Geological Survey of Canada

Open File 1581

GEOPHYSICAL IMAGING SOFTWARE FOR IBM-COMPATIBLE MICROCOMPUTERS*

John Broome[1]

[1] Potential Fields Section
Lithosphere and Canadian Shield Division
Geological Survey of Canada

1987

Canada

ABSTRACT

Gridded geophysical data are often displayed as colour or grey-tone imagery for qualitative interpretation. The software included in this open file allows shaded-relief and intensity images to be generated and displayed on a microcomputer workstation. Panning, zooming, display colour selection, and control of the illumination direction on shaded-relief images can be interactively controlled in real-time. Although the software was developed specifically for aeromagnetic data interpretation, it may be used for display of any data in raster form.

The workstation consists of an IBM-compatible microcomputer equipped with a high-resolution colour monitor and graphics board, a digitizer and a dot-matrix printer. The hardware configuration is the same as that required for MAGRAV2, the interactive gravity and magnetic data modelling program released as Geological Survey of Canada Open File 1334. Graphics are handled by the Multi-Halo graphics subroutine library (not included).

Three Microsoft FORTRAN 77 programs for the workstation are provided in source code form on a floppy disc. An additional VAX-11 FORTRAN program is included for generation of image and data files on a Digital Equipment Corporation "VAX" computer for transfer to the workstation.

TABLE OF CONTENTS

1.0) INTRODUCTION

Colour and grey-tone images produced from gridded geophysical data are a powerful tool for qualitatively interpreting geophysical data. An image is defined as both the visual image produced on paper, or a computer monitor, and the digital grid, or raster, representing that image. The digital representation of an image is a image file, containing columns of 8-bit values which control the colour or grey-tone intensity of each pixel (picture element). Unfortunately the equipment and software required to generate this imagery have been prohibitively expensive in the past. This workstation and accompanying software were developed because of the need for an inexpensive system for interpretation and display of potential field data within the Lithospheric Geophysics Section at the Geological Survey of Canada (GSC).

A demonstration of the workstation at the "Computer Applications in Mineral Exploration Conference" and the "GSC Current Activities Forum" in early 1986 produced many requests for information about the system and the software in particular. This resulted in the August, 1986 release of the interactive modelling program, MAGRAV2, as Geological Survey of Canada Open File 1334 (Broome, 1986). The programs included with this open file allow display and enhancement of data that has already been corrected and interpolated onto a regular grid (or raster).

At the GSC, gridded aeromagnetic data are stored on a remote Digital Equipment Corporation (DEC) VAX-780 minicomputer. Before the gridded data can be viewed they must first be reformatted and downloaded to the workstation. The relationship between the hardware and software is shown diagrammatically in Figure 1. A VAX-11 FORTRAN program (VAXPC) is provided for generation of 16-bit integer data files and 8-bit image files from the floating-point data stored on the VAX-780 computer. These files are then downloaded over 9600 bit per second PACX lines to the workstation. Once the data have been downloaded, the image files can be displayed directly or integer data files can be processed locally, using program IMAGE, to produce shaded-relief or intensity images.

Program DISPLAY allows image files produced by programs IMAGE or VAXPC, to be displayed as a colour or grey-tone images on a colour monitor. The different types of images that can be generated include; shaded-relief, grey-tone intensity and colour intensity. DISPLAY also allows interactive change of the display colours, panning, and zooming of displayed images. DISPLAY also allows an image to be stored in Halo image format which allows the data to be input to commercial microcomputer image processing software such as Image-Pro and HALOVision.

1
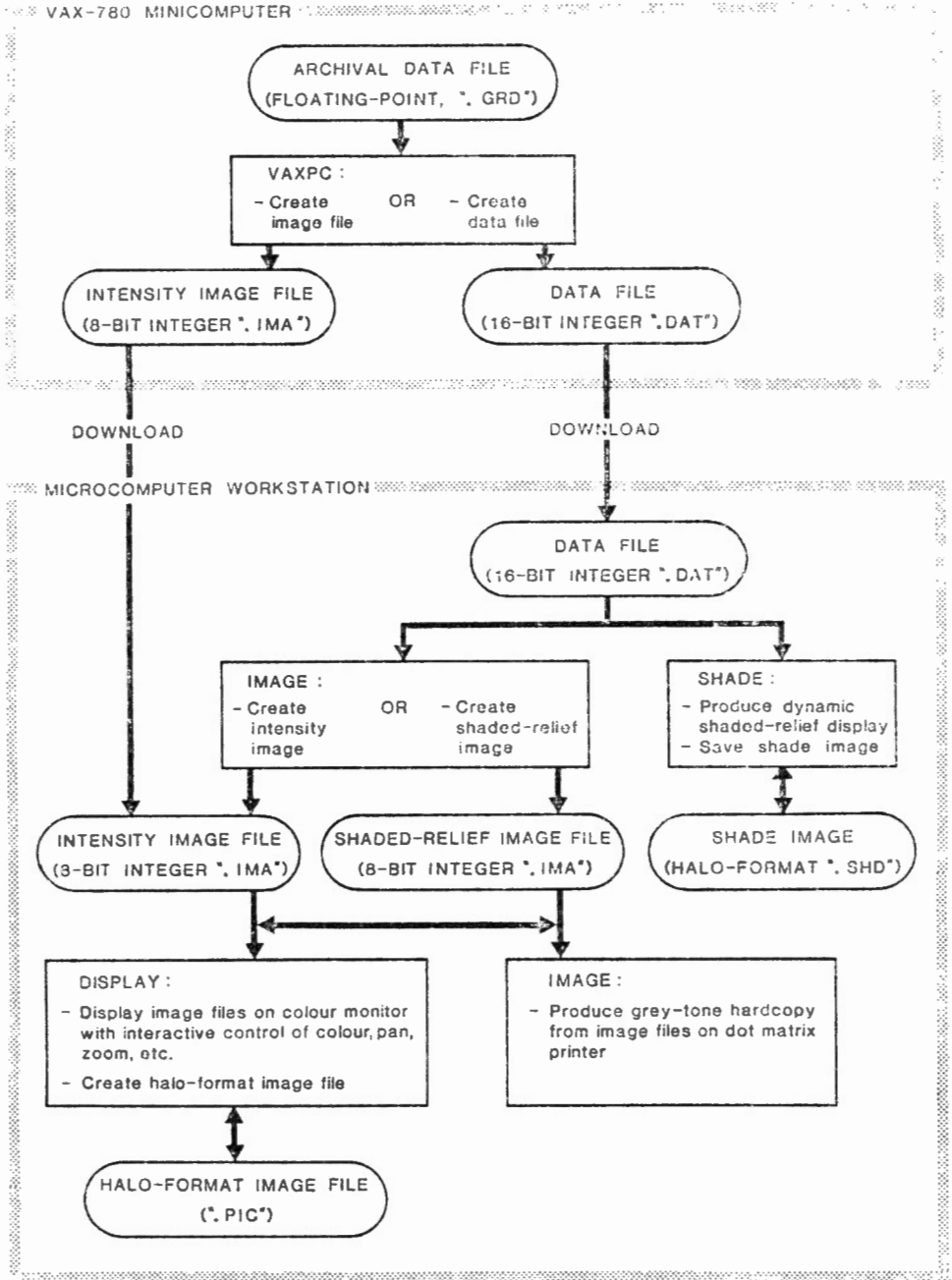
Figure 1 :

This diagram shows the relationships between the four programs and associated computer hardware.

2

Program SHADE allows display of data in shaded-relief form with real-time variation of the illumination direction. At any given illumination inclination the declination can be instantaneously changed to 16 different directions.

The software is provided in source code form on an IBM-format 360 kbyte floppy disc along with batch files for program compilation and linking and a sample data file. In order to use this software, the user must provide a Microsoft FORTRAN compiler and the Multi-Halo graphics library.

Although the workstation hardware, the software and use of each of the programs is described in this manual, some knowledge of geophysical data and image processing is assumed. If you are not already familiar with image processing concepts and terminology I would recommend that you read a general image processing text such as "Digital Image Processing" (Gonzales and Wintz, 1977) before attempting to use the software. A useful reference for potential field interpretation is the course notes for a Canadian Geophysical Union Short Course titled : "Interpretation of Gravity and Magnetic Anomalies for Non-specialists"(Goodacre, 1986). This publication is available from the Canadian Geophysical Union.

2.0) HARDWARE REQUIREMENTS

The three workstation programs, IMAGE, DISPLAY, and SHADE, will operate on any IBM-compatible microcomputer with 256 kbytes of memory, at least 2 floppy disc drives and the required graphics peripherals. This should be considered a minimum configuration and the workstation is much more effective if an IBM-PC/AT or compatible with 640 kbytes of memory and a hard disc is used. A 512 column by 512 row data set requires 256 kbytes of storage space as an image file and 512 kbytes of space as a data file. If only 360 kbyte floppy discs are available, image size will be restricted. A photograph of a workstation bases on an IBM-PC/AT with a 30 Mbyte hard disc, a 1.2 Mbyte floppy disc, and a 360 kbyte floppy disc is shown in Figure 2.

The only difference between the configuration given for MAGRAV2 (GSC Open file 1334) and the one shown in Table 1, is that the Houston Instruments Hipad digitizer has been replaced by a Kurta "Series one" digitizer. The Kurta digitizer is configured to emulate a Summagraphics "Bit Pad One" digitizer for Halo graphics interfacing.

The inadequate graphics performance of the basic IBM-compatible microcomputer is improved by adding a Number Nine Computer Corporation "Revolution" graphics board. This board can display 256 colours simultaneously out of a palette of over 16 million colours at a resolution of 512 by 512 pixels. High graphics resolution and speed are obtained by use of a specialized on-board graphics processor.

4

Figure 2 :
      This photograph shows a complete workstation based on an IBM-PC/AT with a 30 Mbyte hard disc, a 1.2 Mbyte floppy disc and a 360 kbyte floppy disc. A grey-tone intensity image is displayed on the colour monitor.

