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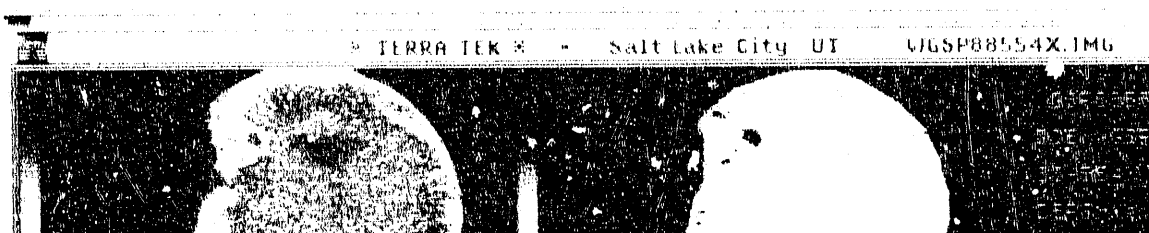
Figure 1H

Cross Sectional and
Masked Images of Sample 1



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1 OF

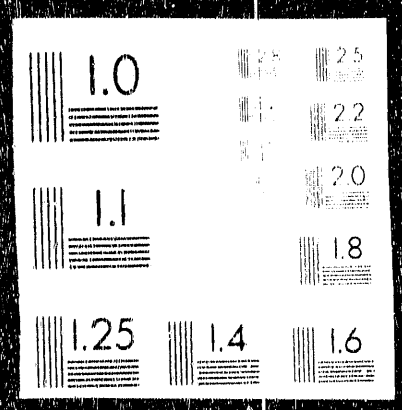
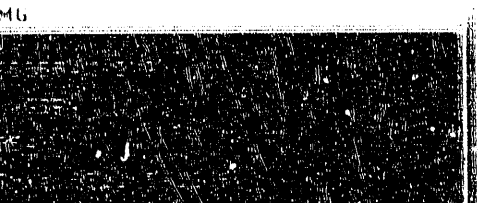
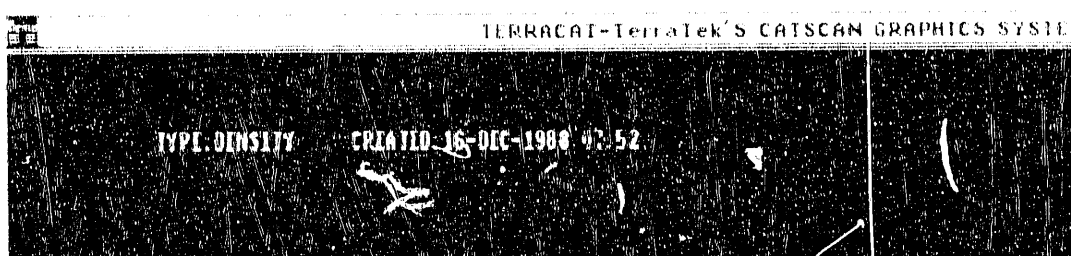


Figure 1I

...tical Reconstruction and
...k Density Log of Sample 1





NOTICE

CERTAIN DATA CONTAINED IN THIS DOCUMENT MAY BE DIFFICULT TO READ IN MICROFICHE PRODUCTS.

TerraTek

Geoscience Services

TerraTek Inc.

DOE/MC/24156--T2

DE92 017790

December 30, 1988

U.S. Department of Energy
Morgantown Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

Attention: Mr. Karl Heinz-Frohne

Subject: Quarterly Technical Progress Report on Project No. DE-FC21-87MC24156 Entitled "Development of Core Analysis Procedures Using X-Ray Computer Tomography"

Period Covered: September 1, 1988 to November 30, 1988

Dear Karl:

During the last quarter we have completed Task 5 - Multiphase Relative Permeables. Output capabilities have been documented in recent reports. Irregular-shaped region of interests capabilities have also been incorporated into analysis programs. This is done through defining a polygon with up to 200 points.

Six samples were sent from Sandia National Laboratories for analysis. These samples are naturally fractured core from the MWX wells. Core was received in early November and scanned. Poor quality images were collected. This was due to two factors--the combination of which provided for poor analysis. These factors are:

A. The core was slabbed and plugged. The scanner is primarily looking for round objects. Slabbed core or any object with sharp edges causes artifacts in the images. Attempts were made to minimize these problems through packing the object in sand, which minimized the problem in lower-density samples.

B. Some of the samples had very high density and high effective atomic number inclusions. These typically cause problems with the resolution of the images. Although we have also been working on this problem, preliminary results are not fully developed. This report is late at the time of writing and further delays were unacceptable.

University Research Park • 400 Wakara Way • Salt Lake City, Utah 84108 U.S.A. • Telephone (801) 584-2400 • Telex 910-925284

The six samples are designated as follows:

Sample	Depth	Desired Scanning Internal	Scanning Interval
1	6311.8-12.6'	1 cm	1 cm
2	6008.7-09.6'	1 cm	1 cm
3	5793.0-94.2'	1 cm	1 cm
4	5996.2-96.7'	5 cm	1 cm
5	5709.3-10.4'	5 cm	5 cm
6	5341.5-42.5'	5 cm	5 cm

In a letter from John C. Lorenz of Sandia National Laboratories dated November 8, 1988, analyses of interest included fracture permeability, microfractures and fracture interconnections. With the core received, these measurements are not possible. Core must be loaded into a passive vessel to flow various fluids for permeability measurements. Because the core was slabbed and plugged, this was not possible. Microfractures or porosity distribution can also be seen by flowing two fluids with contrasting attenuation coefficients and using a subtractive imaging technique. This again could not be done because core could not be inserted into a flow vessel. Similarly, fracture interconnections could not be measured.

Figures 1A through 1H do show the cross-sectional images taken of Sample 1. These images appear in the left-hand column of the figures. Each image is labelled with its corresponding depth. Image 100001 at a depth of 6311.8 feet is shown in the upper left corner of Figure 1A. Image 100002 is below it and the rest follow accordingly.

Each cross-sectional image is made up of a 256x256 array of data. This data array is composed of CT numbers which are collected from the scanner. These CT numbers are defined as normalized attenuation coefficients for the material being scanned. At the energy level used for this data, the CT numbers are approximately proportional to the density of the sample material. Subsequently, colors are assigned arbitrarily to the CT numbers to highlight contrasts in density in the core. Red is assigned to higher-density regions and blue to lower-density regions. Variations from red to blue are shown in the color bars to the left of the images.

Fracture analysis was performed on all the cross-sectional images. The center column in Figures 1A through 1H shows the fracture analysis images.

Fracture analysis is achieved by utilizing a masking technique on the acquired data. A masked image is an artificially generated image that allows visual representation of specific ranges of CT numbers for a specified region of interest of the cross-sectional image. The region of interest for all 15 images is an area just inside the core perimeter.

CT number range assignment is made to view fractures in the region of interest and to quantify the area attributed to fractures. Black is assigned to all regions with a CT number below a minimum threshold value and represents missing pieces of core. The color blue is given to a range of CT numbers which depicts a low-density zone and corresponds to open fractures. Red is assigned to high-density zones and correspond to filled fractures or high-density mineral inclusions. The remainder of the core is assigned the color yellow.

The right-hand column in Figures 1A through 1H gives the statistics for the associated masked image. The statistics show what percentage of area within the region of interest is black, blue, red and yellow. The percentage of red corresponds to the high-density filled fractures. The blue percentage corresponds to the low-density filled fractures or open fracture porosity.

Sample 1 had a large number of high-density inclusions that have high concentration of pyrite. These inclusions cause significant problems in identifying fractures. A new calibration technique is being tried to minimize these problems but was not completed at the time of writing this report. Figure 1I shows a reconstruction of the core over its 1.5-foot length and a bulk-density log of the sample in the region where plugs were not taken. This reconstruction is done by taking a Pixel array in the Y axis of the cross-sectional images and stacking them next to each other.

Figure 3A through 3L shows the results of scans taken in Sample 3. Fractures are not visible until Image 100075. Images 100079 and 100080 were taken in a zone where the core was broken.

Figures 4A through 4C show the results of Sample 4. The masking routine was not used on cross-sectional images taken in Sample 4 because of poor image quality. However, open fractures can easily be seen in the cross-sectional images.

Figures 5A through 5C show the results from Sample 5. These images were taken every 5 cm.

Figure 2A through 2K show similar results for Sample 2. In this case, fractures are much easier delineated. The filled fractures are, however, filled with material of high enough density such that the detectors overshoot their limits causing anomalously low values. Therefore, percentage numbers in masked images in the "black" designations should really be added to the red percentages. Figure 2J show a reconstruction in the Y-110 direction. No fractures are visible . If a reconstruction in the X-128 direction is performed, however, fracture can easily be seen (Figure 2K).

Results of Sample 6 are shown in Figures 6A through 6B. Again, poor image quality precluded doing masking of the cross-sectional images.

In the summary, the analysis of the core is poor due to slabbing and plugging of the core and due to artifacts in the images which require improved initial calibration. New calibration procedures should be completed soon. Whole core is required to do flow type tests for fracture permeability, fracture connection and microfracture measurements.

If you have any questions, please do not hesitate to contact me.

Sincerely,

TERRA TEK, INC.

