>

before running the program. This sets up the terminal to act like a regular VT100-type VAX terminal.

The Tektronix screen is approximately 360 mm x 270 mm, with far less resolution than either the Versatec or Optronics plotter.

A quirky side effect of the GIMAGE/Tektronix combination is that plots come out sideways. In all other respects, a Tektronix screen plot will be identical to a paper plot of the same image data. It will even have a white background and black text annotations. You can plot a file on the screen, checking colours and annotations, then continue the PLOTTER program to plot the same file on a hard copy plotter. The only information you will likely have to change

is the plot size.

Other Devices

The PLOTTER program includes an option to plot on an Applicon plotter, but this has not been tested.

If you are adventurous and have the appropriate UNIRAS documents, you can try plotting on other devices which may be available. To do so, the "Select from GROUTE" option must be selected instead of a specific plotter.

GUIDELINES FOR INTERACTIVE PLOTTING SESSION

This chapter can be reviewed by reading it as the program is run. The capitalized headings in the document correspond to the headings for each of PLOTTER's screens.

Running PLOTTER from a VT100/VT200 type terminal will give the benefit of the special graphics characters used by the PLOTTER program in this mode. If you are on a Tektronix terminal, type

<SETUP>code edit<ENTER><SETUP><ENTER>

before beginning. This sets up the terminal to accept the characters. If this is not done, everything will still function; but some garbage will appear on the screen along with the interactive prompts.

To start PLOTTER, type at the '$' prompt:

run plotter

You will see this title, and a request to enter some information:

FILE PLOTTING FACILITY

LOG FILE

The first thing you are asked to specify is whether or not you want a log file kept. If you indicate yes, the file will be created in you default directory. It will be in ASCII format and will list all of the plotting parameters which are selected over the course of program execution.

A hard copy listing of this file is invaluable for re-running the program with the same or similar parameters. It could also be edited and used with a command file to driver PLOTTER in batch mode.

DIRECTORY

At the prompt to enter a directory name, the response can be something in any of these formats:

```
[dir_name]
[dir_name.dirname]
device_name:[dir_name]
```

and so on. If nothing is entered here, the program will look for all data files in the default directory from which the program was started.

To change the default directory later, simply enter the new directory path as part of a filename when prompted. For example

```
ENTER FILE NAME: my$device:[my_top_dir]newimage.cut.ext
```

The new default data directory will become

```
my$device:[my_top_dir]
```

and the program will look there for all data files until it is changed again.

DATA ORGANIZATION

If you select (1), for channel data organization, you will then have to enter the number of channels. If 3 channels, each of the three data files you specify when prompted later will be assigned to a colour channel. If 2 channels, the first file is used for channels 1 and 3, and the second file for channel 2; and if only 1 channel is specified, the single data file whose name is entered will be used for all three channels. The plot in this last case will be in varying shades of white, grey, and black.

After specifying the number of channels, you are asked whether the files are Morpholog or BSQ format.

Enter the 1 to 3 data file names when prompted. If entering two or three similar file names consecutively, the arrow keys can be used to recall and edit previous lines, saving a small amount of typing. Note that the same file cannot be specified twice for different channels.

If you select (2), for single-channel colour theme data organization, you will have to choose between Morpholog, CUT, RNL, and BSQ file formats. Enter the name of the file with its extension

when prompted.

PLOTTER SELECTION

When asked to select a plotter, there are 5 options, the most useful being: Versatec, Optronics, and Tektronix 41** screen plot. If you select Applicon, a warning will be issued but the program will continue.

If the GROUTE option is selected, the program will continue but later, at the time of graphics initialization, the GROUTE interpreter will request a plotter selection. This option is not recommended unless the UNIRAS documents are available.

PLOT SIZE

Here the default size of the plotted image is shown, along with the number of rows/columns being input and the default plotter pixel size. The size of the plot can be changed by entering a scaling factor.

SCALING FACTOR

This has the effect of multiplying the default dimensions of the plot by whatever real number is entered. For example, 0.25 would reduce it by three quarters; 5.5 would increase it by 5 and one half times.

COLOR SCHEME

Either RGB (red,green,blue = additive colours), or CMY (cyan,magenta,yellow = subtractive colours) must be specified here. Most likely, if the data is from SPANS or EASI/PACE, RGB will be selected.

PALETTE SELECTION

This prompt only appears if option (2), colour themes, was the DATA ORGANIZATION selection.

If (1) is selected here, for a BIC file, then the file name is specified. If it is the same as the data file being used, only with extension .BIC, simply hit <ENTER>. A name for the new PAL file that will created must also be specified. This PAL file can be

modified later using the VAX editor, for re-use by PLOTTER.

If the PAL file option (2) is selected, either hit <ENTER> to specify a file name the same as that of the data file (with extension .PAL substituted), or else enter an entirely new file name.

The colour information from the palette file specified will be loaded into the UNIRAS colour table, replacing the default table values.

ANNOTATIONS

You will be asked in succession whether titles, a legend, comments, or registration marks are required.

LEGEND

If a legend is requested, a title can be given to it. The default is 'Legend'. For no title at all, enter a dollar sign ($) and hit <ENTER>.

Enter the number of themes in the legend. This number can be zero to twelve. For each theme, you will have enter the RGB or CMY

values must be specified, plus a theme title. For a blank title enter a dollar sign ($).

Since a theme colour should match the colour of some feature on the image, the appropriate colour values must be determined ahead of time. This may require some trial and error for EASI/PACE files, but is generally easier to do for SPANS files.