5

TABLE 1

Hardware requirements for the IBM-compatible microcomputer workstation:

Essential :

1) IBM-PC/XT/AT or compatible microcomputer with a minimum of:
    - 256 kbytes memory
    - 2 floppy discs
    - serial port for the digitizer

2) Colour or monochrome text monitor and graphics card

3) 30 or 50 cm high-resolution RGB colour monitor
        (Example: Electrohome model ECM-1311)

4) Number Nine Computer Corp. "Revolution" colour graphics board to drive the RGB colour monitor.
    (512x512x8-bit, interlaced, model no. 111008)

5) Kurta "Series One" digitizing tablet or equivalent

Optional :

6) Dot matrix printer for production of grey-tone hard copies of images, histograms and program listings.
    (The software is setup for an Epson FX-185)

7) Parallel port for printer (Item 6)

8) Modem for downloading images from a host computer

9) Hard disc to replace one of the 2 floppy discs and the addition of a 1.2 Mbyte floppy disc if only a 360 kbyte drive is available.

9) Additional serial port for modem

10) 8087 (or 80287 for the IBM-PC/AT) numeric co-processor chip to increase floating point computation speed.

6

3.0) SOFTWARE REQUIREMENTS

3.1) REQUIRED SOFTWARE

The files found on the floppy disc included with this manual are described in Appendix A. Source files are included for program VAXPC, which is written in VAX-11 FORTRAN for VAX computers, and for programs IMAGE, DISPLAY, and SHADE, which are written in Microsoft FORTRAN for the IBM-compatible workstation described in Section 2.

Before the programs can be run, the source code must first be compiled and linked. To use VAXPC you must have a VAX-11 FORTRAN compiler while for the three workstation programs you will require :

1) The Microsoft FORTRAN 77 compiler (Version 3.31 or higher)

2) The Media Cybernetics , Multi-Halo graphics subroutine library (Version 2.26) with Microsoft FORTRAN binding.

During "linking", the Multi-Halo graphics subroutines are combined with the source code files found on the disc. Subroutines SOUND (generates sound to accompany error messages and program prompts) and INKEY2 (handles non-standard keyboard input) are written in assembly language and are found, already assembled, in library MAGRAV2.LIB. Program IMAGE does not require the Multi-Halo graphics library at all. MS-DOS "Batch" files for compilation and linking are provided on the floppy disc and instructions for their use can be found in Appendix B.

The Multi-Halo graphics subroutine library is used to produce all graphic output on the colour monitor and process operator commands from the digitizing tablet. Multi-Halo is a device-intelligent system which allows software to run on systems with different graphics boards, locators (digitizers or mice) and hard-copy devices with minimal changes. Software using Multi-Halo achieves device-independence by loading device drivers for the particular hardware configuration at run time. Some subroutine calls are specific to particular devices and take advantage of particular capabilities of the device such as subroutine ZOOM which controls the hardware pan and zoom capability of the Number Nine "Revolution" colour graphics board.

The Number Nine board is able to display 256 colours simultaneously out from a palette of over 16 million colours. Many other graphics boards are not able to display this wide a range of colour and so changes may be required to modify the software for the particular capabilities of the hardware in use.

7

Program SHADE cannot be easily modified for systems with less than 256 simultaneously displayable colours.

3.2) OPTIONAL SOFTWARE

Program DISPLAY allows images to be converted from image file format (".ima")to Halo format (".pic")(See Appendix C for an explanation of the different file formats). The Halo format uses image compression techniques to allow smaller image files and faster image transfer from disc to display memory. Storing images in Halo format has the additional advantage that they can be input to powerful commercial image-editing packages such as "HALOVision" and image processing packages such as "IMAGE-PRO". These commercial packages are available from Media Cybernetics Inc..

Communications software is required for both the workstation and host computer to download gridded data files or image files. Software that supports one of the popular error-checking file transfer protocols, such as Kermit or Xmodem ,is best. Public-domain software that supports the Kermit file transfer protocol is available for a great variety of different computers. One popular public-domain microcomputer package supporting the Kermit protocol is PROCOMM.

See Appendix D for information concerning distributors of the software packages described above.

4.0) BRIEF PROGRAM DESCRIPTION

VAXPC

This program is written in VAX-11 FORTRAN for Digital Equipment Corporation (DEC) computers. At the GSC aeromagnetic data are stored on a remote VAX-780 computer in floating-point gridded form with a descriptive header (See Appendix C for a complete description). VAXPC allows the floating-point data files to be converted to 16-bit integer data files or 8-bit integer image files.

IMAGE

Program IMAGE allows the user to :

a) quantize integer data files to create image files for screen display using program DISPLAY.
b) create shaded-relief image files from integer data files.
c) create grey-tone hard copies from image files on an Epson FX-185 dot matrix printer.

8

DISPLAY

This program allows interactive display and manipulation of image files. Intensity or shaded-relief images can be displayed with colour or grey-tone palettes that are either user or program defined. Images can be panned or zoomed to a magnification of 2 to 16 times. Colour palettes and images can be saved in Halo format allowing them to be input to commercial image processing and image editing packages.

SHADE

This program allows integer data files to be viewed as shaded-relief images with interactive control of the illumination direction. At a specified illumination inclination, illumination declination can be varied in 12.5 degree increments.

5.0) VAXPC USER'S GUIDE

VAXPC is the only program in this package that is not written for an IBM-compatible microcomputer. VAXPC is written in VAX-11 FORTRAN specifically for DEC computers running the VAX-VMS operating system, however it could be modified for other brands of computers, since it is written in standard FORTRAN 77. GSC aeromagnetic data are archived as floating-point grids with a descriptive header. The header is used to store information such as; the grid cell size, the type of data, and the geographic corners of the data area, which is not transferred to the workstation. In program VAXPC, the GSC grid header is processed by subroutines REAHDR and DMPHDR which respectively read and display the header on the screen. These subroutines will need to be modified or replaced to be compatible with your gridded data storage format. The grid dimensions are the only header information transferred to the workstation for image files with the addition of scaling and background parameters for data files.

Floating-point data can be converted to two different types of files for transfer to the workstation; 8-bit image files and 16-bit data files. The data are converted to integer form for transfer because floating-point data have different binary representations on different systems. Usually floating-point data are converted to coded ASCII form for transfer between different computer systems. Unfortunately, ASCII files are very large and as a result downloading them to the workstation would be very slow. Transfer of the data in integer form is much faster because the files are more compact. The system used in this software will work only if both computers use the same internal integer format. In this case, both the workstation and VAX-780 use a 2's complement integer format but some computers (CYBER for example) use a 1's complement integer format which would be incompatible.

Data files allow recovery of the original data value at the workstation while image files contain the data only in quantized form for image display.

5.1) DATA FILES

The floating-point grids on the VAX computer are converted to 16-bit integers to halve the size of the files (thus halving the time required for transfer of the files). A background equal to the minimum data value on the VAX grid is subtracted from each value and the dynamic range on the VAX grid (difference between the maximum and minimum value) is scaled to fit the -32766 to +32767 range of 16-bit integers. Grid cells that are set to -9999.0 on the VAX grid, to indicate that they are undefined, are

set to -32767 in the integer data grid. The scaling factor and background removed are included in the grid header so the original floating-point grid values can be recovered at the workstation.

5.2) IMAGE FILES

The 8-bit image files that are used to store image data can be generated either on the workstation using program IMAGE or on the host VAX computer using program VAXPC. Maximum flexibility is achieved by converting the floating-point grid on the VAX to a integer data grid which can be downloaded to the workstation. A colour image can be obtained more quickly by quantizing the grid on the VAX and then downloading the resulting image file to the workstation. This method results in faster production of an image display for two reasons, the quantization process is generally completed faster on the more powerful host computer and the 8-bit image file is transmitted to the workstation more quickly since it is half the size of a 16-bit integer data file.

5.3) USING VAXPC :

In order to use VAXPC it must first be uploaded from the floppy disc to the host computer, modified to match the grid and grid header format you use and then compiled using the VAX-11 FORTRAN 77 compiler and LINK'ed. When the program is executed, a number of questions must be answered. This section explains the prompts and options available to the user and the correct responses. If the program prompts and this explanation provides inadequate information, the comments in the source listing may help.

The first question asked is :

"Enter the name of the input grid file (".grd" will be added):".
Respond with the name of the VAX file containing the floating-point grid. The program expects all floating-point grid files to have the filename extension ".grd". For example, enter "test" and the program will look for file "test.grd". Consistency in grid file names is maintained throughout this suite of programs by using the same filename extensions for all files of one type.

"Enter type of output : "
Select "1" for an 8-bit image file with filename extension ".ima" or "2" for a 16-bit data file with filename extension ".dat".

11

"Enter name of output file:"
Enter the file name without the filename extension. I usually use the same name as the input floating-point data grid.

If data file output is selected, the background removal and scaling factors are calculated automatically. If image grid output is selected the user must choose from a number of quantization options.

"Enter type of quantization levels:"
Four types of quantization level determination are offered.

Option 1 is the standard 39 levels used for the published GSC one to one million scale regional aeromagnetic maps.

Option 2 is the standard 39 levels for published GSC vertical magnetic gradient maps.

Option 3 allows manual quantization level selection. The number of levels selected by the user can range from 2 to 254 and the quantization levels can be either entered manually by the user or calculated automatically by the program. The automatically determined levels can be calculated linearly or optimised for the particular data grid using the histogram equalization method (see Section 6.1.2). The histogram equalization method calculates levels that result in an equal area on the image for each level, or colour.

Option 4 allows previously stored quantization levels to be retrieved from disc. Quantization levels files are identified by the filename extension ".lev". A descriptive header is stored with the level values to help identify the contents.

"Do you wish to edit any quantization levels ? (y/n) : "
The user is given the opportunity to view and, if required, change quantization levels.

"Save quantization levels to disc ? (y/n) :"
The user may save quantization levels to a disc file for later use if desired. A quantization levels file is created with a user-specified name and filename extension ".lev". The user is also prompted for a descriptive header that is stored with the quantization levels. Saving the levels is particularly useful when multiple images are to be generated with the same quantization levels.