John C. Sharer

Figure 1A

Cross Sectional and
Masked Images of Sample 1

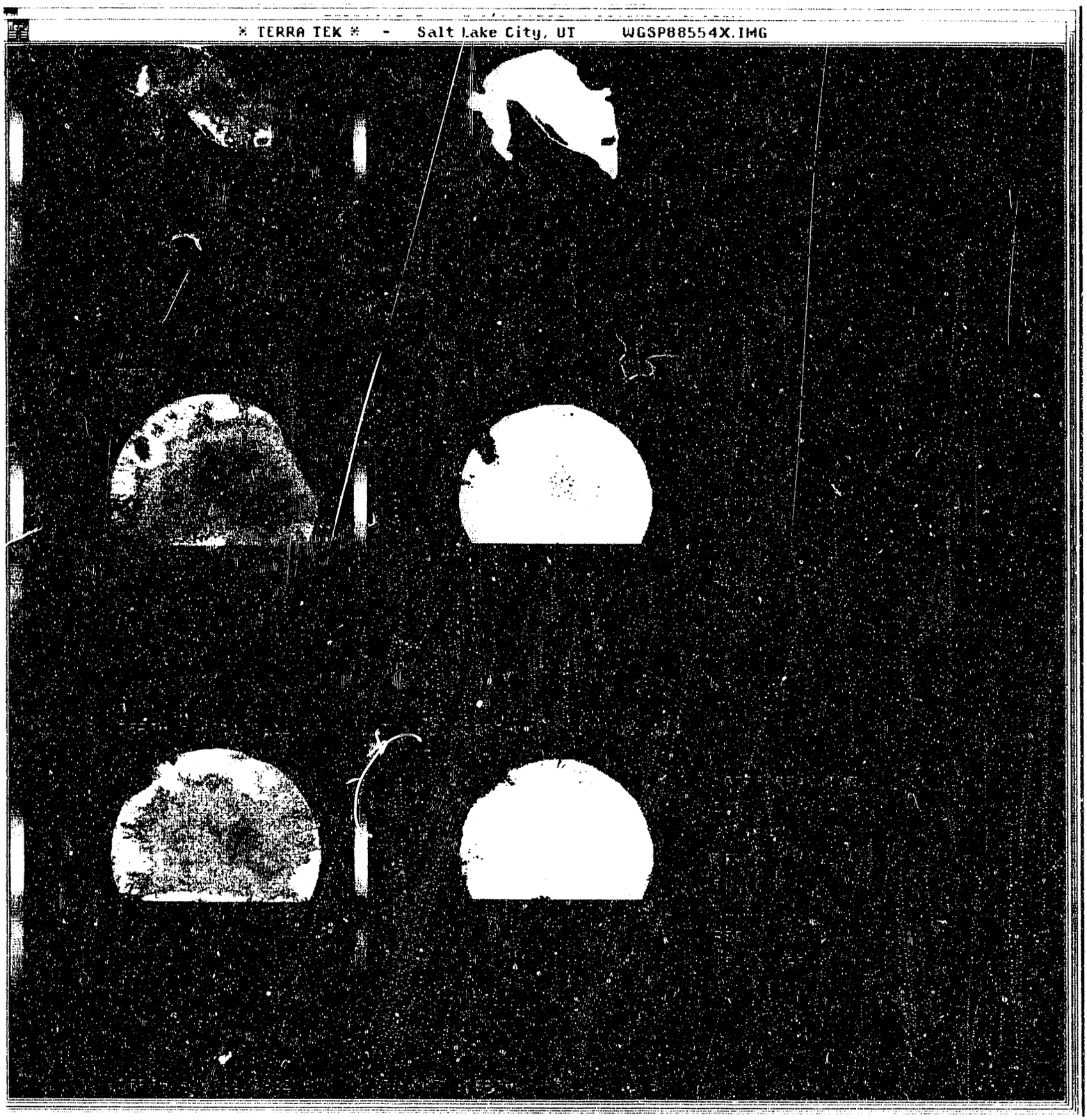


Figure 1B

Cross Sectional and
Masked Images of Sample 1

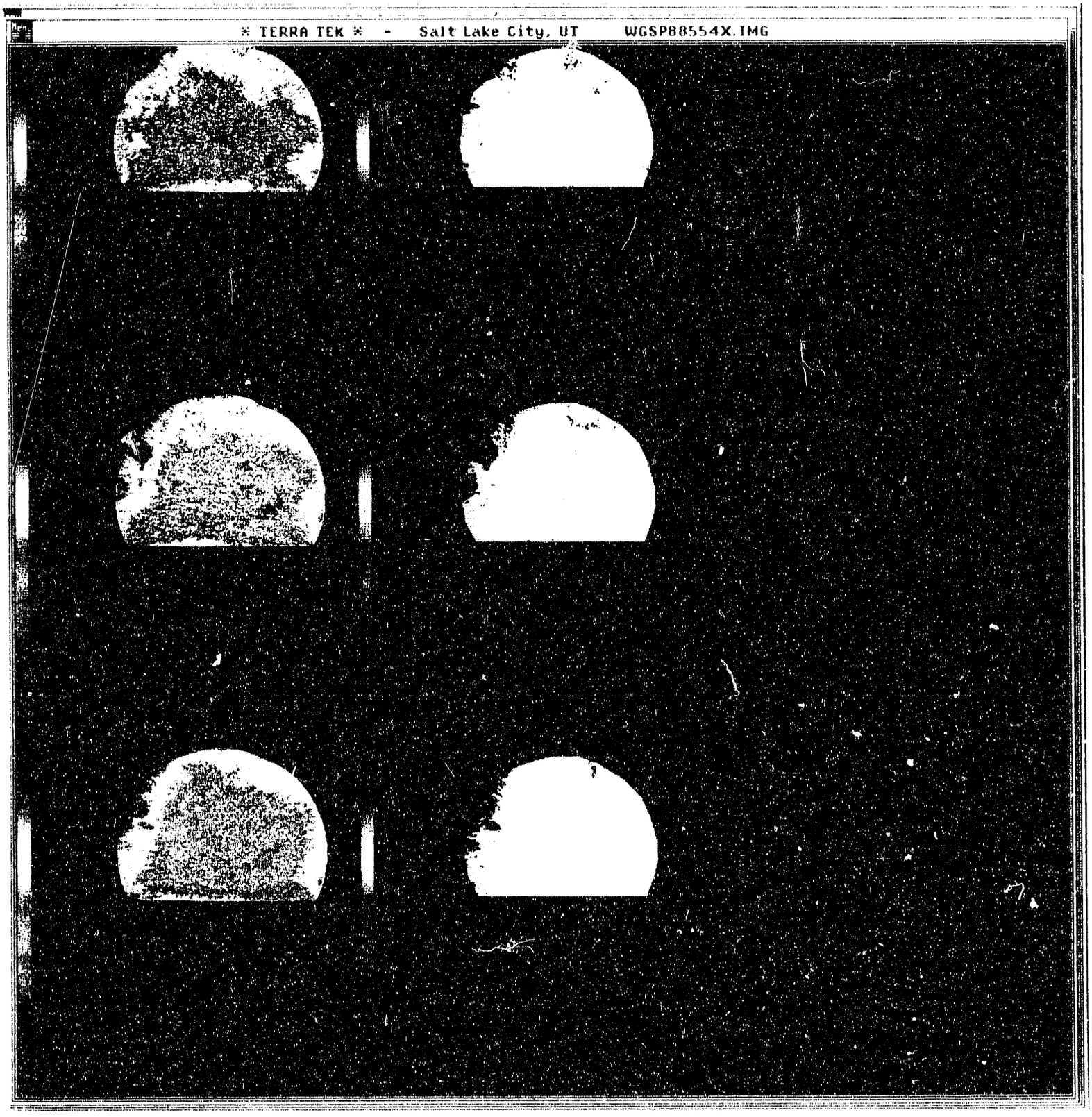


Figure 1C

Cross Sectional and
Masked Images of Sample 1

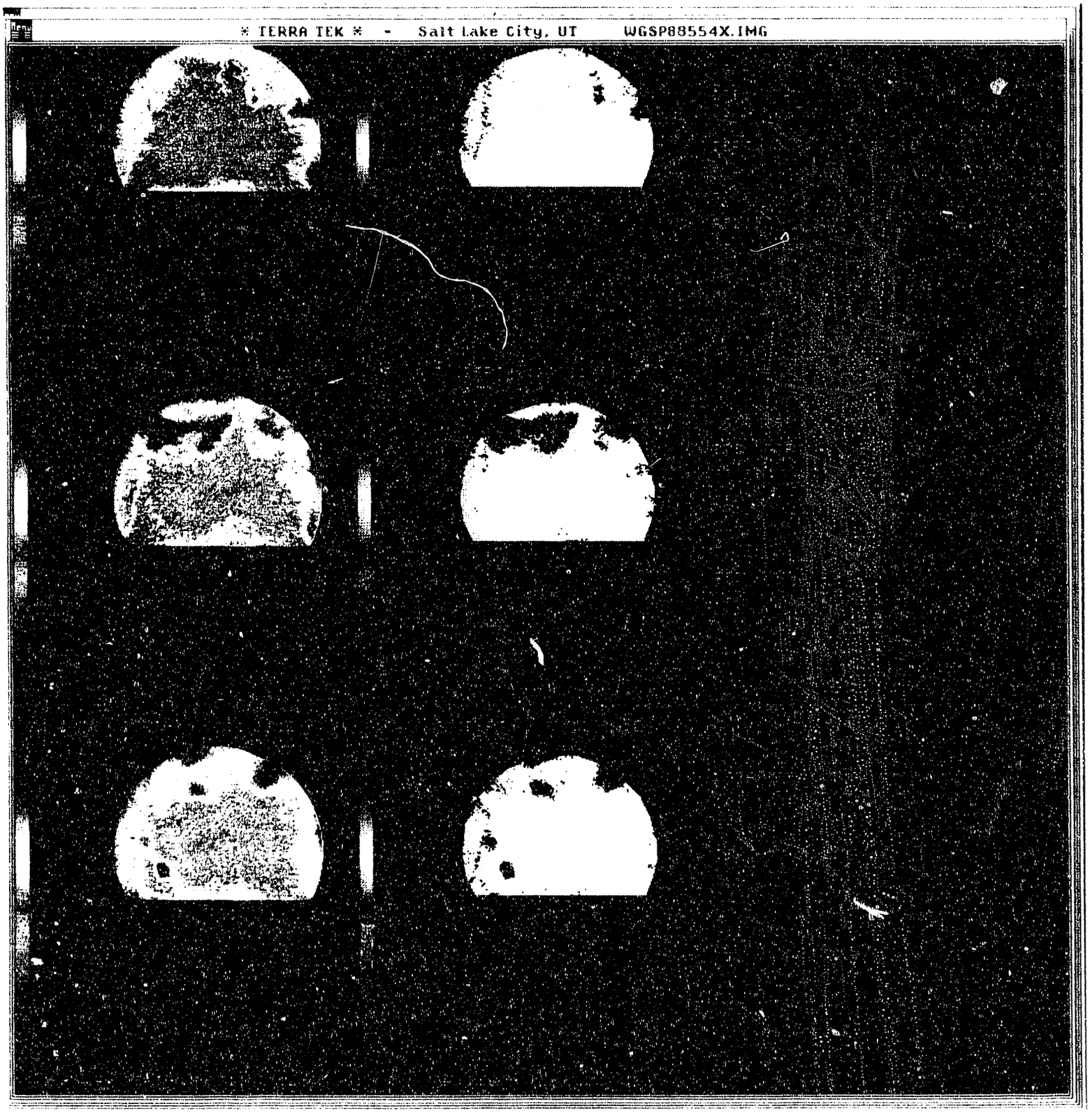


Figure 1D

Cross Sectional and
Masked Images of Sample 1

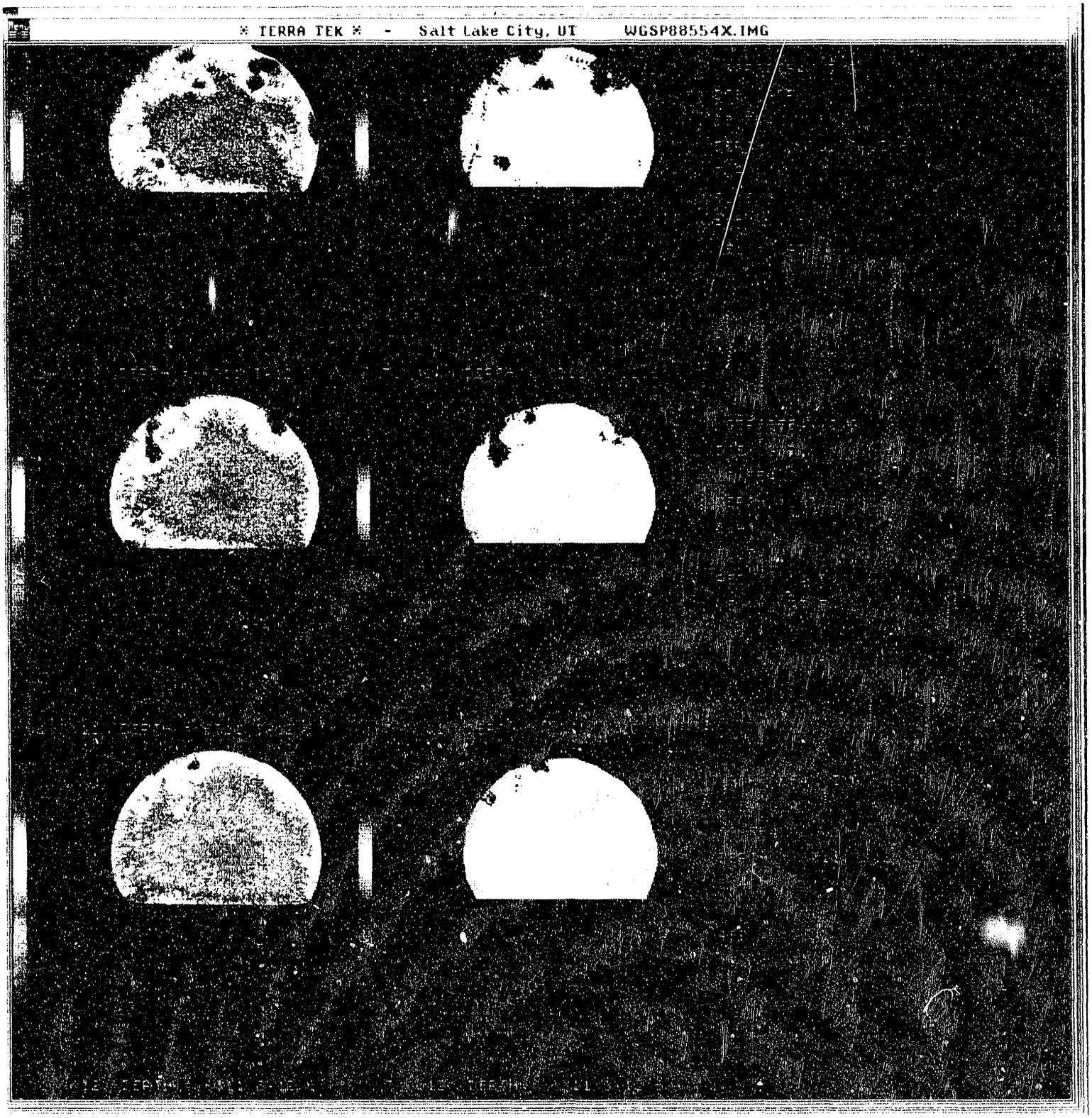


Figure 1E

Cross Sectional and
Masked Images of Sample 1

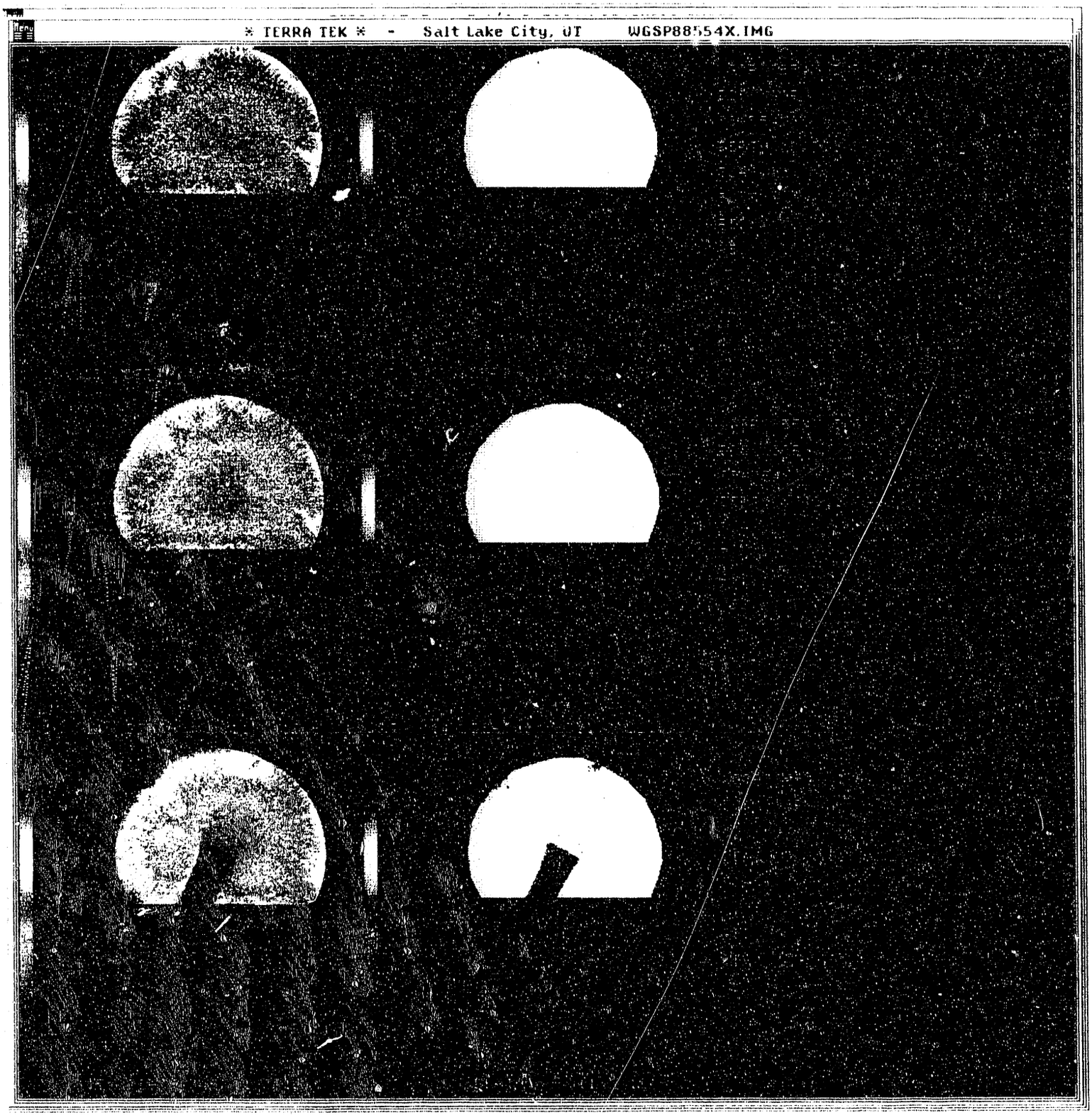