If you answer 'Y' when asked for a scale, enter the width of your image area in meters. The result will be a horizontal scale plotted under the legend, showing the distance covered by one third of the area's width. For example, if your image is 12.0 km wide, the scale will look like this:

```
|----------------------|
        4.0 km
```

To plot an orientation arrow, enter an azimuth angle corresponding to the orientation of north on your image. The arrow will be plotted between the legend themes and the scale. For example, you if specify an angle for the arrow of 90, you will get a result like this:

```
------------> N
```

A chance to review and edit the legend will be allowed before PLOTTER continues.

TITLES

To plot titles centered at the bottom of the image, enter them as text strings when prompted. There is a primary and a secondary title, with the former slightly larger than the latter. To get a blank line for either title, type a dollar sign ($) and <ENTER>.

COMMENTS

Up to four comment lines can be plotted in small print to the lower right of the image. Enter a blank line by typing a dollar sign ($) then <ENTER>.

REGISTRATION MARKS

These will be plotted outside each corner of the image. This option is recommended for Optronics colour separations.

ORIGIN

Enter the X-Y coordinates in millimeters of the origin at which the plot will begin. The origin is in the upper left corner, except for the Tektronix 4109, for which the origin is at the lower left.

For hard copy plots, the origin position selected can be reviewed in relation to areas already covered by previous plots. In the representation of the plotting surface which you are shown, 'X's are areas covered previously, '*'s are areas of possible overlap between the new and old images, and '.'s are where the new plot would fall on a blank area.

If the origin is positioned so that the image may spill off the paper, a warning is issued but the program will continue. In theory, UNIRAS should plot the image on separate pieces of paper which can then be pasted together, but this has not been tested.

Also to be noted:

1) Allow extra room on the right and bottom of any image for which there will be a legend, comments, or titles. While the actual width depends on variables such as the lengths of titles, a good rule of thumb is to allow 1/3 of the image width on the right for a legend and/or comments, and 1/5 of the image height on the bottom for

titles.

2) The PLOTTER program does not perform any strict check to

determine whether you are covering up a previously plotted image, so keep track of exact plot positions.

ABBREVIATION

To abbreviate the plot, specify a number of rows to plot before quitting. This option is intended to provide a way of checking annotations on the Tektronix 4109 screen without having to wait the 5-20 minutes required for an entire image to be plotted.

INITIALIZING GRAPHICS

On a Tektronix screen, this is the last message you will see before the terminal is switched over to graphics mode and plotting commences. At the end of the plot, various messages will appear, but the most important one is to hit the keys <SHIFT><D_ERASE>. This clears all text from the screen, allowing an unimpeded view of the graphics just plotted. To continue, hit <ENTER>.

If plotting on other devices, various messages sre displayeddescribing what is going on in the UNIRAS/GIMAGE initialization and then in the actual plotting. Just keep hitting <ENTER> until you get to this screen heading:

FINISHED PLOTTING

The final size of the plotted image will be shown and then the quetion is asked whether to plot another image. If 'N' is entered, the PLOTTER program will be over.

Otherwise, the entire program can be repeated. Defaults will be in most cases the values which were previously entered. If the same hardcopy plotter is selected again, the plots that follow will be added on to the same same paper or transparency to form a mosaic. If you select a different plotter, the original plot file will be closed and cannot be re-opened to add more image data.

Batch Mode

PLOTTER could also be run in batch mode by defining sys$input to be a file instead of keyboard input. The file specified would have to contain all the information needed by PLOTTER, including replies to every prompt that would normally be entered interactively.

HIGH RESOLUTION PLOTS ON VERSATEC

SPANS image files (.CUT) are limited to the resolution of the graphics board they were generated on, for example, .CUT files generated on a VGA card have 680 X 420 pixels while .CUT files generated on a PRO 1280 card have 1280 X 1024 pixels. These resolutions generally do not reflect the true resolution of the map file. Typically, a 1:50000 map would be quaded at level 12 giving the it a resolution of 4096 X 4096.

To recapture the acutal resolution of the map file for large plots on the Versatec or Optronics plotters the following approach may be used

1. In SPANS define a window that encloses the map area only. This is not necessary, but facilitates scaling.

2. In SPANS use the UNIV-LIB/ADD-MOD/WINDOW/SPLIT function. This function allows you to select a scale for the final output and then automatically breaks the map into a series of windows where each window is the size of the screen and when put altogether will produce a map of the desired scale.

3. The map can then be displayed in the series of windows generated in step 2 and then browsed (This can be done as a batch in command mode.)

4. The resulting .CUT files can then be annotated.

5. Use PLOTTER to fit all the windows back together to produce the large scale high resolution plot.
NOTE: The windows created by the UNIV-LIB/ADD-MOD/WINDOWS/SPLIT function have an overlap associated with them. This can be accommadated in PLOTTER by overlaping the windows the appropriate amount or the file windict.inp can be edited in SPANS to remove the overlap.

After Plotter

Having finished a hard copy plot, such as for the Versatec or Optronics, the plot file which was generated must be sent to the actual device. VERSPLOT.COM and OPTPLOT.COM are examples of command files which carry out this task for the Versatec and Optronics plotters, respectively. These two files are included with PLOTTER and may be used as is or modified as necessary (see Appendix C "Other Programs").

The plot file will be named whatever has been assigned to the logical name UNIRAST. If this is unknown, type at the VAX '$' prompt:

```
show logical unirast
```

To change the assignment, type

```
assign device_name:[dir_name]file_name.ext unirast
```

ACKNOWLEDGEMENTS

A student working in the GeoPhysics Division, C. Turner, wrote several utility routines (ENTINT, ENTREAL, L_CHAR, and F_CHAR) which are included in the PLOTTER source code. The program for writing Versatec plot files, QVERC, was created by D. J. Ellwood of the Geological Information Division.

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