"Enter first and last column to extract : "
"Enter first and last rows to extract: "

     Prior to these prompts, the first,last and number of rows and columns on the input grid are displayed. The user must then select the first and last rows and columns to be extracted from within the range displayed. Array dimensions in the program are currently set to limit the number of grid rows on the input grid to 1500, but the number of grid columns is unlimited. The graphics system in the workstation can display an image with maximum dimensions of 512 by 512 pixels, but areas up to 1024 by 1024 pixels can be downloaded and read by the workstation software. If an area with more than 512 rows or columns is selected a warning message is printed to remind the user he has exceeded the displayable area. The larger area can still be displayed but at a reduced resolution.

     All required information has now been entered and the program will produce an output file for transfer to the workstation. This file can then be downloaded to the workstation using a modem and communications package or directly using an IBM-format floppy disc.

6.0) IMAGE USER'S GUIDE

IMAGE performs 3 functions on the workstation:

1) Quantization of integer data grids to produce image files.

2) Production of grey-tone image hard copy on an Epson FX-185 dot-matrix printer.

3) Production of shaded-relief image files from integer data files.

IMAGE does not use the Multi-Halo graphics library so an executable file can be produced with only the Microsoft FORTRAN 77 compiler and linker. The current version of the program is dimensioned to handle images with up to 1024 rows. The only limit on the number of columns is the space available on the storage device.

After executing IMAGE, the user must first choose from the three options described above. An explanation of each of these options follows.

6.1) PRODUCTION OF AN IMAGE FILE FROM A DATA FILE

An 8-bit image file is produced by quantization of a 16-bit data file into a user-specified number of levels, ranging from 2 to 254. The following questions must then be answered :

"Enter name of input data file (".dat" will be added) : "
The name of the 16-bit integer data file must be entered. The filename extension ".dat" will automatically be added. A response of "esc" will return you to the main menu.

"Enter name for output image file(".ima" will be added) : "
The name for the output image file must be entered. The filename extension ".ima" will automatically be added. Using the same root name as the input data file helps keep your files organized.

"Enter name for level file or "new" if a new one is to be created (".lev" will be added) :"
To calculate new quantization levels enter "new", otherwise enter the root name of an existing levels file.

If "new" is entered the program will prompt you for a name for the new levels file it will generate. The program will then ask ;

14

Enter number of quantization levels :
The number of levels may range from 2 to 254. The user is then asked ·if level boundaries are to be automatically generated or manually entered.

6.1.1) Manual Quantization level entry

Due to background removal and scaling, the possible range of values on the integer data file is limited. If manual level entry is chosen, the permissible range is displayed on the screen and values outside that range generate an error message.

6.1.2) Automatic Quantization level generation

Quantization levels can be calculated automatically either linearly or using the histogram equalization technique[1]. Linear quantization is obtained by dividing the range between the minimum and maximum values on the data file linearly to produce equally spaced quantization values. In reality the majority of data values are concentrated in only part of the total data range. As a result, linear quantization produces an image in which most data are quantized into a small number of levels, with a resulting loss of detail on the image. The histogram equalization technique calculates the quantization levels that produce equal numbers of data values in each level thus producing an image containing a maximum amount of detail.

The program first calculates linear-quantization levels and gives the user the option of generating a histogram of the linearly-quantized data distribution on the printer. Figure 3a shows the result of linear quantization of data grid "test.dat" using 128 levels. The contents of data file "test.dat" are described in Appendix A. The program then asks if the quantization should be histogram equalized. In general, histogram equalization will produce a more detailed image. During histogram equalization a warning message "no. of sublevels insufficient" may appear, indicating that the majority of the data values are strongly concentrated in a very small part of the overall data range. This occurs because the method used to calculate the equalized levels is an approximation to theoretically perfect equalization which produces less accurate results when the data are strongly concentrated in a limited range. The quantization levels can usually still be used to produce an acceptable image in spite of these warnings.

---

[1] The histogram equalization technique is described in "Digital Image Processing" by Gonzalez and Wintz (1977), pages 119 to 127.
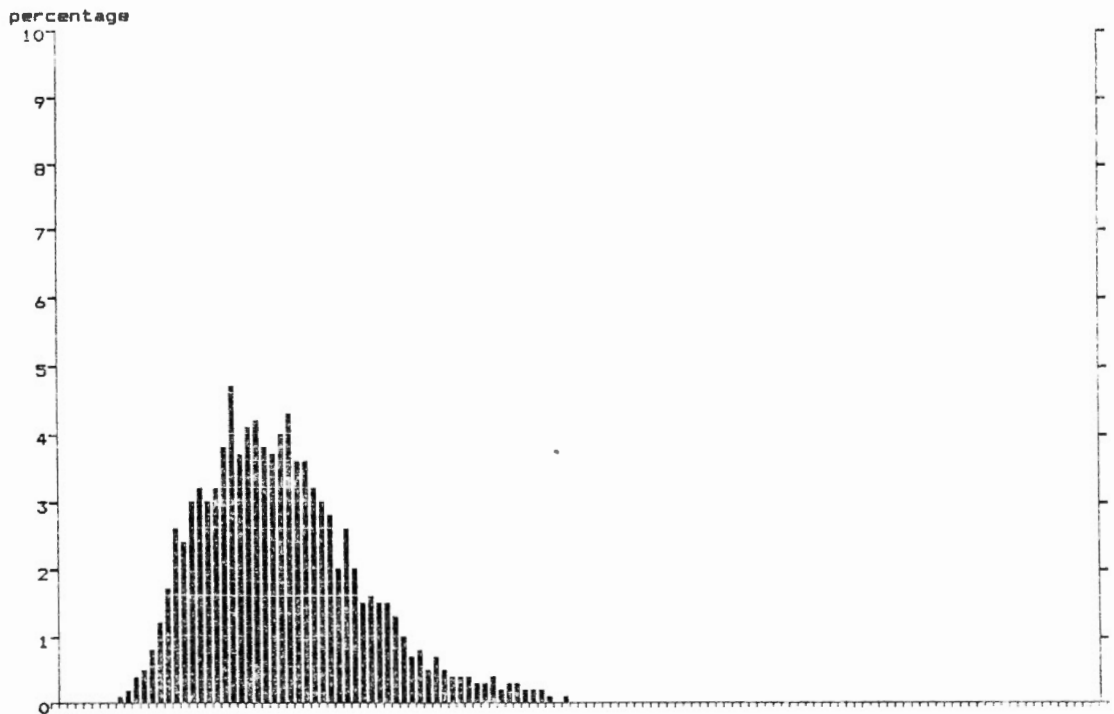
OUTPUT DATA DISTRIBUTION :

<u>**Figure 3** :</u>
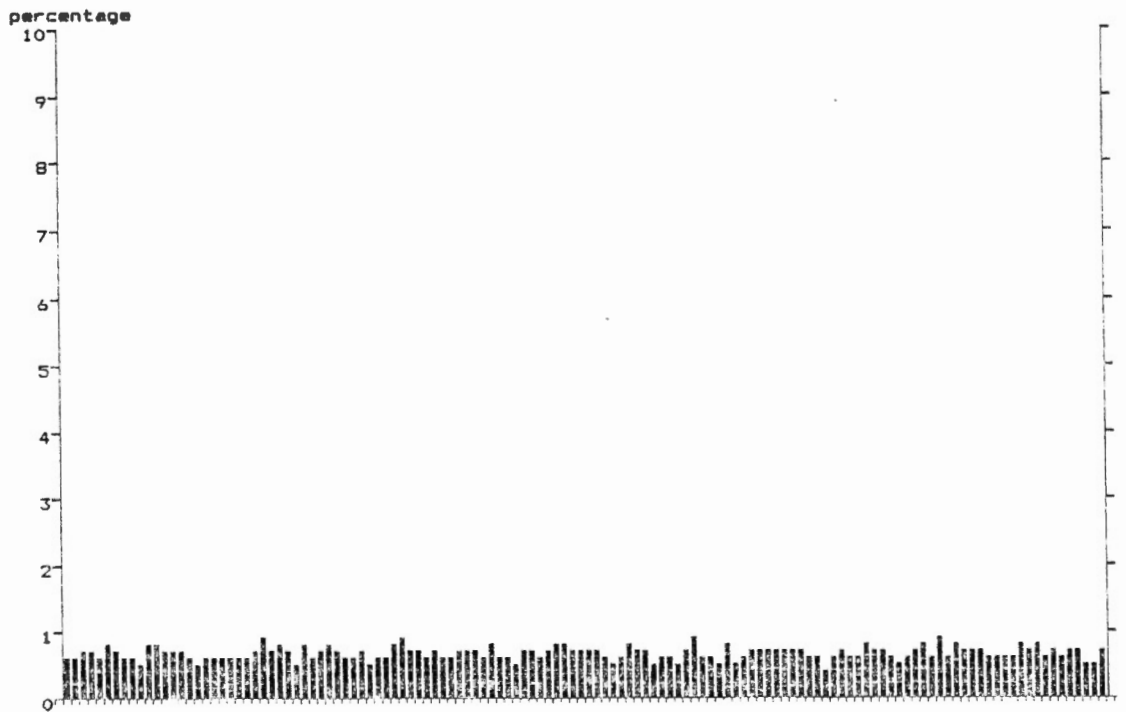Figure 3a shows the histogram produced on the Epson printer by linear quantization of data file "test.dat" into 128 levels. Figure 3b shows the histogram resulting from histogram-equalized quantization of the same data file.

16

6.1.3) Using previously generated quantization levels :

If a levels file is used to quantize a data file other than the one which created it, some of the quantization levels may be beyond the scaling range of the new data file. In this case, the program will change the offending value(s) to either the maximum or minimum allowable on the new data file.

After the quantization levels are determined, they are written to the levels file and displayed on the screen. The user is then given an opportunity to edit them. The program now quantizes the integer value for each data value and writes the result to the output image file as an 8-bit integer.

"Plot histogram of output data distribution ?(y/n)"

A histogram of the quantization level populations can be produced on the printer. If histogram equalization is chosen the populations of each level should be approximately equal. Figure 3b is the histogram resulting from histogram equalization of data file "test.dat" into 128 levels.