Figure 1F

Cross Sectional and
Masked Images of Sample 1

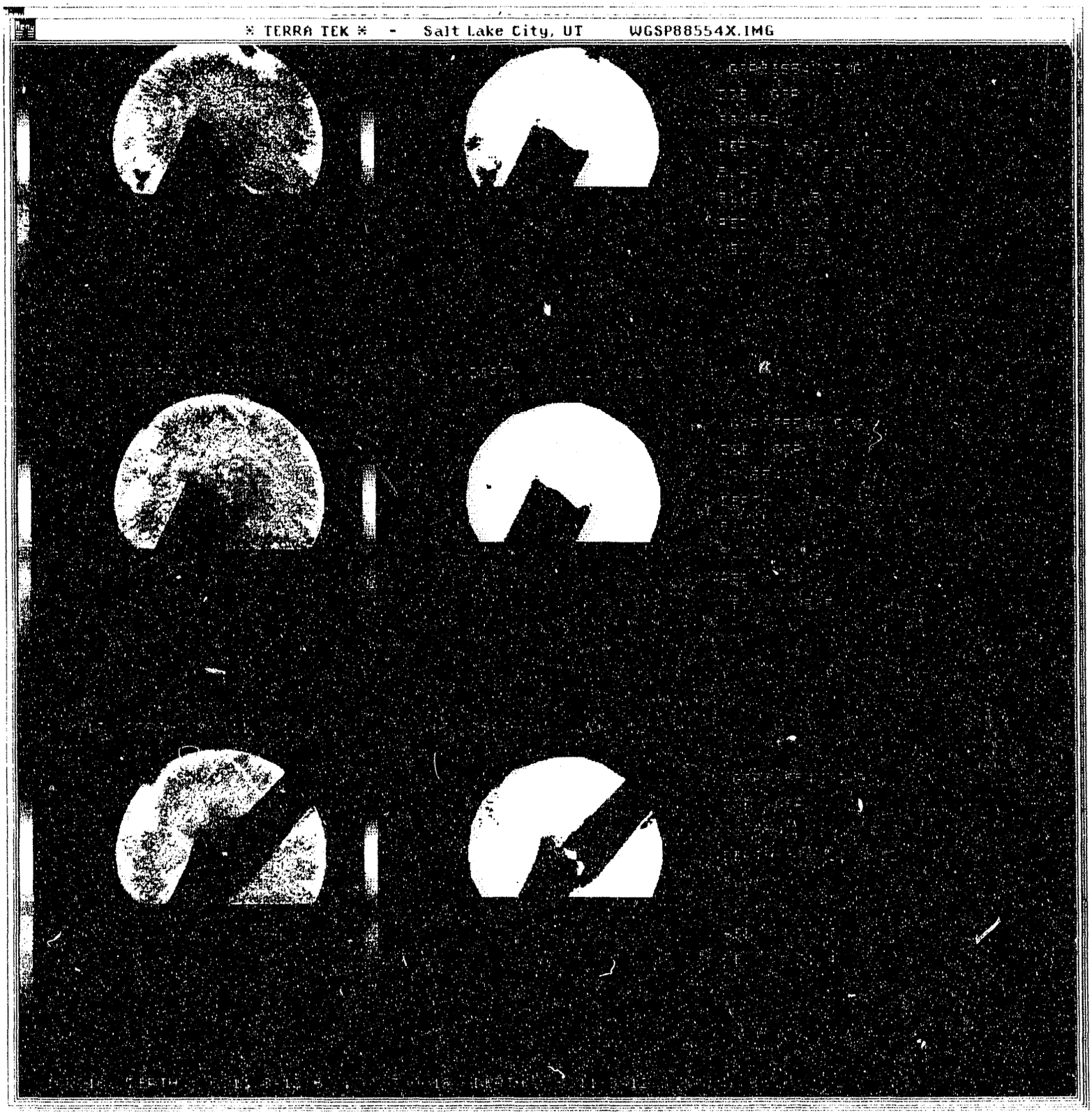


Figure 1G

Cross Sectional and
Masked Images of Sample 1

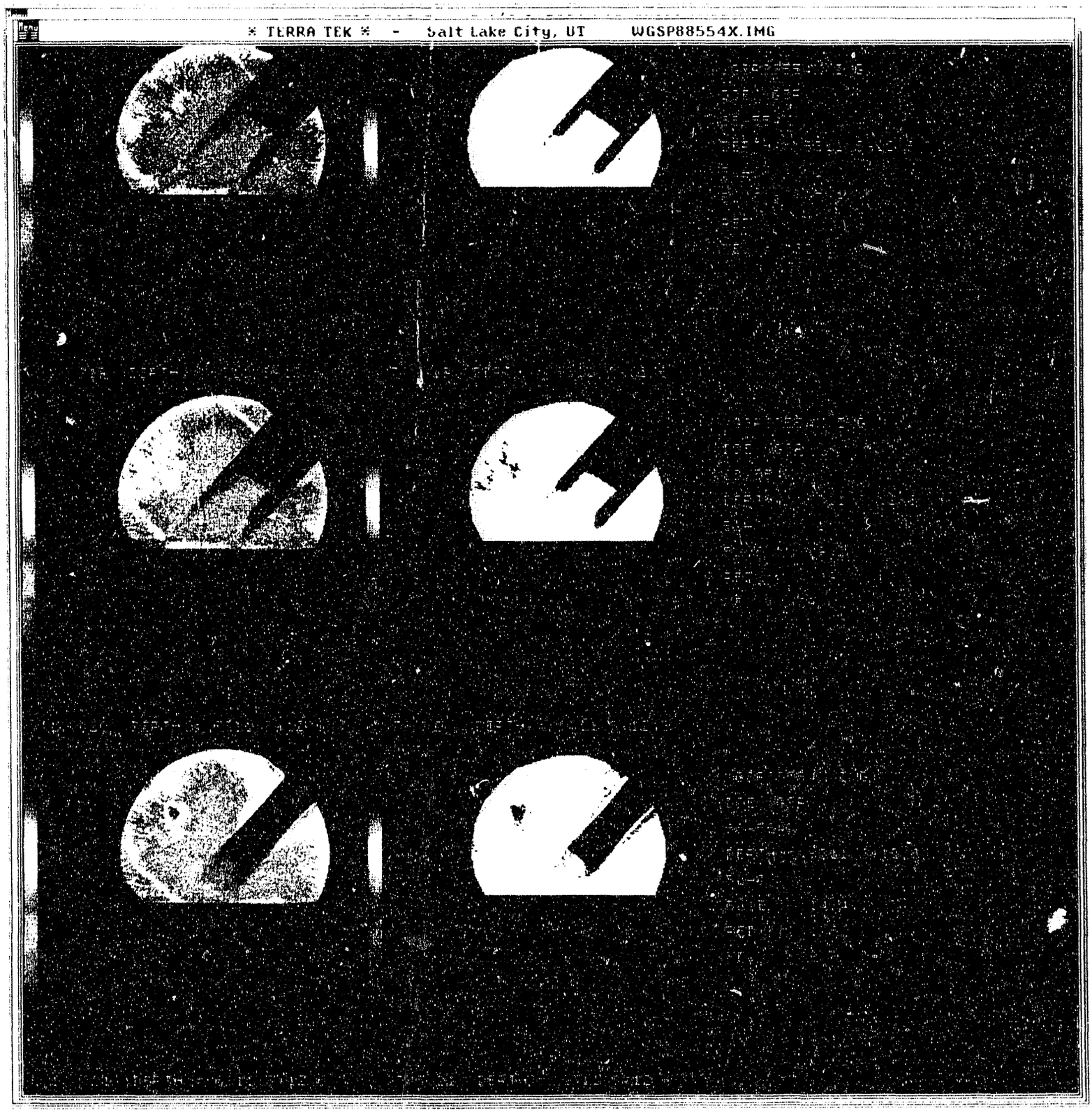


Figure 1H

Cross Sectional and
Masked Images of Sample 1

Figure II

Vertical Reconstruction and
Bulk Density Log of Sample 1

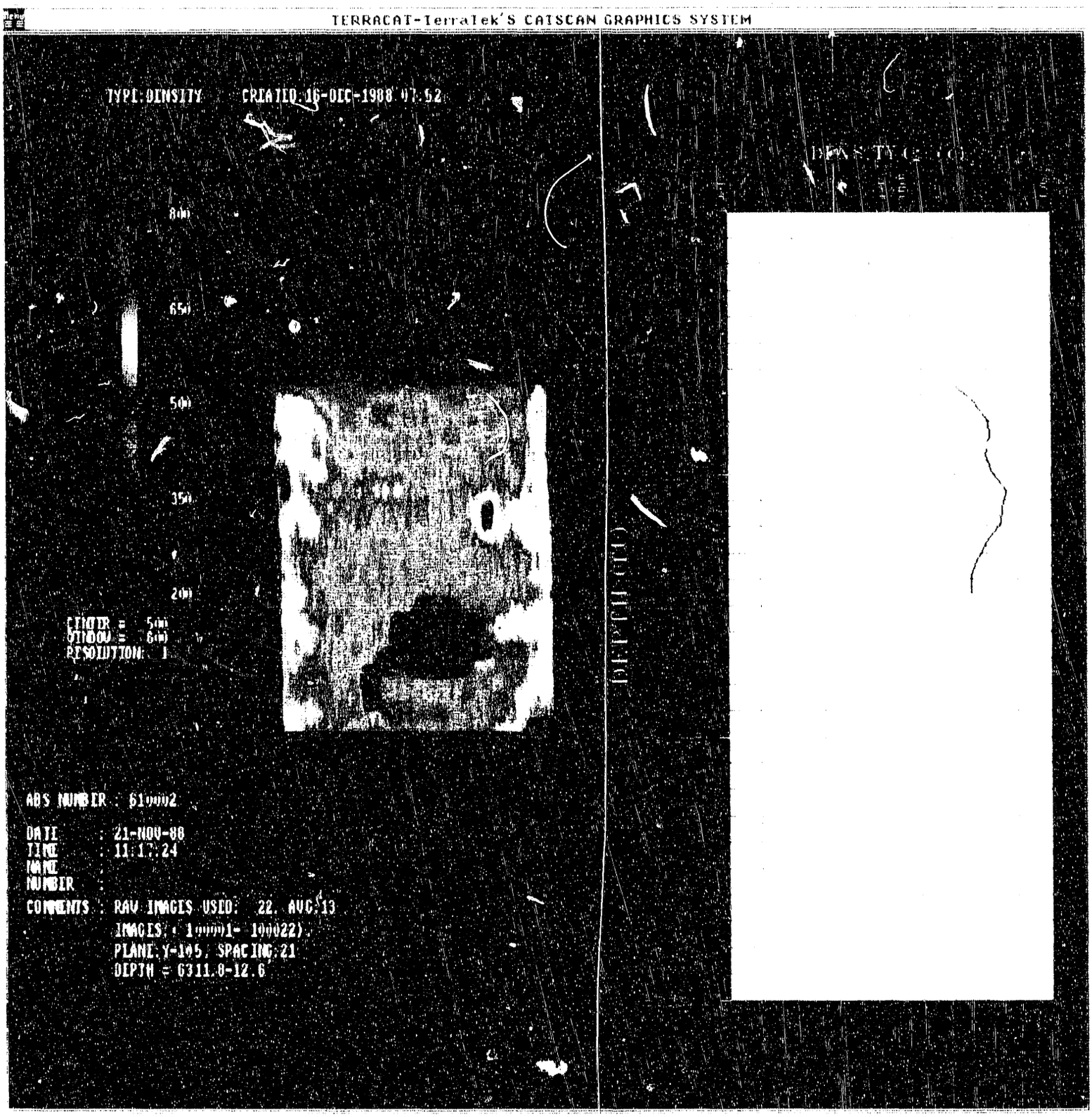


Figure 2A

Cross Sectional and
Masked Images of Sample 2

Figure 2B

Cross Sectional and
Masked Images of Sample 2