6.2) PRODUCTION OF GREY-TONE HARD COPIES OF IMAGES

Production of different grey tones on a standard dot matrix printer is achieved by assigning each grid cell, or pixel, to a square area equal to some multiple of the dot size on the printer and varying the number of dots in the block. The block size used here is 4 by 4 dots, so the number of different dot densities, or grey-tones, is 17 (4 x 4 + 1). Image files quantized into more than 17 levels are automatically requantized into 17 levels. Figure 4 shows a grey-tone hard copy produced from a histogram-equalized, 128-level intensity image produced from data file "test.dat". The image is oriented so that the bottom of the screen image is on the left side.

The Epson FX-185 printer is capable of 979 dots across the page resulting in a plot 244 pixels wide. Hard copies of images with more than 244 rows require multiple passes. The program automatically divides the image horizontally into sections 244 pixels wide. Subroutine PNTIMA is currently set up for the Epson FX-185 printer which is a 13 inch wide printer but the subroutine could easily be modified for an 8 inch wide Epson FX-85 by changing the number of pixels printed per line to 144 (576 dots/line divided by 4). To modify this subroutine for other printers the control codes that set the graphics parameters would probably have to be changed.

Figure 4 :
This grey-tone image was produced on the Epson printer from
a 128 level histogram-equalized intensity image produced from
data file "test.dat". The original printer output was
approximately 35 cm by 35 cm.

To produce a hard copy of any image file, either intensity or shaded-relief, enter the name of the file when asked. The program will also ask for a label that will be printed on the image. The label may have up to 64 characters.

6.3) PRODUCTION OF SHADED-RELIEF IMAGES FILES

Shaded-relief images are useful for enhancing small high-frequency features in potential field data (Broome et al.,1985). Shaded-relief images are produced by calculating and quantizing the reflectance of a surface defined by the magnetic data (Teskey and Broome, 1984). The reflectance of a surface is a measure of the proportion of the illuminating light which will be reflected back to an observer from the surface. The apparent brightness of the surface is dependent on the angular relationship between the illumination direction and the surface, with maximum brightness occurring when the two are perpendicular. The reflectance of the surface is defined by a simple algorithm (Horn and Bachman, 1978) which determines the cosine of the angle between the normal to the surface at that point and a specified illumination direction (see Figure 5). This reflectance model is one of the simplest of many available but produces good results with potential field data. The floating-point reflectance values are linearly-quantized into a user specified number of levels to produce the shaded-relief image. Figure 6 is a grey-tone hard copy of a reflectance image produced from data file "test.dat".

Small features are often invisible on intensity images because their amplitude is so small that they are lost within one quantization interval. Since the reflectance is determined by the local surface gradient, small steep anomalies will be enhanced more than larger low-frequency anomalies. Because reflectance is dependent on the illumination direction, directional enhancement of the data is possible. This is a major attraction of this technique as it allows anomalies trending in a particular direction to be enhanced by choosing a perpendicular illumination direction. This directionality also means that more than one shaded-relief image must be generated to extract all the detail in the data set. This aspect of shaded-relief imagery is discussed in more detail in Section 8.

To produce a shaded-relief image the following questions must be answered to define certain parameters and file names :

"Enter name for input data file (".dat" will be added) :"
   Enter the root name of the input data file to be displayed in shaded-relief form or enter "esc <CR>" to return to the main menu.

19

ILLUMINATION DIRECTION   SURFACE NORMAL

NORTH

λ

ϕ

θ

ONE SURFACE
ELEMENT DEFINED
BY ONE GRID READING
IN EACH CORNER

GRIDDING
INTERVAL

REFLECTANCE = COS (λ)
ILLUMINATION INCLINATION = ϕ
ILLUMINATION DECLINATION = θ
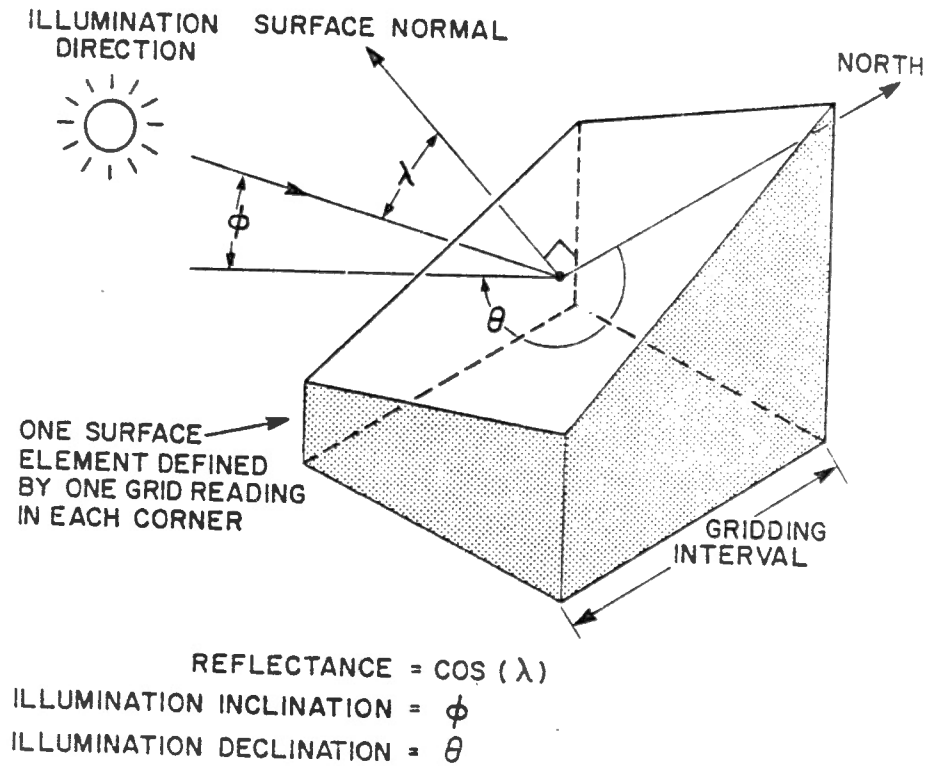
Figure 5 :
     The geometry used by the reflectance algorithm to calculate
reflectance values for production of shaded-relief images. The
reflectance is equal to the cosine of the angle between the
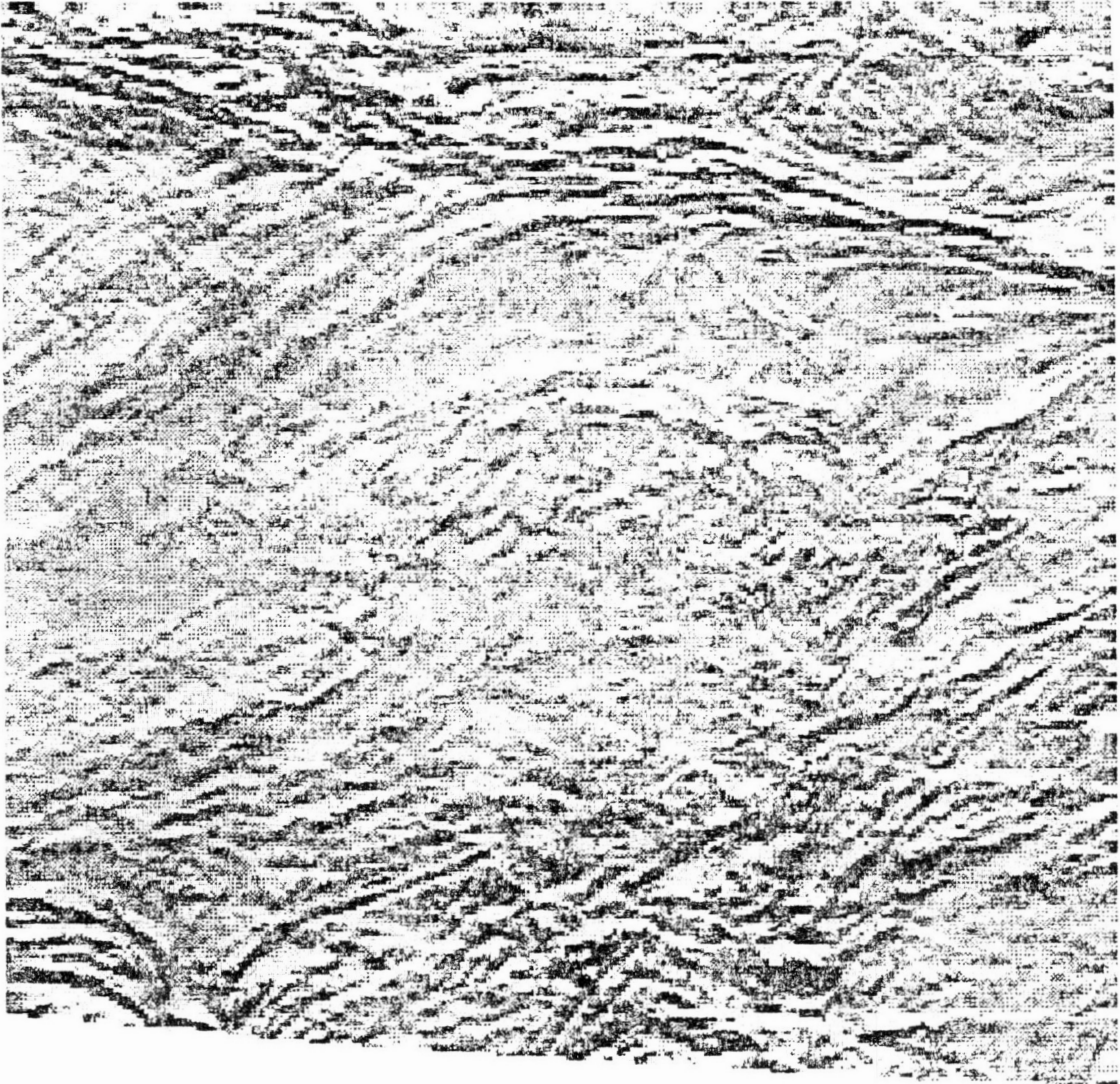surface normal and the illumination direction.

Figure 6 :
    This shaded-relief image was produced on the Epson printer
from data file "test.dat". An inclination of 40 degrees,
declination of 0 degrees and scale factor of 1 were used. The
reflectance quantization histogram for this image is shown in
Figure 7.

21

"Enter name for output image file (".ima" will be added) :"

Enter the name for the output shaded-relief image file. I use the data file name with the addition of an "s" to distinguish it from the intensity image file.

"Enter illumination inclination (degrees) : "

The illumination inclination is measured in degrees from the horizontal. Experience has shown that an inclination of 40 degrees is optimal for most purposes. Illumination from directly above (90 degrees) is useful for enhancing arcuate and circular features in the data and removes the directionality of the method.

"Enter ill. declination (deg.cw. from north : "

The illumination declination is entered in degrees measured clockwise from North. For example, for illumination from the East enter 90. Images produced by illuminating from directions separated by 180 degrees will show identical detail and will be the negative of each other. Generally, illumination from the top of the map is more effective.

"Enter vertical scale factor (try 1.0) :"

The scale factor is required to ensure the correct amount of contrast in the resulting image. Increasing the scale factor increases the contrast. The program is set up so that a scale factor of 1.0 will give the correct contrast for typical aeromagnetic data which have a data range of approximately 500 nanoteslas. Data grids with a smaller range will require a larger scale factor or the resulting image will lack contrast. The effect of the scale factor can be seen in the reflectance distribution histogram which is discussed later.

"Enter number of levels to output(2-254) : "

The number of levels to be used for the linear quantization process must be selected. Maximum image detail is obtained by using the maximum permissible number of levels (254).

"Print the reflectance distribution histogram? (y/n):"

If required, a histogram can be plotted on the printer showing the distribution of the quantized reflectance values. If the data on the data file have a reasonable amount of relief and the scaling factor was chosen correctly, the histogram should be bell-shaped as shown in Figure 7. This histogram was produced from data file "test.dat" using an inclination of 40 degrees, a declination of 45 degrees and a scale factor of 1. If the histogram shows most values concentrated in a few levels, the scale factor used was probably too small.
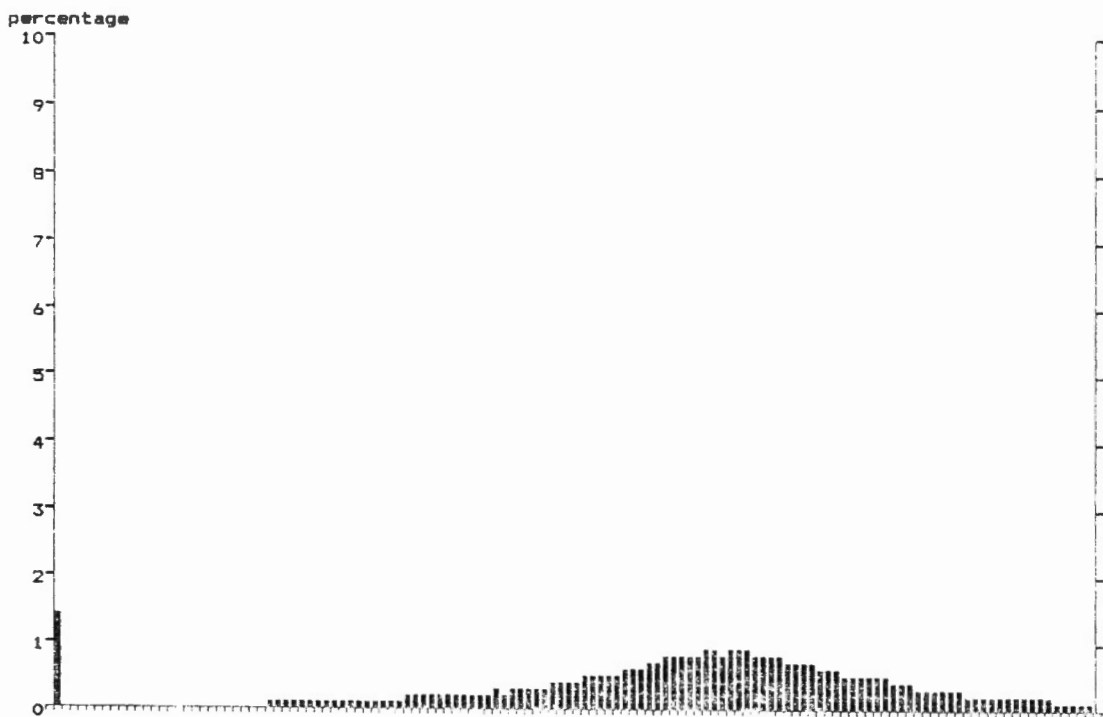
REFLECTANCE DISTRIBUTION :

percentage

Figure 7 :
      This reflectance distribution histogram was produced during
generation of the shaded-relief image shown in Figure 6.

23

7.0) DISPLAY USER'S GUIDE

DISPLAY is an interactive program for display of images on a colour monitor. The program is partly controlled from menus and partly from the digitizing tablet. Image files are read into display memory on the Number Nine Graphics board and displayed on the colour monitor using colours defined in the colour lookup table (CLUT).

7.1) DISPLAY MEMORY AND COLOUR LOOKUP TABLE INTERACTION

The speed with which colours can be changed on the image is due to the relationship between the image data stored in display memory, the CLUT and the colour monitor. Each pixel on the display is represented in display memory by an 8-bit value. This value is the level calculated during quantization for that pixel. Each of the 256 possible values in display memory are assigned red, green, and blue colour intensities in the CLUT to define the colour displayed on the monitor for all pixels with that level. This set of intensity values defines the "colour palette". Intensity values for each colour range from 0, representing no intensity, to 255 for full intensity. The colour image on the screen is redrawn in the colours specified in the CLUT, 30 times per second from display memory. This method of display generation allows display colours to be changed quickly since only the red-green-blue (RGB) intensities for a particular level must be changed in the CLUT to change the colours of all pixels with that level.

The maximum number of different colours that can be simultaneously displayed is determined by the number of different values possible for each pixel, 256 in this case. The maximum number of colours that the system can generate is determined by the number of different possible combinations of RGB intensities in the CLUT, which is 16,777,216 in this case (256x256x256).

7.2) DIGITIZER INITIALIZATION

In order to use the digitizing tablet to control the program and locate the cursor, the digitizer must be configured correctly and the Multi-Halo resident locator driver must be loaded. On the back of the Kurta digitizer there are 12 switches which must be set correctly so the digitizer can communicate with the computer. In the top 8-switch block, switches 1 to 5 should be off and 6 to 8 should be on. In the lower block, switches 1 to 3 should be off and 4 should be off. The use of resident locator drivers is described in detail in Section 9 of your Multi-Halo manual. MS-DOS "batch" file "init.bat" on the floppy disc will load driver "halobpoi.com" for the Kurta digitizer. File "halobpoi.com" is provided with the Multi-Halo package and must

24

be copied to the default drive and directory before "init.bat" is run. Other types of digitizers are supported by the Multi-Halo package and could be used. The use of a different digitizer would probably require changes to file "init.bat" and coordinate scaling changes in subroutine DIGIT.

7.3) GRAPHICS DEVICE DRIVERS

Multi-Halo uses device drivers to link applications software to the graphics devices installed in the micro-computer. The device driver for the Number Nine "Revolution" board is provided with the Multi-Halo package as file "halonine.dev". The two programs which use Multi-Halo (DISPLAY and SHADE) require this file to be on the default drive and renamed "halo.dev". If "halo.dev" is not found or does not contain the correct file, an error message will be generated and the program will abort.

7.4) USING DISPLAY

Upon execution the user is first asked :

"Save display memory?(y/n) : "
If the user responds "y", the current image stored in display memory will not be erased and the user can proceed with processing of the existing image. Since the existing colour palette is lost, the user is asked to select the type of colour palette.

If the user responds "n", the contents of the Halo format file "logo.pic" is displayed if the file is present in the default directory. File "logo.pic", which is included on the floppy disc, is simply a Halo-format "banner" image identifying the software system which was created with "HALOVision" , the Halo image editing package. Display memory is cleared when the user proceeds.

7.5) THE MAIN MENU

The user next sees the main menu :

```
        Main Menu
        ---------
    1 - To palette menu
    2 - Produce hard copy on the printer
    3 - Read in an image
    4 - To graphics tablet control
    5 - Save the current image
    6 - Quit
```

An explanation of each of these options follows :

1 - To palette menu
Control is transferred to the palette menu.(see Section 7.7)

2 - Produce hard copy on the printer
Multi-Halo provides printer drivers and subroutines to generate bit-mapped images of display memory on a number of popular colour and monochrome printers. To use this function, the appropriate printer driver must be copied to the default directory and loaded (by Halo subroutine SETPRN in subroutine PRINT). If the selected printer driver is not found an error message will be generated and the program will return to the main menu. More information on Halo printer drivers and subroutines can be found in your Halo manual in Section 8.

3 - Read in an image
To view an image file, it must first be read into display memory. Image files with two different formats can be read, image files (with filename extension ".ima") generated by programs IMAGE or VAXPC or Halo format image files (with filename extension ".pic") .

Halo format images can only be read directly to display memory without scaling. Since Halo format image files do not contain the number of levels in the image, the user is asked to : **"Enter the no. of levels on Halo image (1-254) :"** from the keyboard so that the number of active colours can be set. The user is then given the option to :**"Read in the matching palette?(y/n):"** to determine if the palette file with the same root name as the Halo image and filename extension ".pal", is to be read into the CLUT.

The header record in image files generated by program IMAGE or VAXPC contains the image size and the number of levels. These values are displayed on the text monitor after being read and the number of active colours is set equal to the number of levels. The image files can be loaded into display memory using different types of scaling and display logic. The four available types of image scaling are :

1 - Read image directly to display memory
When the image is read directly to display memory without scaling there is a one to one relationship between image file pixels and display pixels. In some monitors the aspect ratio is not one and a square image will appear rectangular on the screen. The maximum size of image that can be displayed is limited by the display resolution, 512 by 512 in this case.

26

2 - Read image to memory with correct aspect ratio
In this type of scaling the image is read into display
memory and scaled to correct for the aspect ratio
distortion of the display. The aspect ratio correction
is specified by variable "aspect" in program DISPLAY.
The current value of 1.33 is common but it may have to
be changed for your monitor.

3 - Expand/contract to fill screen
With this type of scaling, a grid of any size up to
1024 by 1024 is scaled to fill the screen with an
aspect ratio of 1.