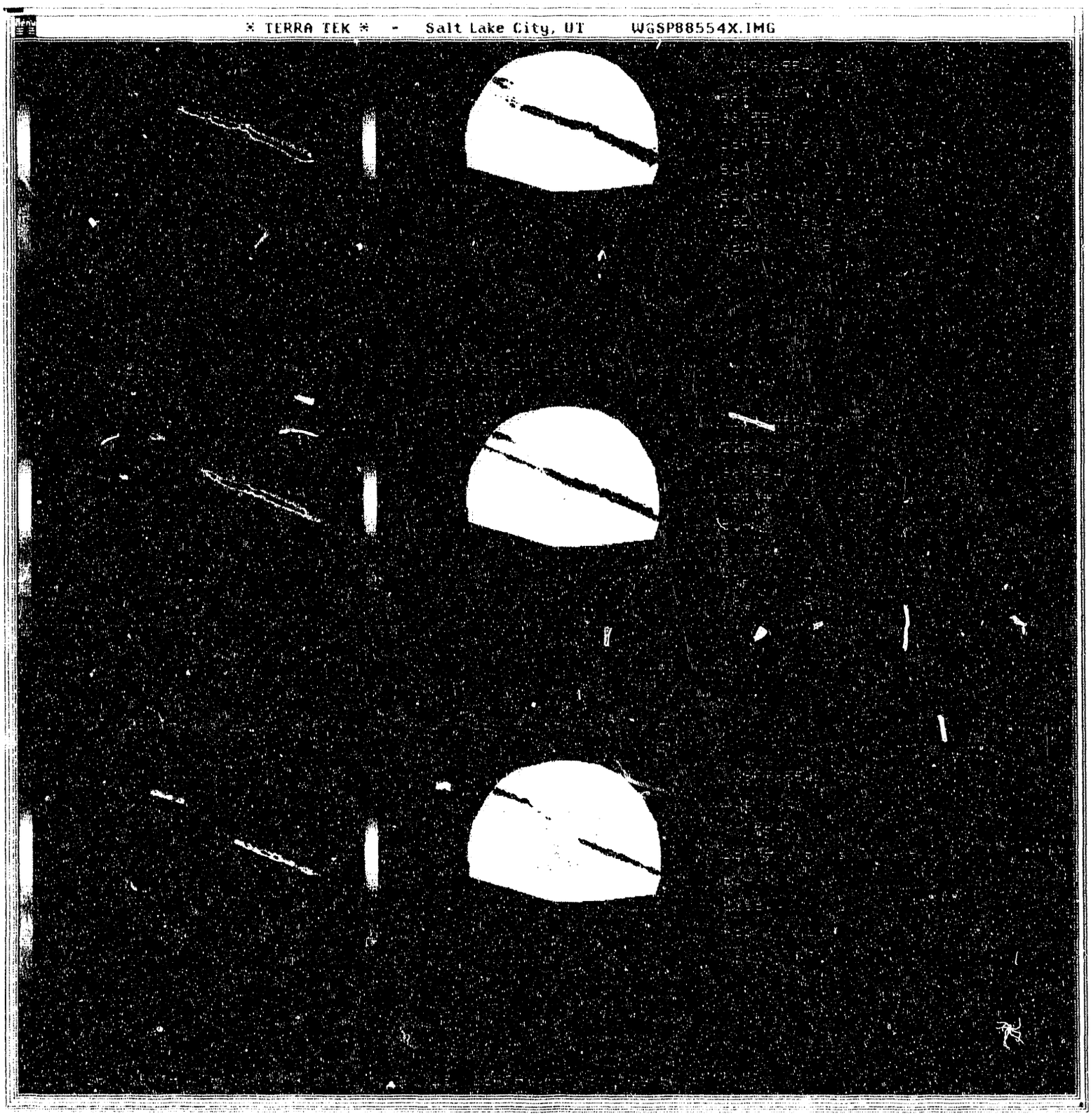


Figure 2C

Cross Sectional and
Masked Images of Sample 2

Figure 2D

Cross Sectional and
Masked Images of Sample 2

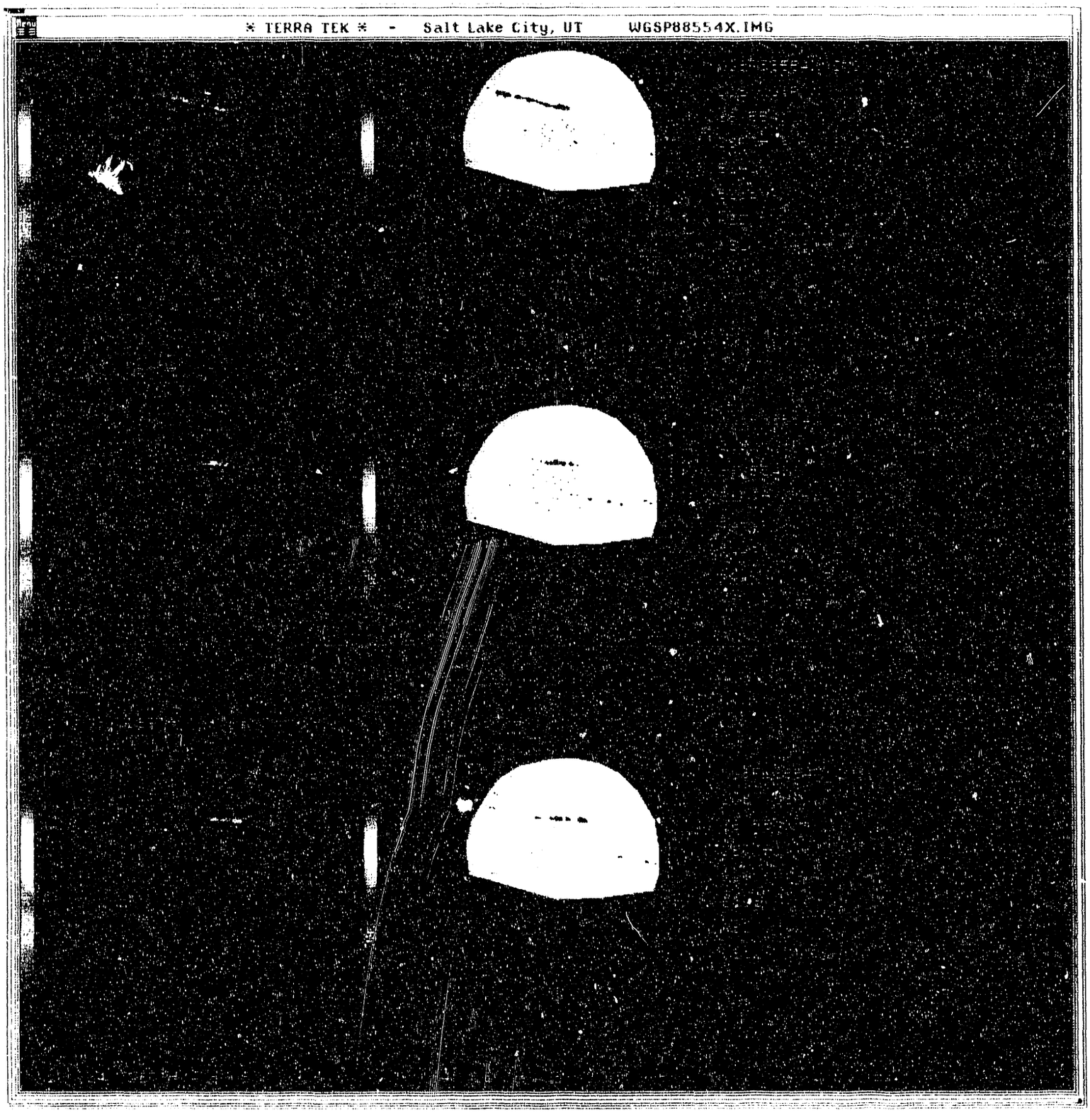


Figure 2E

Cross Sectional and
Masked Images of Sample 2

Figure 2F

Cross Sectional and
Masked Images of Sample 2

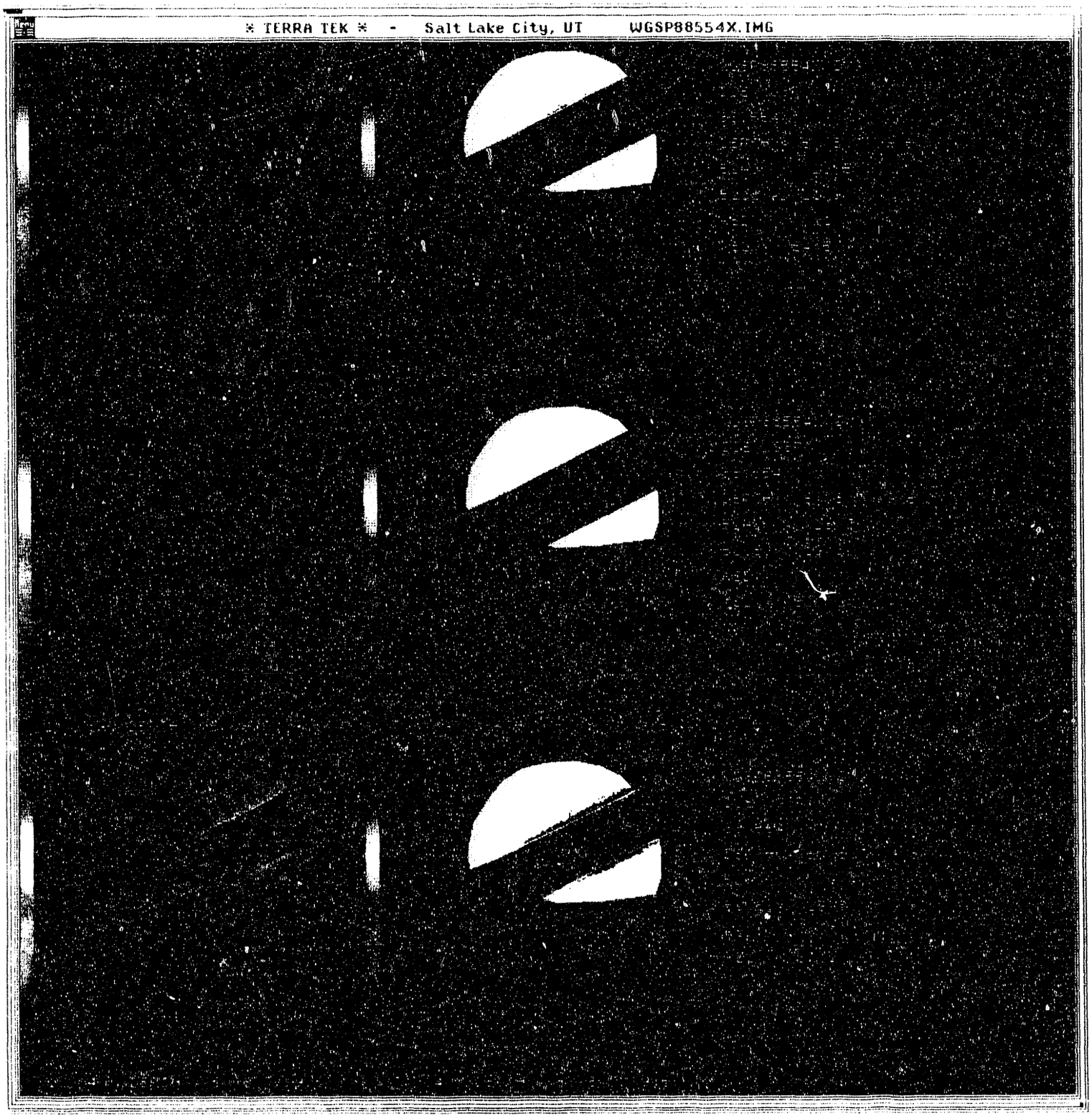


Figure 2G

Cross Sectional and
Masked Images of Sample 2

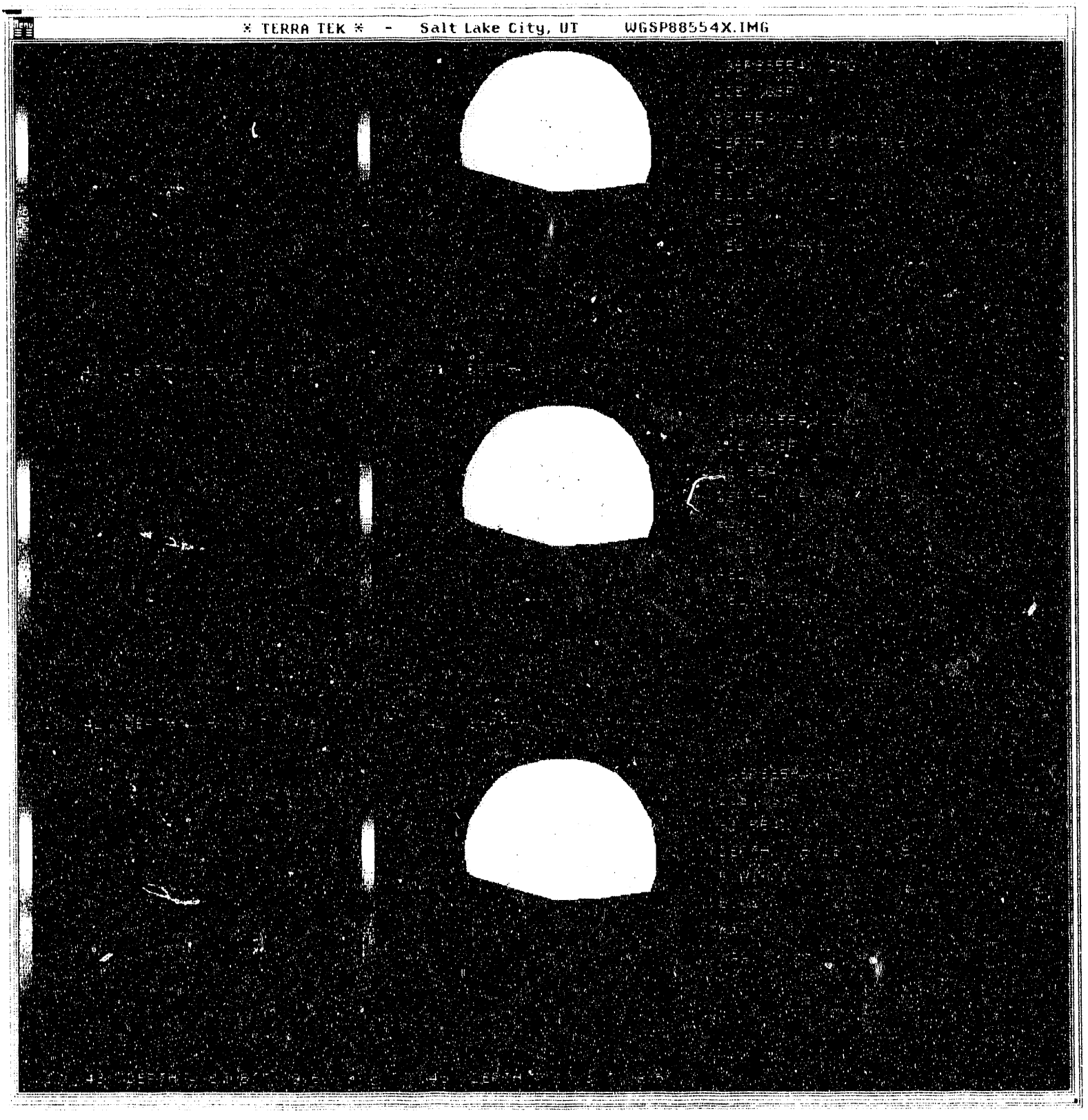


Figure 2H

Cross Sectional and
Masked Images of Sample 2