4 - Expand/contract to fill screen with correct aspect ratio
This type of scaling is the same as type three except
the aspect ratio set in variable "aspect" is used.

Display logic defines how the new image being read is
combined with the image currently in display memory. Display
logic acts on a pixel by pixel basis by comparison of the
existing 8-bit value in display memory and the new 8-bit
value to be loaded into display memory. Eight different
types of image display logic are possible allowing composite
images to be generated :

1 - Overwrite existing image
Read the new image into display memory overwriting the
existing image. This is the standard display logic for
displaying single images.

2 - Overwrite existing image and display negative
Same as option 1, except the image is displayed as a
negative of the image in the file by inverting the
quantization levels.

3 - "XOR" current and saved image.
Performs a logical exclusive "or" of the stored and new
image. This results in the difference between the two
images being displayed.

4 - "OR" current and saved image
Performs a logical "or" of the stored and new image.
This allows the new image to be superimposed on the
old.

5 - "AND" current and saved images
Performs a logical "and" of the stored and new images.
This results in only common bits in the stored and new
image values being retained

27

6 - "OR" current and saved images and display negative
The same logic as option 4 except the negative of the result is displayed.

7 - "AND" current and saved images and display negative
The same logic as option 5 except the negative of the result is displayed.

8 - Overwrite where saved image is in colour 0.
With this option display memory is overwritten only in background areas.

4 - To graphics tablet control

Program control is transferred from the keyboard to the digitizing tablet. Program options are selected by placing the cursor in the template square corresponding to the desired option and depressing the cursor button. The template and options are described in detail in Section 7.8.

5 - Save the current image

This option allows the current image in display memory to be written to disc as a Halo format image file with filename extension ".pic". The Halo image format is useful because it allows the image to be loaded to display memory from disc more quickly than ".ima" format image files. It also allows transfer of image data between this set of workstation software and the commercial image editing and processing packages mentioned previously.

7.6) COLOUR PALETTES

The colour palette is the 256 sets of RGB intensity values that are loaded into the CLUT to define the display colours. Some general considerations apply to all palette manipulation. Colours 1 and 256 are reserved. Colour 1 is used for undefined and colour 256 is used for text. The red, green, and blue (RGB) intensities for colour 1 are set to zero which produces the colour black. RGB intensities for colour 256 are set to 255 which produces the colour white. Palette manipulation and initialization routines modify only colours within the current active range which is 1 to the number of active colours. The number of active colours is usually set equal to the number of quantization levels used to produce the image files. This is done automatically when image files are loaded, but must be done manually for Halo format images.

7.7) THE PALETTE MENU

The palette menu controls palette initialization and manipulation. Seven options are available using the Palette Menu:

Palette Menu :

1 - Edit the colour palette
2 - Re-initialize the colour palette
3 - Read in a palette from disc
4 - Palette display on/off
5 - Save the current palette to disc
6 - Reduce the number of colours displayed
7 - Change the number of active colours
8 - Continue

An explanation of each of these options follows :

1 - Edit the colour palette
This option allows the user to change the red, green and blue intensities of each palette colour. After the user identifies the colour number to be changed, the current RGB intensities are displayed and the user is asked to enter new values. To exit this option enter 999 when prompted for the colour number to be changed.

2 - Re-initialize the colour palette
This option allows the user to select one of six program defined palettes. The palette is redefined only in the current active colour range. The following options are available :

1 - Grey-tone
A linear grey-tone palette obtained by setting equal RGB intensities.

2 - Linear colour palette
A colour palette similar to the standard colours used for published GSC aeromagnetic maps. In general, blue colours are used for lows and reds are used for highs.

3 - Stepped colour palette
In the stepped colour palette, the contrast between adjacent colours is increased to enhance detail. A number of different effects can be obtained by varying the user specified number of steps per level.

29

4 - Monochrome red
             A linear red palette

        5 - Monochrome green
             A linear green palette

        6 - Monochrome blue
             A linear blue palette

3 - Read in a palette from disc
     This option allows the user to define the colour
     palette from a previously created palette file. All
     palette files have filename extension ".pal". Palette
     files created by DISPLAY are compatible with commercial
     Halo-based image editing and processing software
     packages.

4 - Palette display on/off
     This option toggles on and off a palette display bar
     which shows the current colour for each of the 256
     palette entries. The palette display is non-
     destructively displayed along the bottom of the image.

5 - Save the current palette to disc
     This option allows the current colour palette to be
     stored on disc for later retrieval. All palette files
     are created with filename extension ".pal" and are
     compatible with other commercial Halo-based image
     editing and processing software packages.

6 - Reduce the number of colours displayed
     An image displayed using a smaller number of colours
     than the number of active colours is sometimes more
     effective. The user is informed of the current number
     of active colours and asked how many colours are to be
     displayed. The active colours are then divided into
     groups, the number of groups being equal to the number
     of display colours required. The colour of all levels
     in a group are set equal to the initial colour of the
     highest level in that group.

7 - Change the number of active colours
     Only the active colours in the palette are initialized
     and modified. The active colours are from 2 to the
     specified number of active colours. Different effects
     can be created by changing the number of active levels
     and then re-initializing the palette. If display memory
     is saved when DISPLAY is initiated, the number of
     active colours is initialized to 254 which may not be
     correct for the image in display memory.

8 - Continue
>   Program control returns to either the main menu or the
>   digitizing tablet depending on which was used to
>   request the palette menu.

7.8) DIGITIZER CONTROL OPTIONS

The digitizer is used to position the crosshair cursor on
the colour display, control image pan and zoom functions and
initiate program options. Cursor positioning using a digitizer is
much easier than with keyboard cursor keys. A number of program
options are available from the digitizer tablet. These options
are called by positioning the digitizer cursor over the
appropriate template square and depressing the left cursor button
(with a 3-button cursor). The digitizer template is shown in
Figure 8. The large area on the template above the three rows of
command option boxes is referred to as the screen area.

A description of each of the options on the digitizer
template follows in top to bottom, left to right order.

** TOP ROW **

Main menu
>   Program control returns to the main menu.

Palette menu
>   Program control is transferred to the palette menu.

Red increase
>   Each time the cursor button is depressed the red intensity
>   of all active colours (see "Set active colours) in the
>   palette is increased by 2 units resulting in an overall
>   increase in red content in the displayed image.

Green increase
>   Same as "Red increase" but for green.

Blue increase
>   Same as "Red increase" but for blue.

Zoom in
>   Each time the cursor button is depressed, the currently
>   displayed image is magnified by a factor of 2. Zoom, which
>   may range from 2 to 16 times, is performed in hardware by
>   pixel replication. The current zoom factor is displayed on
>   the text monitor. At any zoom factor other than 1, the
>   entire image cannot be seen. To allow different parts of the
>   image to be viewed, the image may be "panned" . Panning is

31

OISPLAY

MAIN MENU	PALETTE MENU		RED ↑	GREEN ↑	BLUE ↑	ZOOM IN	DISPLAY PALETTE	INITIALIZE PALETTE	SHAPE PALETTE
			RED ↓	GREEN ↓	BLUE ↓	ZOOM OUT	ROTATE PALETTE FORWARD	ROTATE PALETTE REVERSE	
ABORT COMMAND			CHANGE COLOUR	SET ACTIVE COLOURS			LIGHTEN PALETTE	DARKEN PALETTE	

Figure 8 :
This template is placed on the digitizer control surface to identify program control areas and the cursor control area. The overall dimensions of the actual template should be 25.4 cm by 25.4 cm and it should be positioned shifted to the lower left corner of the digitizer control area.

32

performed by moving the cursor to the screen area and
depressing the cursor button. The area displayed will be
centered on the cursor position.

Display palette
This option alternately displays and removes the palette
display. The palette display shows the current colour
palette and is positioned along the lower edge of the
screen. When the image is zoomed, the palette display may be
invisible because it is positioned on a part of the screen
currently not displayed.

Initialize palette
This option transfers program control directly to the colour
palette initialization option of the palette menu. After the
desired palette type is chosen from the keyboard, program
control returns to the digitizer.

Shape palette
Areas of some images may be difficult to analyze because of
inadequate colour contrast. This option allows the palette
colour distribution to be changed from the standard linear
distribution to a non-linear distribution which may enhance
the contrast in these areas. The type of palette
modification is controlled by a shaping factor and the
colour range to be changed is specified by defining a
central colour and a colour range with the digitizer cursor.
The shaping factor defines whether the colour range is to be
compressed or expanded. Factors greater than 1 cause
compression and values from 0 to 1 cause expansion. The
colour in the center of the colour range of interest is then
identified with the cursor and the colour range to be
changed is specified by first selecting the lower colour
limit then the upper colour limit. If a shaping factor of
less than 1 is used (compression) colours will be shifted
towards the central colour. Colours can be identified with
the digitizer cursor either from the image data or the
palette display.

** MIDDLE ROW **

Red decrease
Each time the cursor button is depressed the red intensity
of all active colours in the palette is decreased by 2 units
resulting in an overall decrease in red content in the
displayed image.
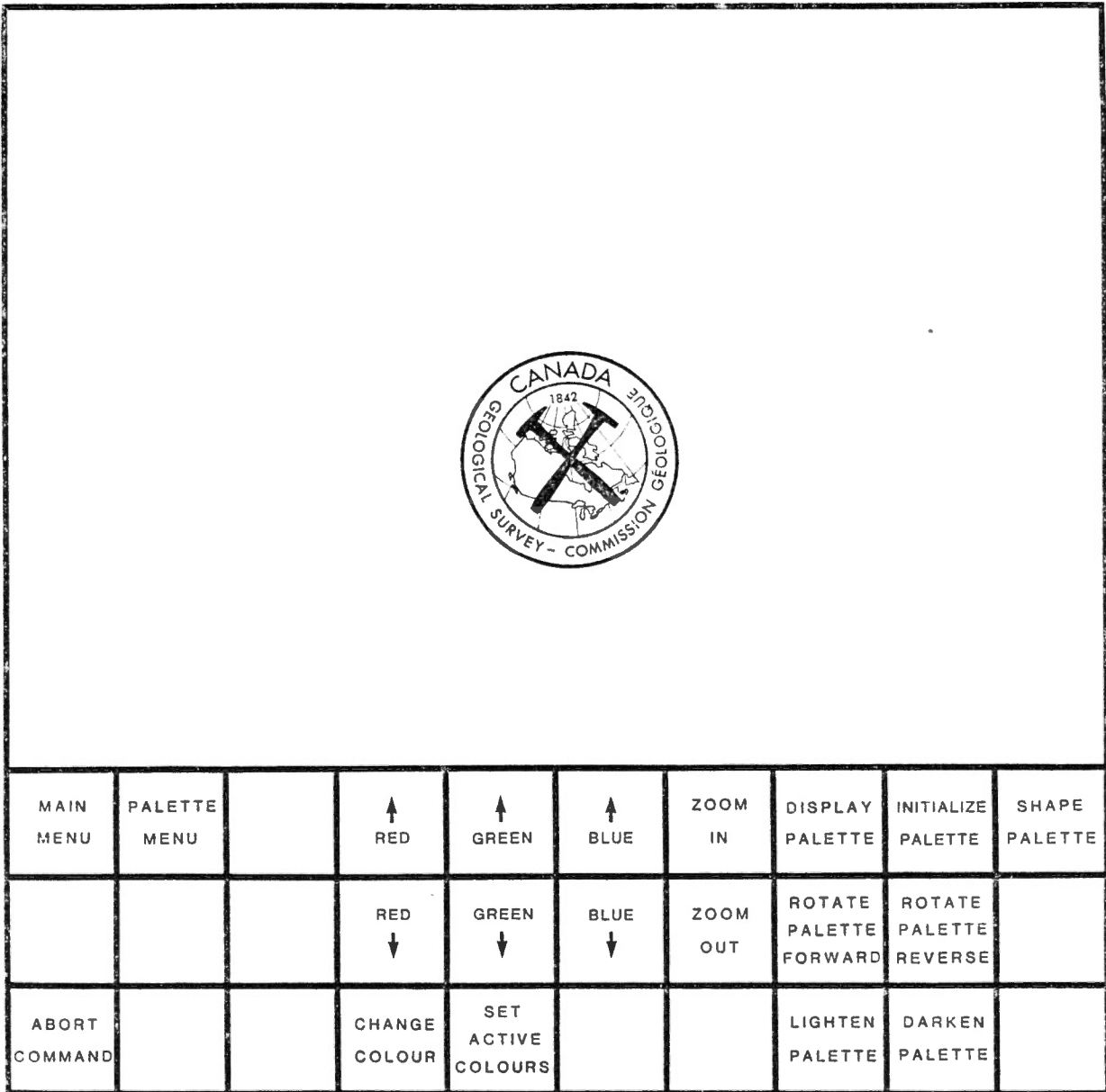
Green decrease
Same as "Red decrease" but for green.

Blue decrease
Same as "Red decrease" but for blue.

Zoom out
Same as "Zoom in" but zoom factor is halved.

Rotate palette forward
All active colours in the palette are shifted to the level above and the colour at the top is moved to the bottom. This process "rotates" all the colours in the palette to change the colour assignment in the image. The process is analogous to taking a stack of plates and moving the bottom plate to the top thus shifting all plates down one in the sequence.

Rotate palette backward
Same as "Rotate palette forward" except the order of "rotation" is reversed.

** BOTTOM ROW **

Abort command
Used to exit the "Change colour" option

Change colour
This option allows a colour to be identified on the monitor using the cursor and changed. The RGB intensities of the selected colour are displayed on the text monitor and the user is prompted to enter new values. All entries in the palette with identical RGB intensity values are also changed.

Set active colours
This option allows the user to change the number of colours in the palette which are affected by palette initialization and manipulation options. The colours in this range are referred to as the active colours.

Lighten palette
This option increases the RGB intensities of all active colours by 3 each time the option is called. This has the effect of lightening the image.

Darken palette
This option is the reverse of "Lighten palette" and reduces the RGB intensities of all active colours by 3. This has the effect of darkening the image.

8.0) SHADE USER'S GUIDE

Shaded-relief images can be generated using program IMAGE and then displayed using program DISPLAY or printed using program IMAGE. Program SHADE uses the reflectance algorithm (see Section 6.3) to generate a shaded-relief display that allows interactive variation of the illumination direction in real-time through colour lookup table (CLUT) manipulation.

In conventional shaded-relief images, the reflectance values for a specified illumination direction are quantized to produce an image file that can be processed for display in the same manner as quantized intensity images. In program SHADE, display memory contains gradient information in two orthogonal directions. This gradient information is translated into a shaded-relief display using a CLUT generated using the reflectance algorithm and specified illumination direction. This allows the apparent illumination direction to be changed by reloading the CLUT with values calculated for a different illumination direction. By precalculating and storing the CLUT values for a number of illumination directions, the time required to change the illumination inclination becomes the time required to reload the CLUT which is a fraction of a second.

In SHADE, illumination inclination is set and CLUT values are precalculated for 16 different declinations around the "compass" in 12.5 degree increments. As a result, illumination declination can be changed instantaneously but, illumination inclination change involves a short delay while 16 sets of CLUT values are calculated for the new inclination.

8.1) SHADE IMAGES

The program first asks the user to choose from two options:

        1 - Create a shade image from a data grid
        2 - Read an existing shade image

A shade image containing gradient data calculated from the original data grid must first be calculated before a shaded-relief display can be produced. The shade image can be saved in Halo image file format to avoid the delay associated with it's calculation if the same data are to be viewed again. Option 1 is chosen to generate the shade image and option 2 is used to read an existing shade image. Shade images are written with filename extension ".shd".

To generate a shade image the names of the input data file and shade file must be specified. Arrays in SHADE are dimensioned to accept data files with a maximum size of 1024 rows. Gradients are determined simply from the difference in the values assigned to the immediate pixel and adjacent pixels to the north and west. A vertical scaling factor must be specified to ensure that the gradients calculated from the data fall within a range of approximately -8 to 7. If an incorrect vertical scaling factor is used, the resulting image will either lack contrast or exhibit contrast variation as the declination is changed. One of the four image scaling options described in Section 7.5 must also be selected to specify how the image is to be loaded into display memory. The program will then progress through the data grid, column by column, calculating the shade image and loading it into display memory.

8.2) INTERACTIVE DISPLAY MANIPULATION

After the shade image has been calculated or read into display memory from a file the program asks the following questions:

"Enter desired illumination inclination (deg.) : "
The illumination inclination must be specified for calculation of the CLUT values for the 16 different illumination declinations. The illumination inclination is specified in degrees from the horizontal. An inclination of 40 degrees is generally a good value to use, but different inclinations may produce useful effects. Illumination from directly above (inclination = 90 deg.) removes the directional aspect of the shaded-relief method and tends to enhance circular and arcuate anomalies.

"Enter contrast factor :"
The contrast factor allows the user to make minor modifications in the contrast of the shaded-relief image. A contrast factor of 1 makes no modification of image contrast. If image contrast is poor or excessive and trying different contrast factors does not correct the problem, the shade image should be regenerated with a different vertical scaling factor.

Once the inclination and contrast factor are specified, "Processing ..." will appear and there will be a short delay while the program calculates 16 new sets of CLUT values. When this is finished, text will appear on the text monitor describing use of the keyboard function keys to control the interactive part of the program. The function keys control the different features as follows :

36

F1 : This key rotates the illumination direction in a clockwise direction. Each time the key is depressed the declination is increased by 12.5 degrees. The current inclination, declination and scale factor are displayed on the text monitor.

F2 : This key decreases the illumination declination by 12.5 degrees resulting in a counter-clockwise rotation.

F6 : This key toggles the display between grey-tone and colour. Experience has shown the grey-tone representation to be more effective.

F8 : This key alternately displays and removes a half sphere display from the lower right corner of the shaded-relief display. This convex half sphere display non-destructively overlays the image and gives an intuitive indication of the illumination direction which aids in interpretation of the shaded-relief image.

F10 : This key allows redefinition of the illumination inclination and contrast factor.

ESC : The "esc" key exits the interactive part of the program.

Before exiting the program, the user is asked:

"Do you wish to save the image ? (y/n) : "
If the image is to be viewed again, the delay of calculating the shade image can be eliminated by saving the image as a Halo format file before exiting the program. Shade images are stored with filename extension ".shd". Using the same name for both the shade image and the original data file helps to keep your files in order.

9.0) FUTURE PLANS

Future workstation development plans include the addition of a Tektronix 4296 colour ink-jet plotter to the system for production of colour hard copy output from MAGRAV2 and DISPLAY.

Software for frequency-domain filtering of potential field data is also planned. Operators such as reduction to the pole, continuation, high pass, low pass, band pass, derivative and directional filters are planned. The slow speed associated with this type of filtering on microcomputers will be alleviated by using an assembly language fast Fourier transform.

10) MODIFICATIONS AND DISTRIBUTION

Many individuals have expressed interest in microcomputer software produced at the GSC. By distributing this software at the cost of reproduction, it is hoped that it will receive widespread use. This use will probably lead to modifications, improvements, and corrections to errors which may exist in the program. The author would appreciate if any significant corrections or improvements to the program are reported so they can be incorporated in later versions of the program. Please distribute only unmodified versions of the program.

So you can be informed of updates to this package of software, please send me your name, address, open file disc number, and the revision number you have. You will be informed by mail of any revisions as they occur. Please check file "read.me" for revision information.

MAGRAV2 revision 1.4 is now available. A number of improvements have been made and errors in the program have been corrected. New source code files for revision 1.4 is available by simply sending me the original disc supplied with the open file in an appropriate mailer. It will be returned to you with the revised MAGRAV2 files.

11) DISCLAIMER

This program is provided on an "as is" basis. Neither The Geological Survey of Canada nor any of it's staff members are liable for any errors in the programs or any problems associated with use of the programs.

12) REFERENCES

Broome,J.
    1986:   MAGRAV2: An interactive magnetics and gravity
                 modelling   program   for   IBM-compatible
                 microcomputers, Geological Survey of Canada, Open
                 File 1334, 21 p..