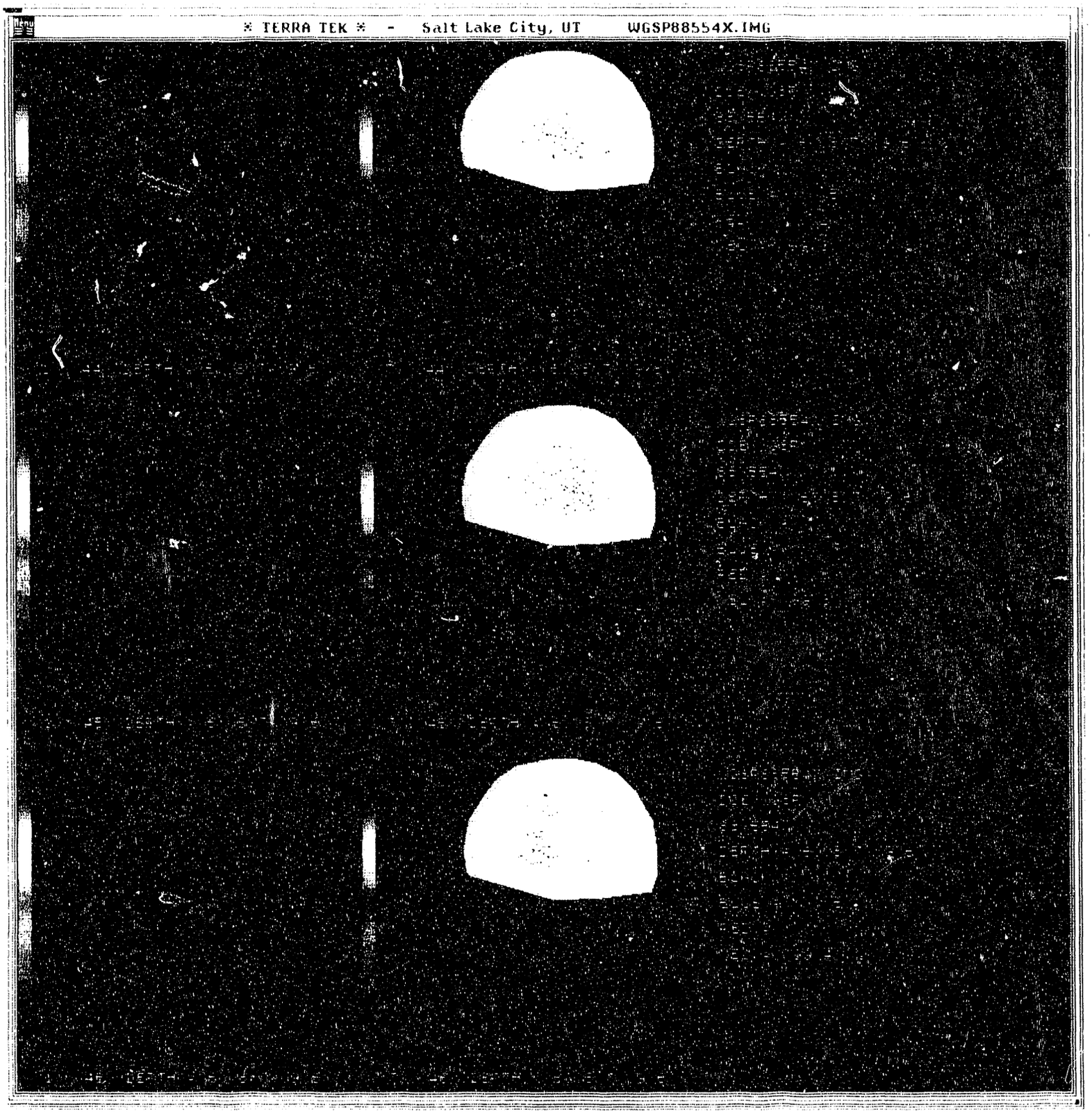


Figure 2I

Cross Sectional and
Masked Images of Sample 2

Figure 30

Vertical Reconstruction
and Bulk Density Log
of Sample 2 - Y Direction

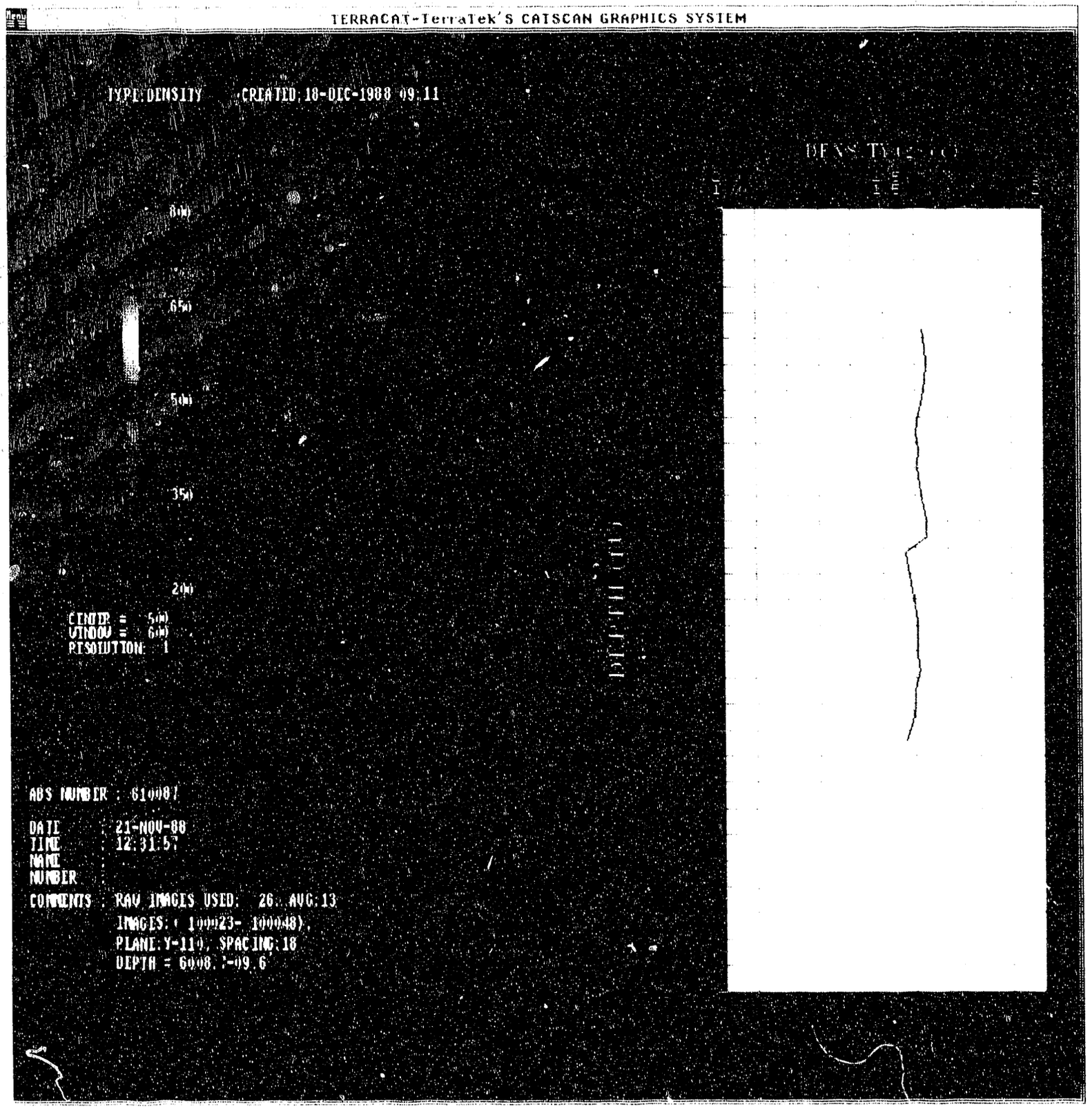


Figure 2K

Vertical Reconstruction
and Bulk Density Log
of Sample 2 - X Direction

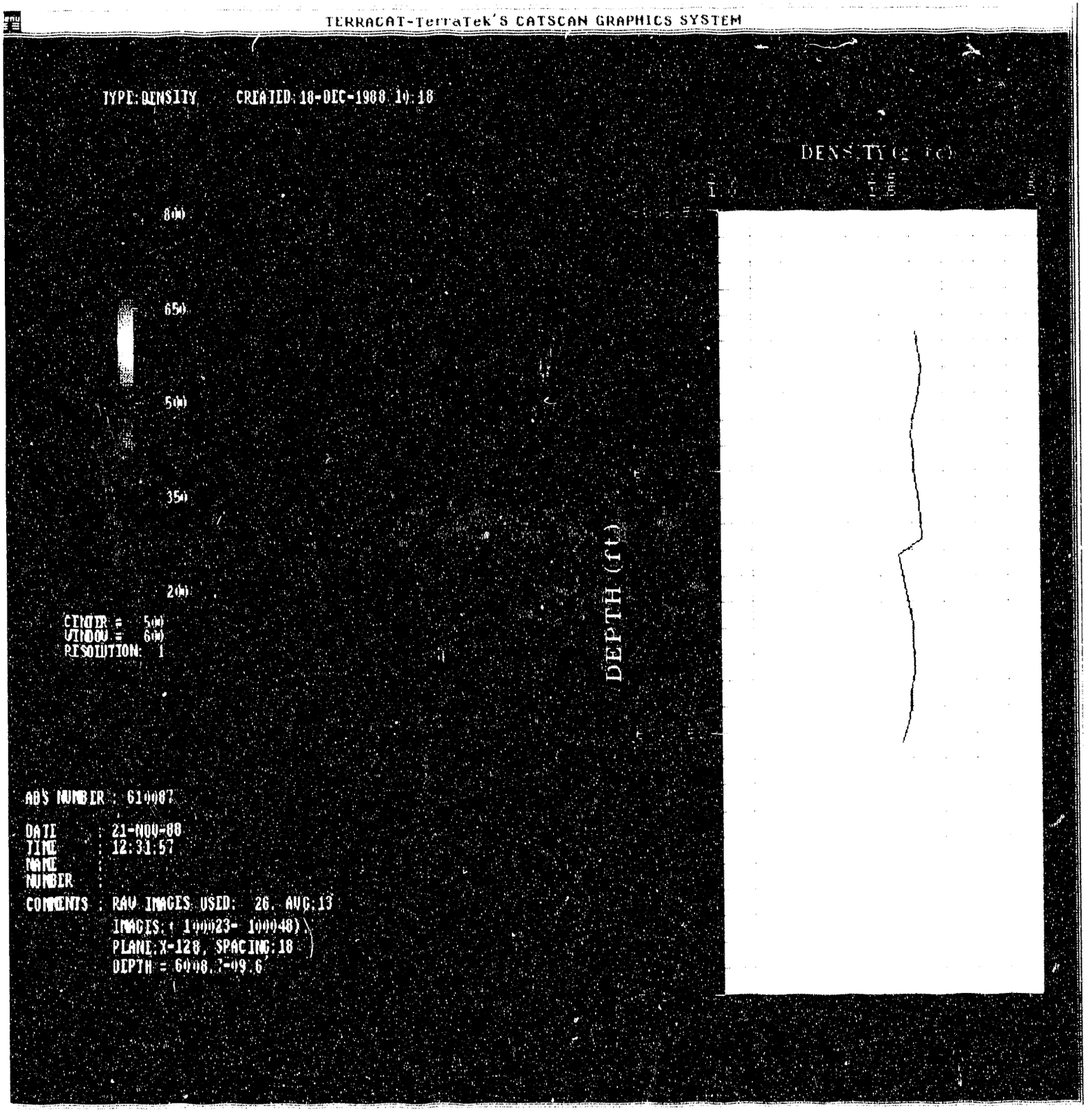


Figure 3A

Cross Sectional and
Masked Images of Sample 3

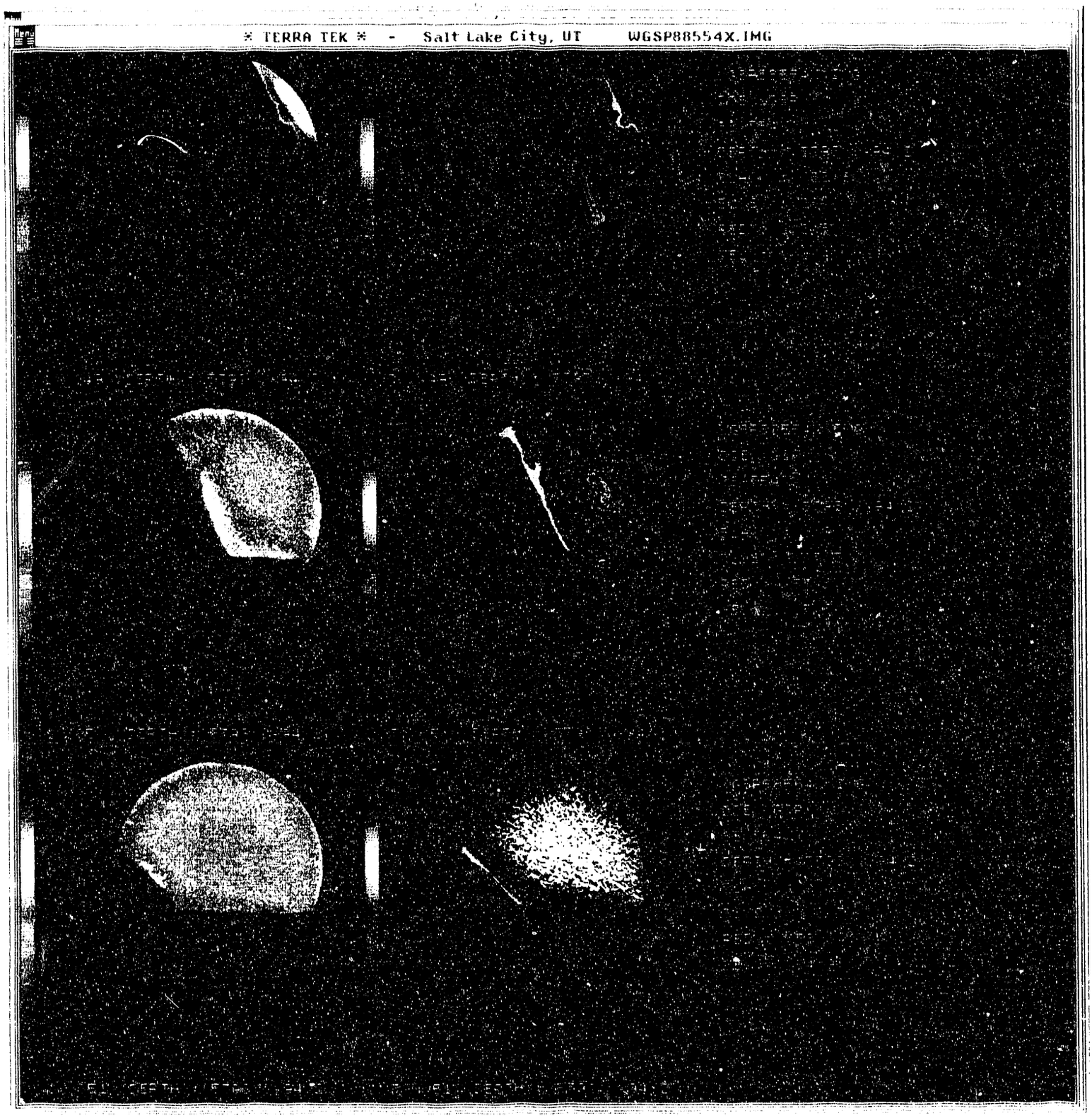


Figure 3B

Cross Sectional and
Masked Images of Sample 3

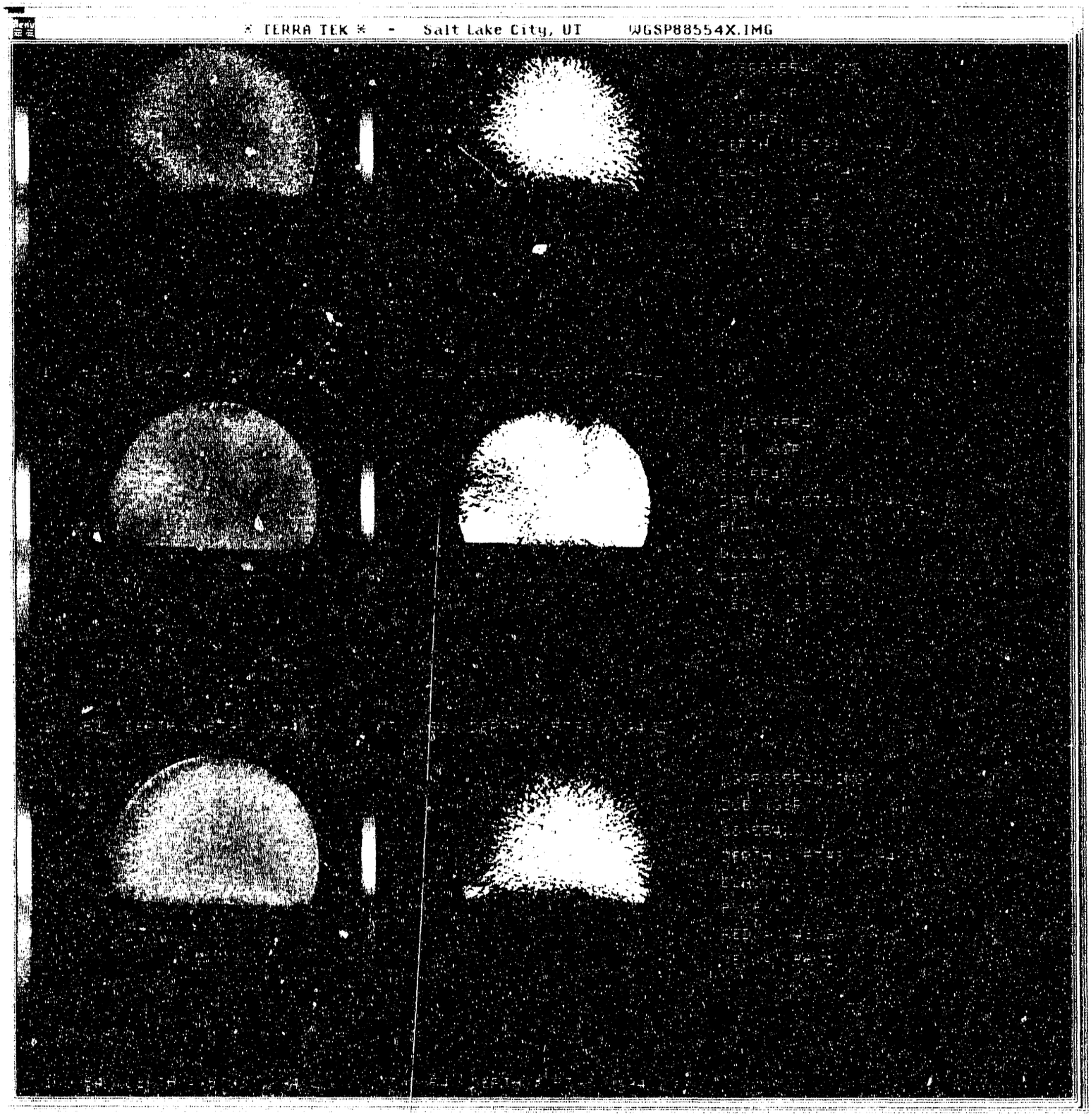


Figure 3C

Cross Sectional and
Masked Images of Sample 3

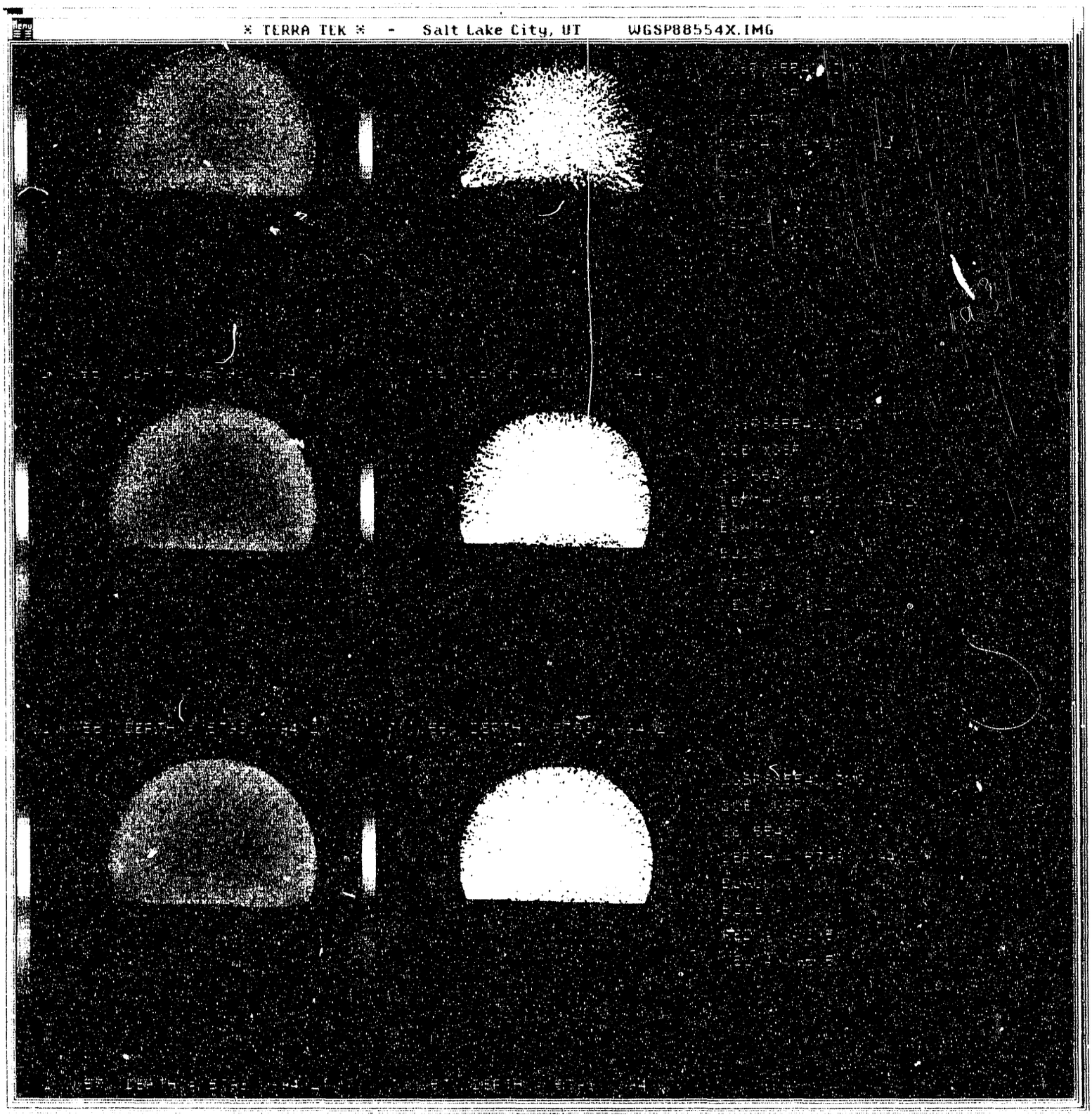


Figure 3D

Cross Sectional and
Masked Images of Sample 3

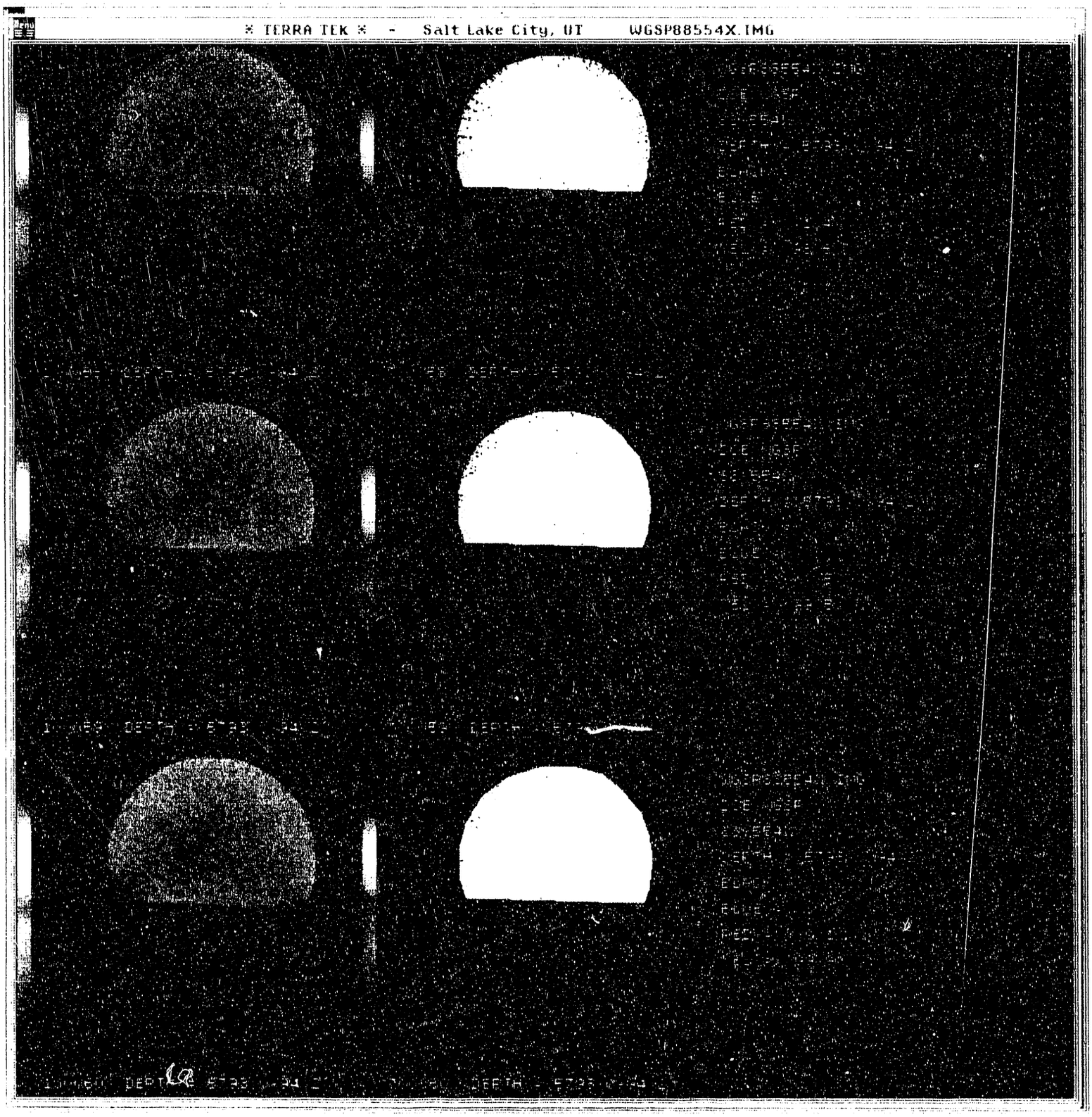


Figure 3E

Cross Sectional and
Masked Images of Sample 3

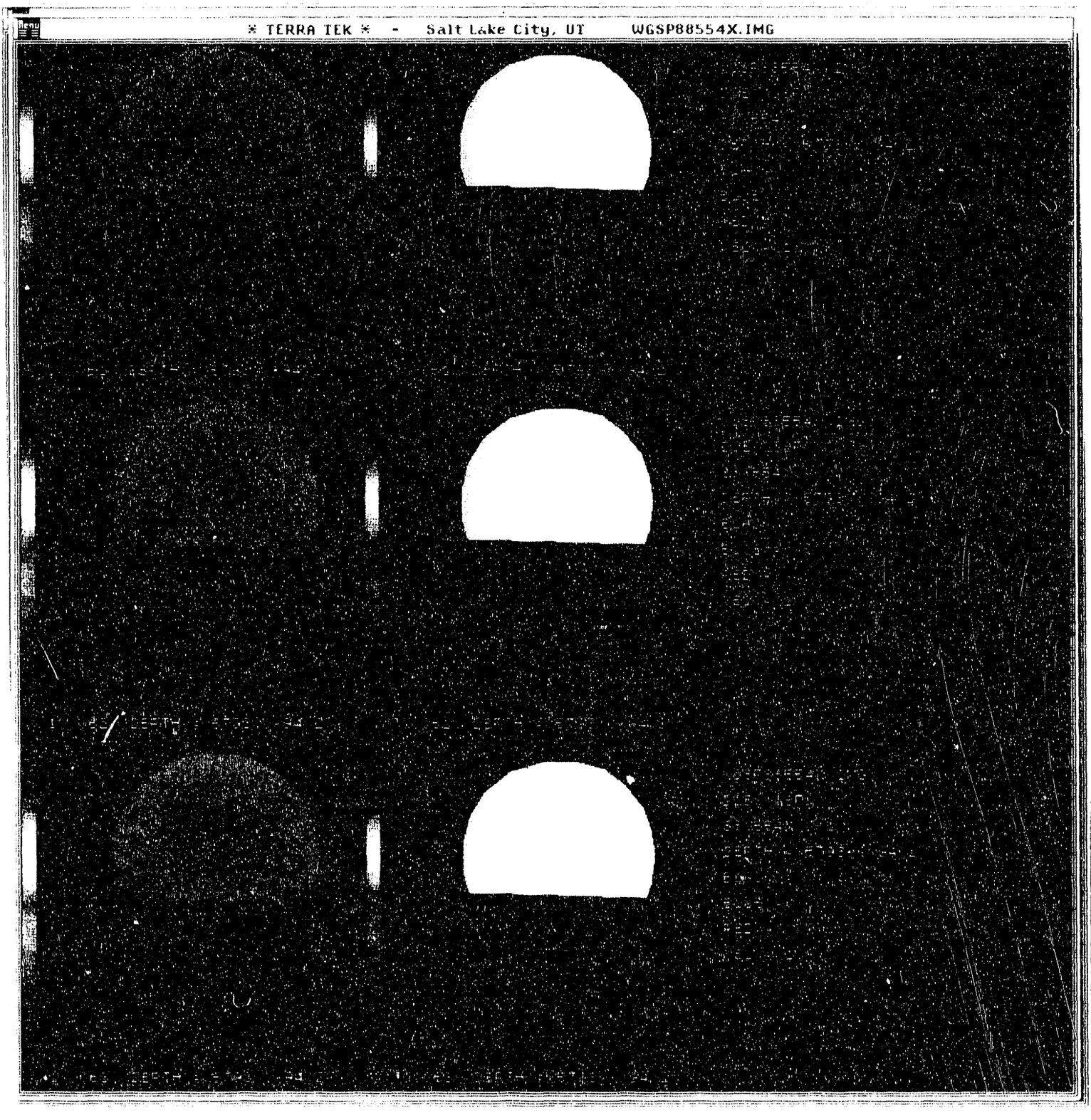


Figure 3F

Cross Sectional and
Masked Images of Sample 3

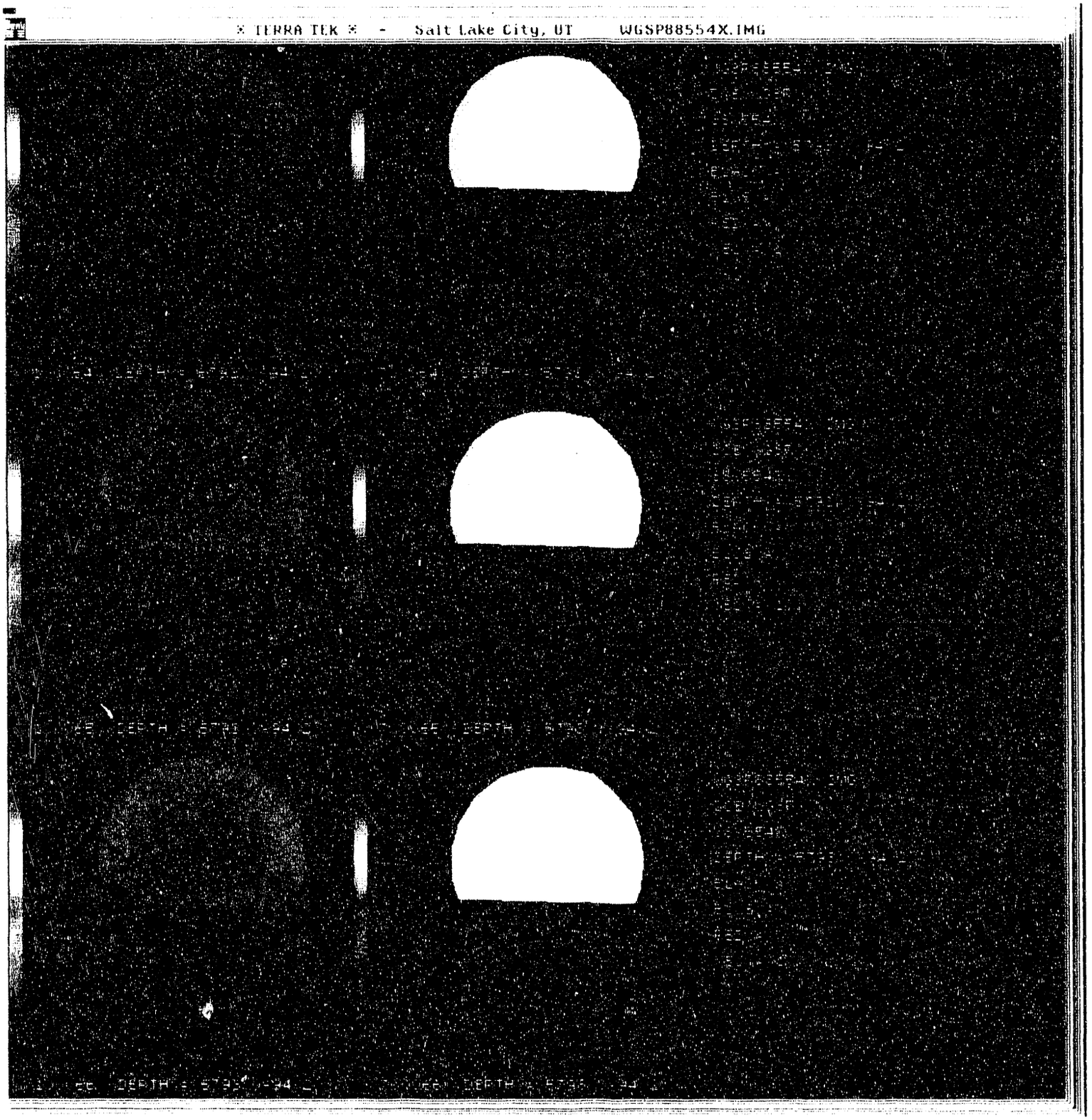


Figure 3H

Cross Sectional and
Masked Images of Sample 3