Broome,J., Simard,R., and Teskey,D.
    1985:   Presentation of magnetic anomaly map data by
                 stereo projection of magnetic shadowgrams, Can.
                 Journal of Earth Sciences, p. 311-314.

Geological Survey of Canada
    1983:   Magnetic anomaly map of Quoich River, Northwest
                 Territories (1:1 000 000), Geological Survey of
                 Canada Map NQ-15-16-17-M.

Goodacre,A.K.
    1986:   Interpretation of gravity and magnetic anomalies
                 for non-specialists, Notes from a Canadian
                 Geophysical Union Short Course given May 1986,
                 organized by A.K. Goodacre, 361 p.

Gonzales,R.C., and Wintz,P.
    1977:   Digital image processing,
                 Addison-Wesley, 431 p..

Horn,B.K.P., and Bachman,B.L.
    1978:   Using synthetic images to register real images
                 with surface models, Communications of the ACM,
                 vol. 21, p. 191-198.

Teskey,D., and Broome,J.,
    1984:   Computer programs for production of shaded relief
                 and stereo shaded relief maps, in Current
                 Research, Part B, Geological survey of Canada,
                 Paper 84-1B, p. 375-389.

APPENDIX A

The following files are provided on the floppy disc :

Fortran source files :

1) VAXPC.FOR
   VAX-11 FORTRAN source code for program VAXPC

2) IMAGE.FOR
   Microsoft FORTRAN source code for program IMAGE

3) DISPLAY.FOR
   Microsoft FORTRAN source code for program DISPLAY

4) SHADE.FOR
   Microsoft FORTRAN source code for program SHADE

Batch files

5) INIT.BAT
   Batch file to load the Halo device driver and set the
   characteristics for the digitizer.

6) COMPMF.BAT
   Batch file to compile Microsoft FORTRAN programs (ver. 3.31)

7) LINKMF.BAT
   Batch file to link Microsoft FORTRAN object modules with the
   FORTRAN, Magrav2, and Multi-Halo libraries.(ver. 3.31)

Data files

8) TEST.DAT
   A 16-bit integer data file containing aeromagnetic data for
   testing software. This data set is 256 columns by 256 rows
   in size and is part of the GSC regional aeromagnetic
   coverage. This particular grid is from the southwest corner
   of the Quoich River sheet (GSC Map NQ-15-16-17-M). The
   southwest corner of the grid is located at approximately:
   latitude, 63 degrees, 50 minutes; longitude, 95 degrees. The
   data are at an altitude of 300m, grid cell size is 812.8 m.,
   and the Definitive Geomagnetic Reference Field has been
   removed.

9) LOGO.PIC
   A Halo format image file containing the banner image
   displayed when DISPLAY and SHADE are executed.

10) MAGRAV2.LIB

Object library file containing assembly language subroutines
SOUND and INKEY2. This library must be in the default
directory when LINKing the workstation programs.

11) READ.ME

This text file contains information about changes and
revisions not included in the user's guide.

APPENDIX B

Compiling and linking VAXPC

After "VAXPC.FOR" has been transferred to a VAX computer, It must first be edited to convert the program to accept the gridded data file format in use on your system. This will require either changes or replacement to subroutines REAHDR and DMPHDR. The expected file format for gridded data files on the host computer is described in Appendix C.

"VAXPC.FOR" must then be compiled by the VAX FORTRAN compiler using the command :

      $ FORTRAN VAXPC <CR>

and linked using the command :

      LINK VAXPC <CR>

      File "VAXPC.EXE" is now available for execution.

Compiling and linking IMAGE, DISPLAY, and SHADE

Each of the FORTRAN source code files must be compiled and linked to produce executable files. To simplify this process two batch files "compmf.bat" and "linkmf.bat" are provided on the floppy disc. A hard disc is strongly recommended to facilitate compilation.

To use batch file "compmf.bat" the following files must be present on the default directory. :

      1) FOR1.EXE (supplied with Microsoft FORTRAN compiler)
      2) PAS2.EXE ("   "   "   "   "   )
      3) FORTRAN source code file.
      4) COMPMF.BAT

To compile SHADE type :

      A:> COMPMF SHADE <CR>

You be will informed of any errors and "Compilation complete" indicates completion. The output file will be "SHADE.OBJ".

42

To link a program using "linkmf.bat" the following files must be present on the default drive :

    1) LINK.EXE   (supplied with Microsoft FORTRAN compiler)
    2) MATH.LIB   ("   "   "   "   "   )
    3) FORTRAN.LIB ("   "   "   "   "   )
    4) MAGRAV2.LIB
    5) Program object module (output from compilation)
    6) LINKMF.BAT
    7) HALODVXX.OBJ (supplied with Multi-Halo package)
    8) HALOF.LIB   ("   "   "   "   )

To link SHADE type :

    A:> LINKMF SHADE <CR>

You will be informed of errors and "Link completed" indicates completion. The output executable file will be called "SHADE.EXE".

NOTE: Program IMAGE does not use Multi-Halo subroutines. As a result, files 7 and 8 above are not required for linking. To link IMAGE without Multi-Halo, edit the "link...." statement in "linkmf.bat" removing "+halodvxx" and "+halof".

The following file formats are described here :

1) Floating-point data grid
                    on the VAX (".grd" filename extension)
2) 16-bit integer data grid (".dat"   "   "   )
3) 8-bit integer image grid (".ima"   "   "   )
4) Halo format image grid   (".pic"   "   "   )
5) Palette files   (".pal"   "   "   )
6) VAX quantization files   (".lev"   "   "   )

IMAGE AND DATA FILE FORMATS

Four types of data files are used by the software.

1) Floating-point data grid on the
                              VAX host. (".grd" extension)
2) 16-bit integer data grid on VAX and   (".dat"   "   )
   workstation.
3) 8-bit integer image grid on VAX and   (".ima"   "   )
   workstation.
4) Halo format image grids   (".pic"   "   )

The grid of data on file types 1-3 is stored in the same
order. Data are written column by column from West to East.
Within   each   column values are stored from South to North.
Differences between grid types are in the formats used for
writing the values, the headers, and undefined value flags.

1) Floating-point grids on the VAX host. (".grd")

Each value is written as a standard floating-point number.
Boundary values are flagged with -9999.0. A detailed header
containing projection information, grid cell size, data area
coordinates, a comment field, and a data type indicator is used
and read and displayed with subroutines WRTHDR and DMPHDR
respectively. This information is written in the first four
records of the file. The next record after the header contains :

ICF, ICL, IRF, IRL (format: integer*4 , (32-bit))

    ICF : number of the first column on the grid
    ICL :   "   "   "   last   "   "   "   "
    IRF :   "   "   "   first row   "   "   "
    IRL :   "   "   "   last   "   "   "   "

(ICL-ICF + 1) columns of data follow, each column containing (IRL
- IRL + 1) values.

2) 16-bit integer data grids (".dat")

The first record is the header containing :

NRO, NCO, NTYPE, IZOFF, IZSCL (integer free format)

NRO   : number of rows on the grid, or number of values/column

NCO   : number of columns

NTYPE : value indicating type of grid (not used)

IZOFF : The background removed from the original floating-point value before it was scaled to fit the 16-bit integer field. This value is used to restore the 16-bit data to a floating-point number after data transfer to the workstation. For more information see program VAXPC and subroutines CVTITR, CVTRTI, and SETCVT in the workstation software.

IZSCL : The scaling factor used to compress the dynamic range of the floating-point value on the VAX data grid into the -32766 to 32767 range of the 16-bit integer. This value is used to restore the 16-bit integer value to a floating-point value after data transfer to the workstation. For more information see program VAXPC and subroutines CVTITR, CVTRTI, and SETCVT in the workstation software.

After the header record, NCO columns of data follow, each containing NRO 16-bit integer values. Undefined values are set to -32767 in this grid.

3) 8-bit integer image grids (".ima")

The first record on the file is the header containing :

NRO, NCO, NTYPE, NZCLP1, IDUM (integer free format)

NRO   : The number of rows on the image, or the number of 8-bit values in a column.

NCO   : The number of columns

NTYPE : The type of grid (not used)

NZCLS : The number of levels found on the image (maximum of 254). This is used to set the number of active colours in DISPLAY.

IDUM : A dummy variable, unused.

After the header record, NCO columns of data each containing NRO 8-bit values follow. Undefined values are set to 0.

4) Halo image files (".pic")

Please refer to your Multi-Halo manual for information on this encoded image file format.

OTHER FILE FORMATS

5) Palette files (".pal")

Please refer to your Multi-Halo manual for information on palette files.

6) Quantization files (".lev")

Quantization files are found on both the VAX (created by VAXPC) and the workstation (created by IMAGE). The data content of the two files is identical but the VAX files have the addition of an 80 character ASCII descriptive header as the first record.

VAX ".lev" file :
Record 1 : 80 character ASCII header
Record 2 : NZCLS, number of levels (integer free
format)
Record 3 : "NZCLS" quantization levels (floating-point)

Workstation ".lev" file :
Record 1 : NZCLS,"NZCLS" quantization levels (format:
integer*4, real*4)

APPENDIX D : SOURCES

This section provides addresses for some of manufacturers and distributors of software and hardware mentioned in the publication.

1) The Multi-Halo graphics subroutine library,
   Image-Pro image processing package, and
   HALOVision image editing software are produced by :

   Media Cybernetics, Inc.,
   8484 Georgia Avenue, Suite 200,
   Silver Spring, Maryland,
   USA, 20910.

   Ph: 301-495-3305

2) The "Revolution" colour graphics board is available from :

   Number Nine Computer Corp.,
   725 Concord Avenue, Cambridge,
   MA 02138, USA.

   Ph: 617-492-0999

3) The Microsoft FORTRAN compiler is produced by :

   Microsoft
   16011 NE 36th Way,
   Box 97017, Redmond, WA
   98073-9717

4) The "Kermit" communications software is available from :

   Kermit Distribution,
   Columbia University Center for Advanced Computing
   Activities, 612 West 115th St.,
   New York, NY, 10025.

5) The "Procomm" communications software package is available from:

   PIL Software Systems,
   P.O. Box 1471, Columbia, MO,
   USA, 65205.