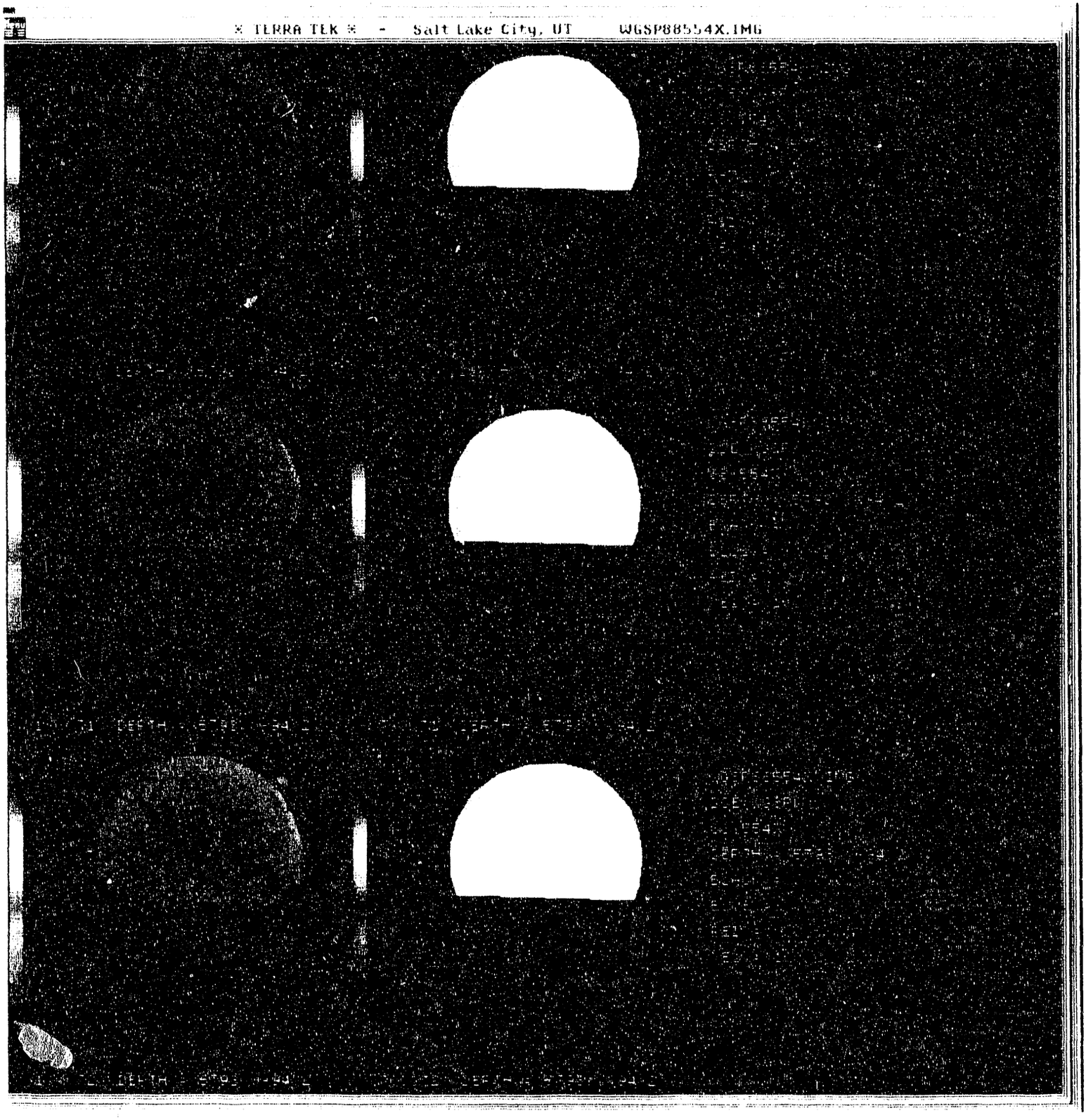


Figure 3I

Cross Sectional and
Masked Images of Sample 3

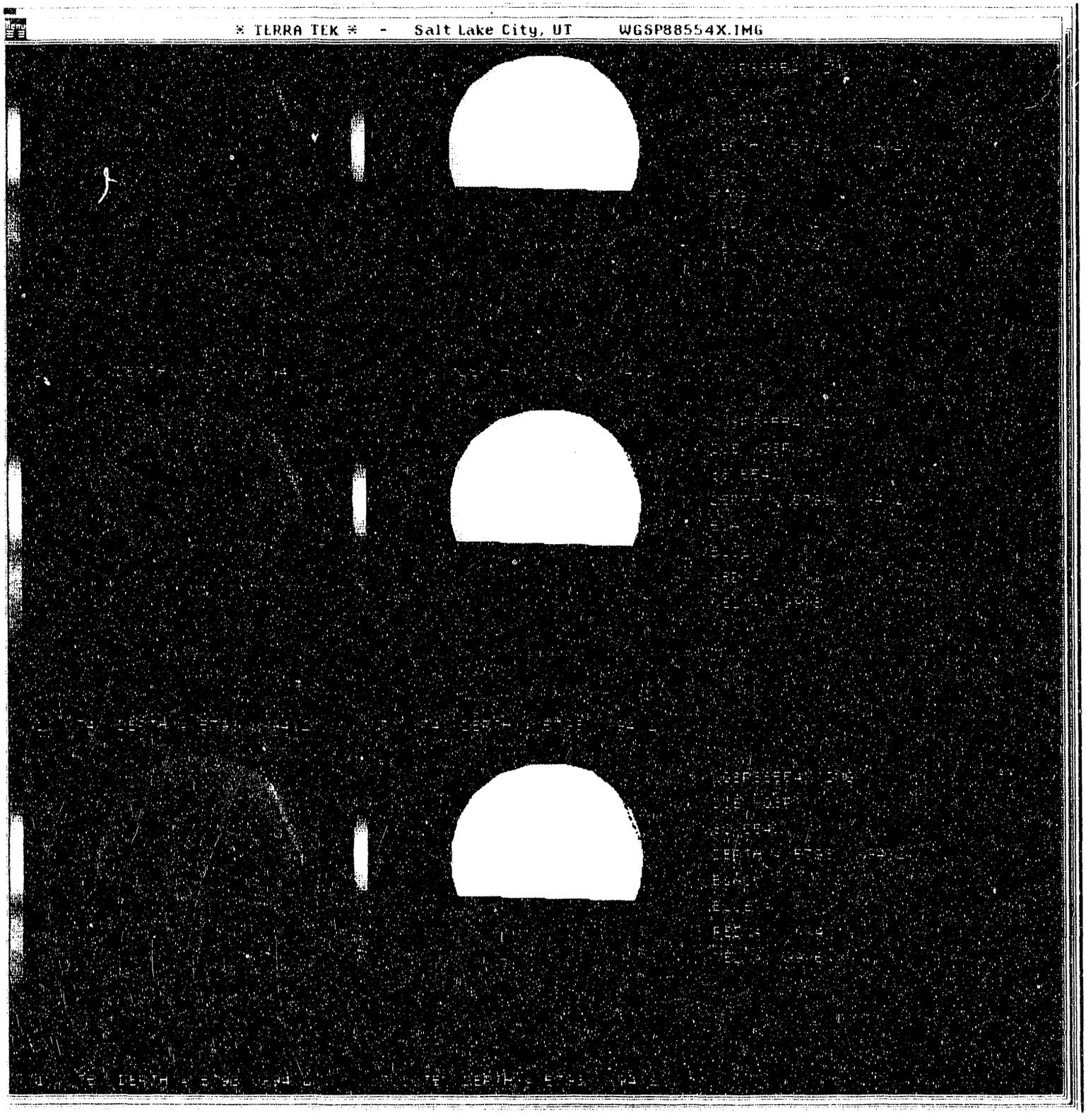


Figure 3J

Cross Sectional and
Masked Images of Sample 2

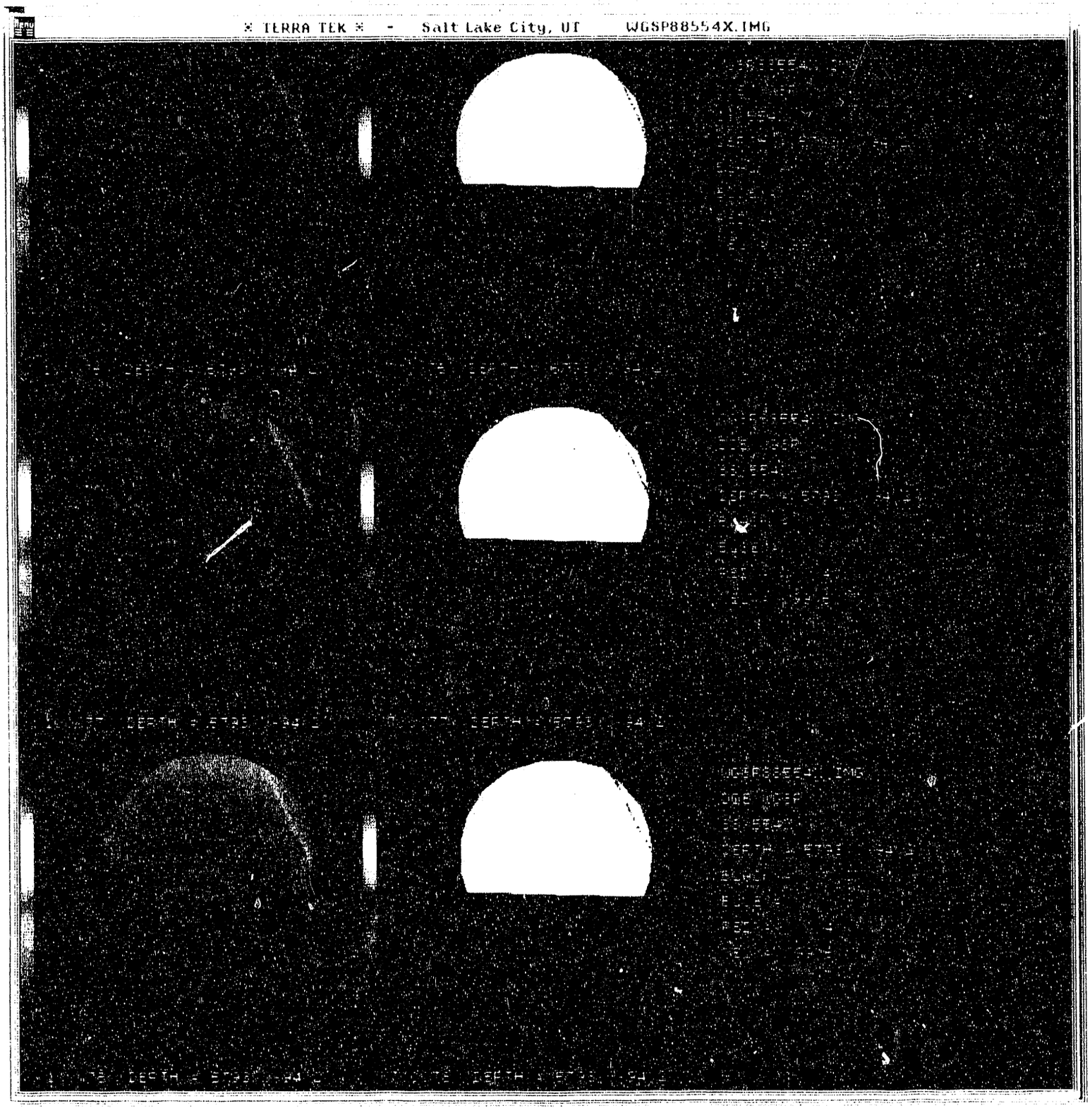


Figure 3J

Cross Sectional and
Masked Images of Sample 2

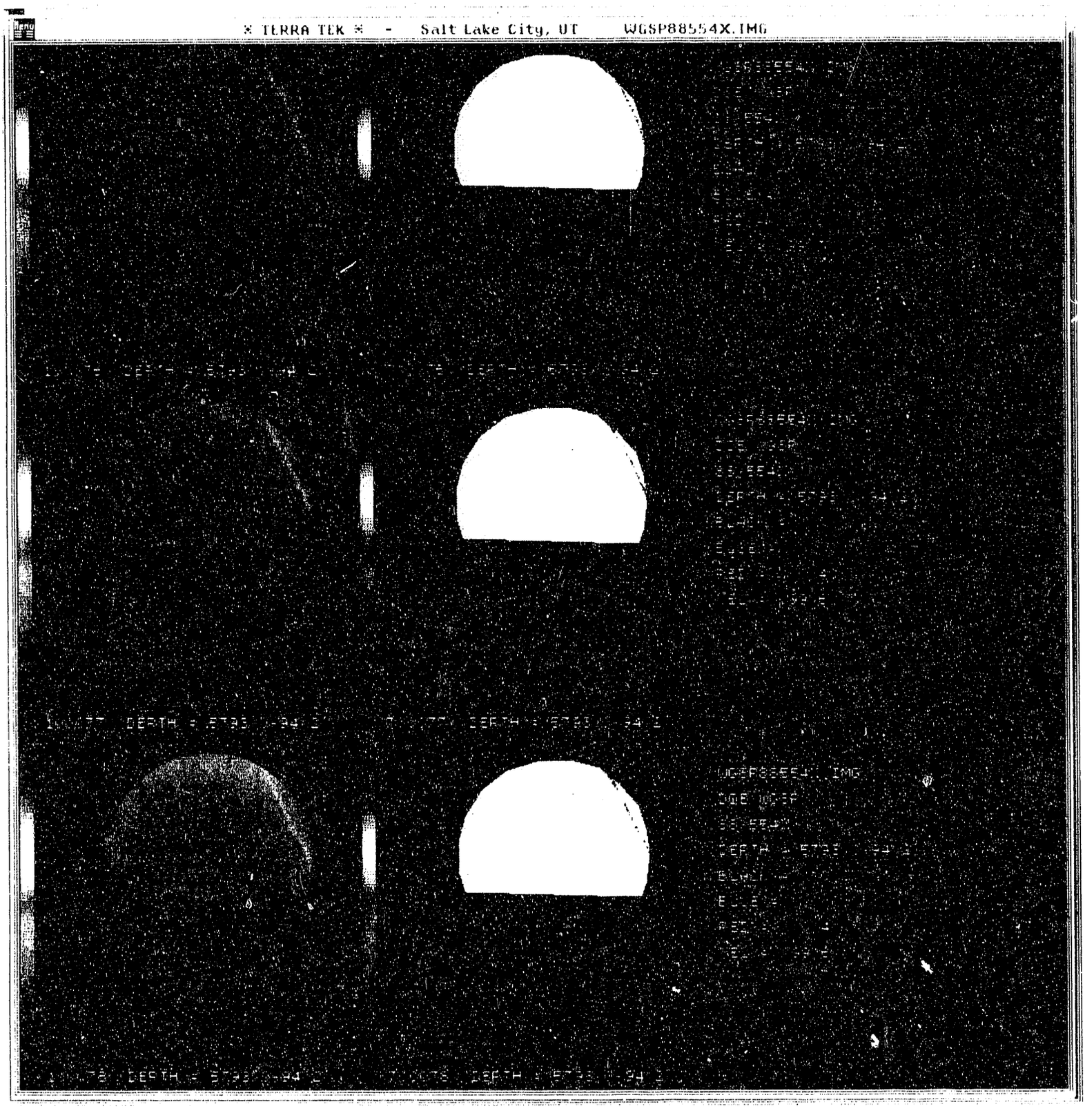


Figure 3K

Cross Sectional and
Masked Images of Sample 3

Figure 3K

Cross Sectional and
Masked Images of Sample 3

Figure 3L

Vertical Reconstruction and
Bulk Density Log of Sample 3

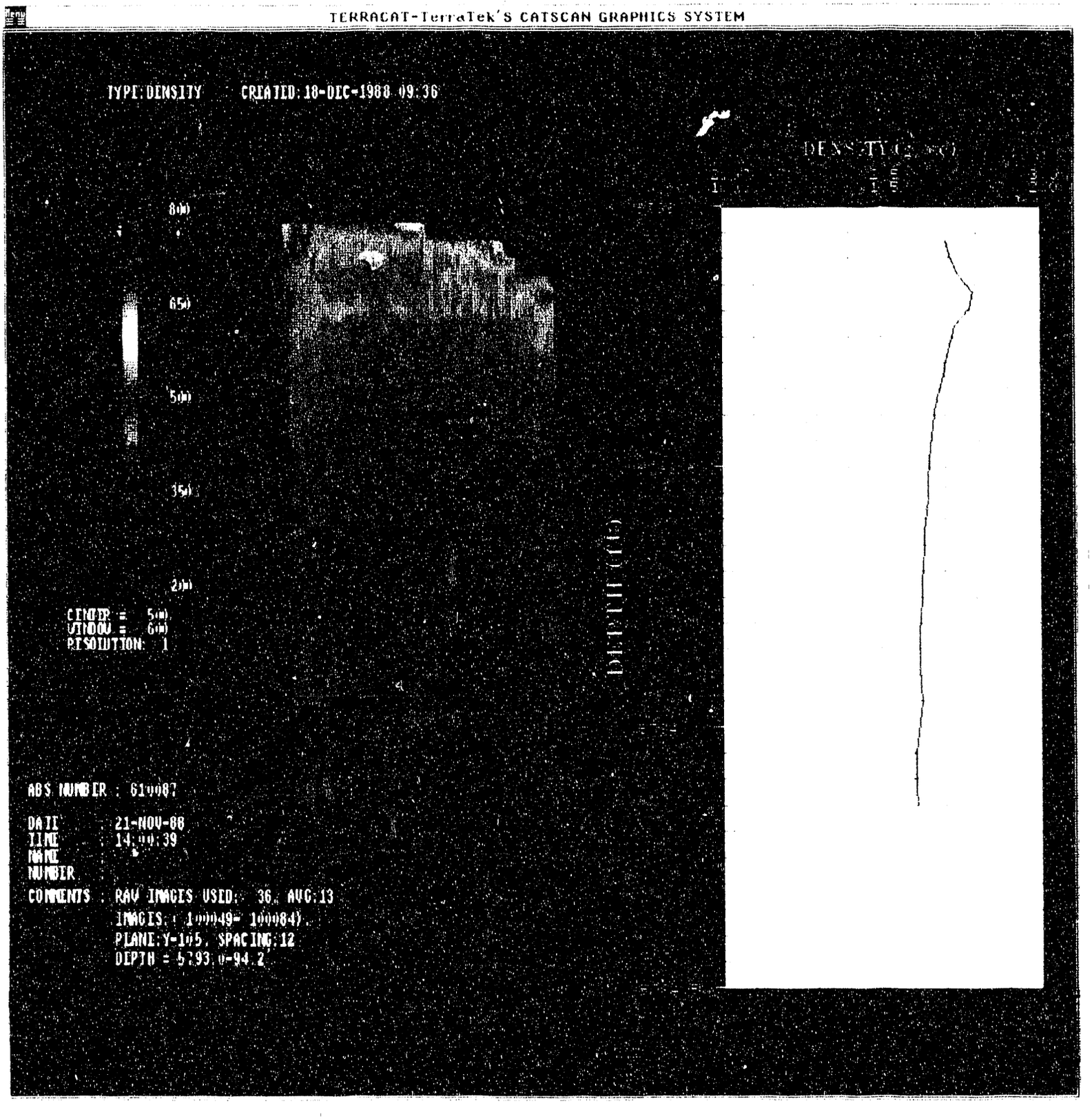


Figure 4A

Cross Sectional Images
of Sample 4

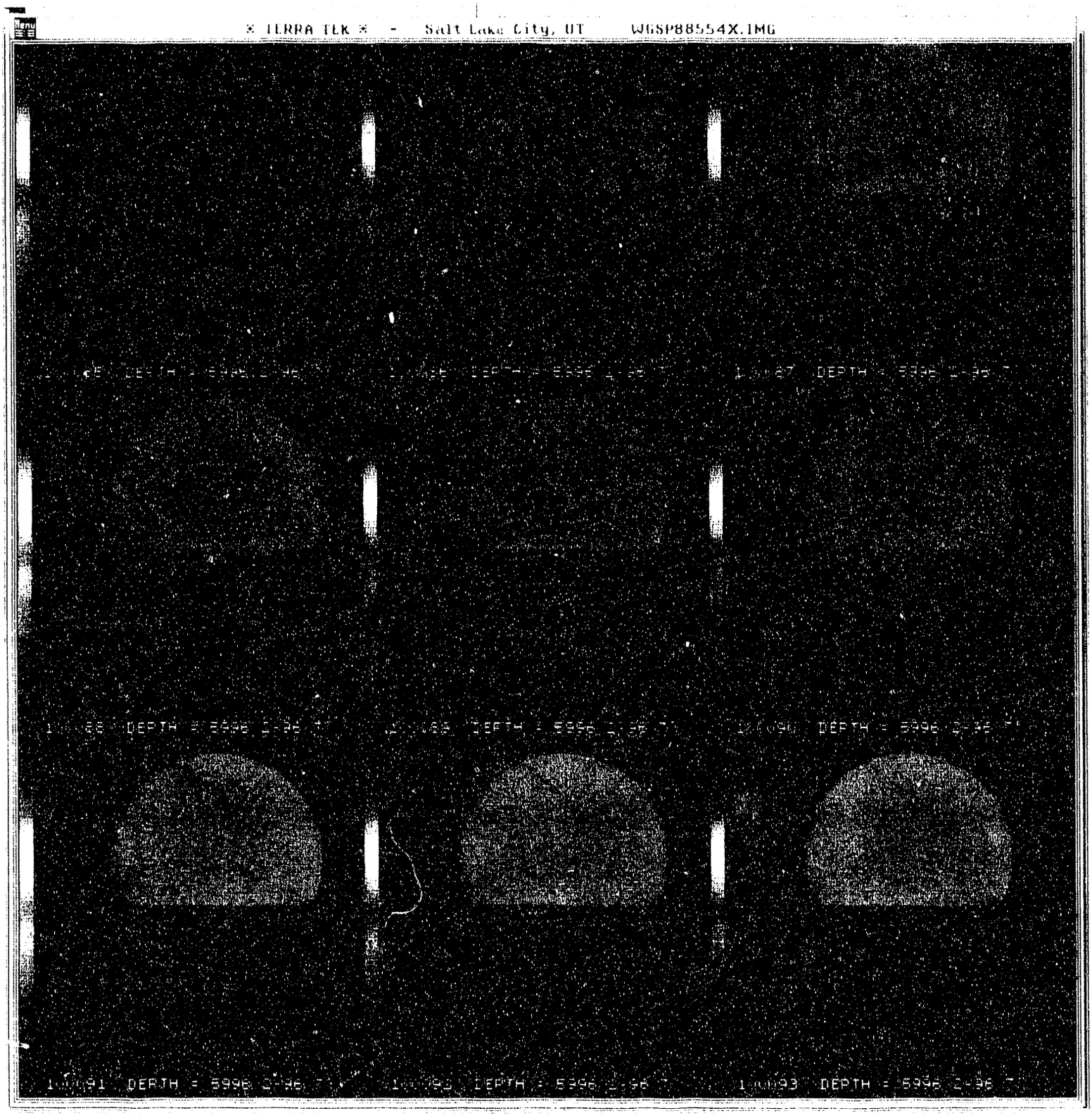


Figure 4B

Cross Sectional Images
of Sample 4

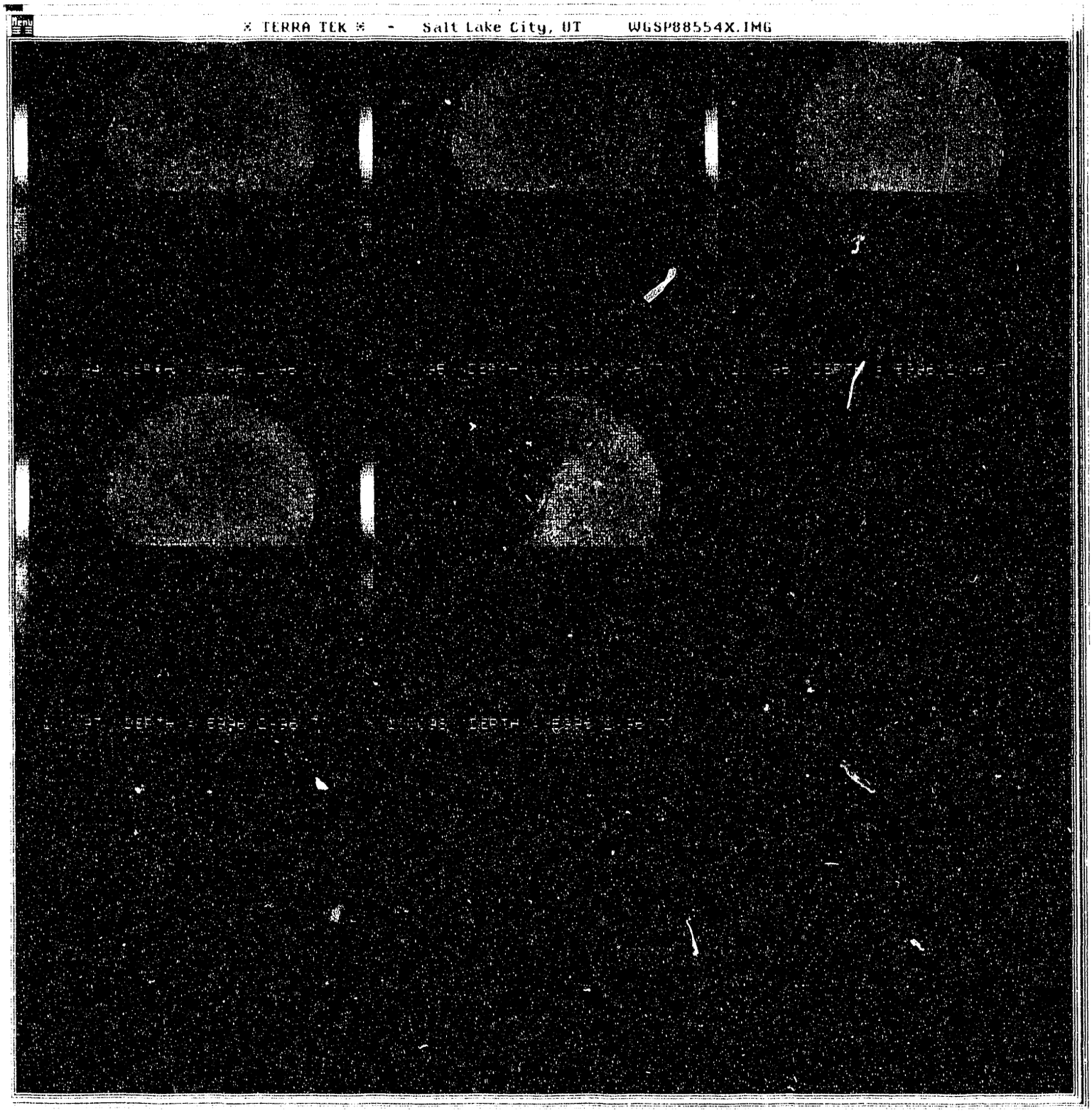


Figure 4C

Vertical Reconstruction and
Bulk Density Log of Sample 4

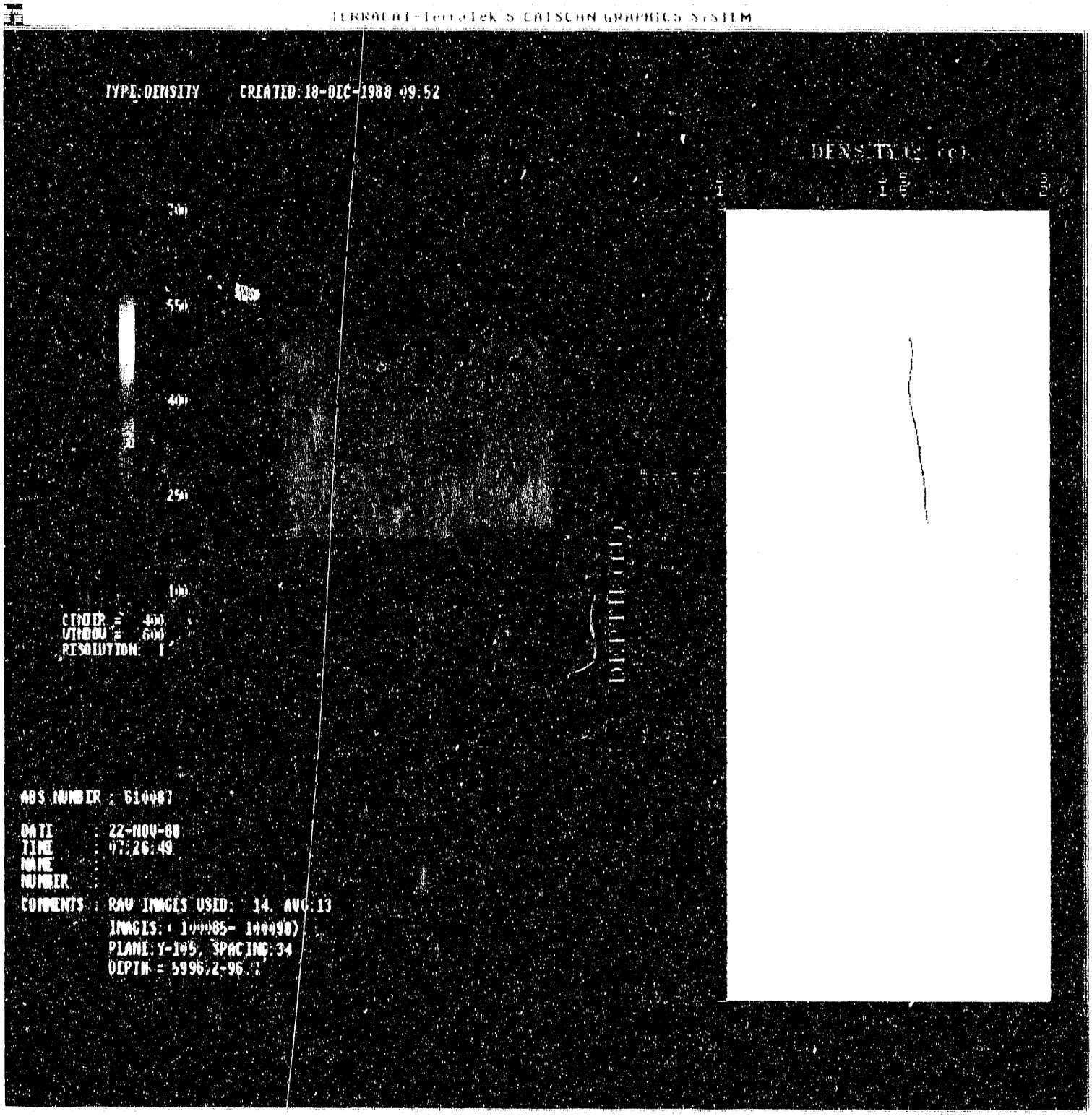


Figure 5A

Cross Sectional and
Masked Images of Sample 5

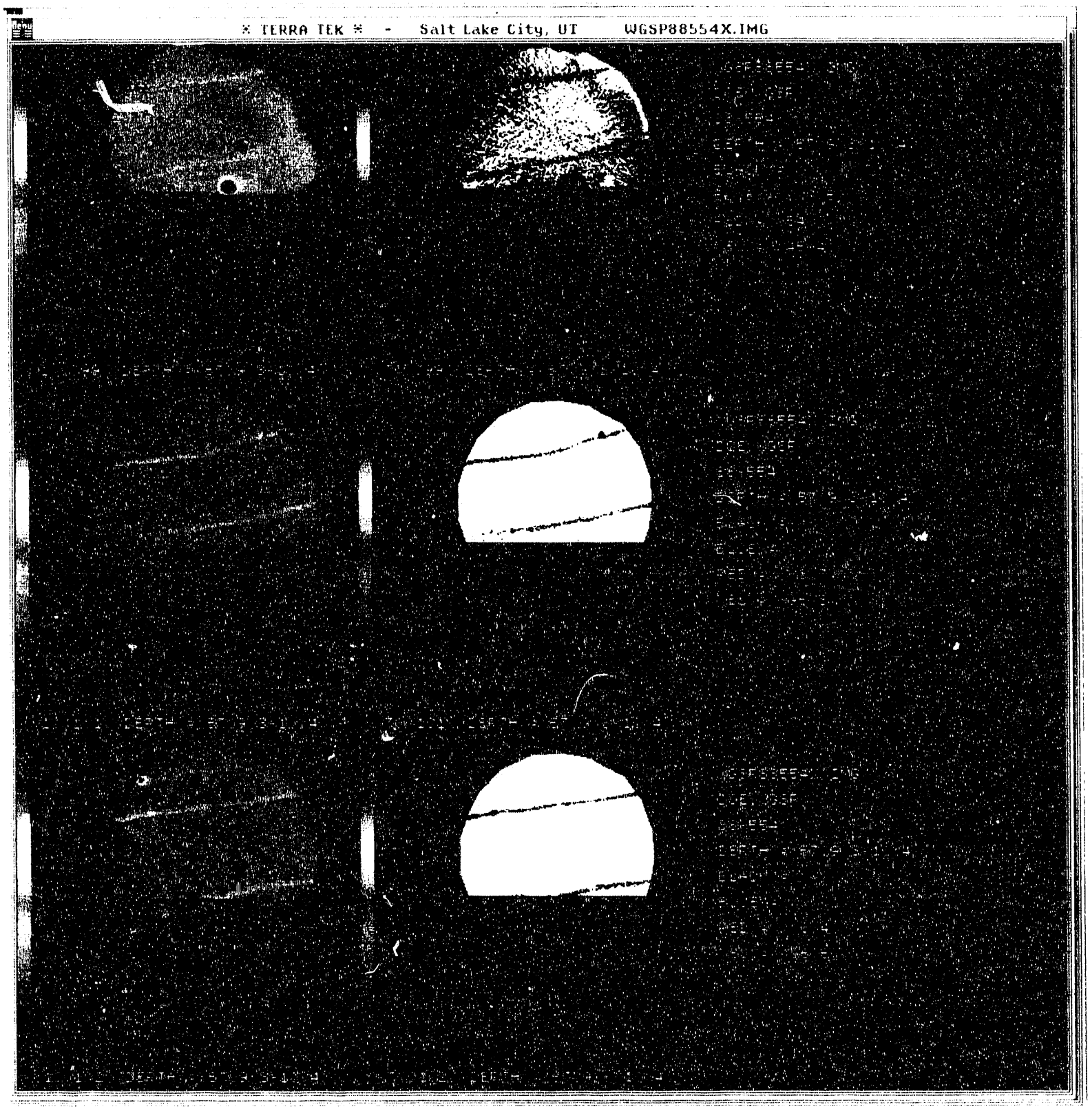


Figure 5B

Cross Sectional and
Masked Images of Sample 5

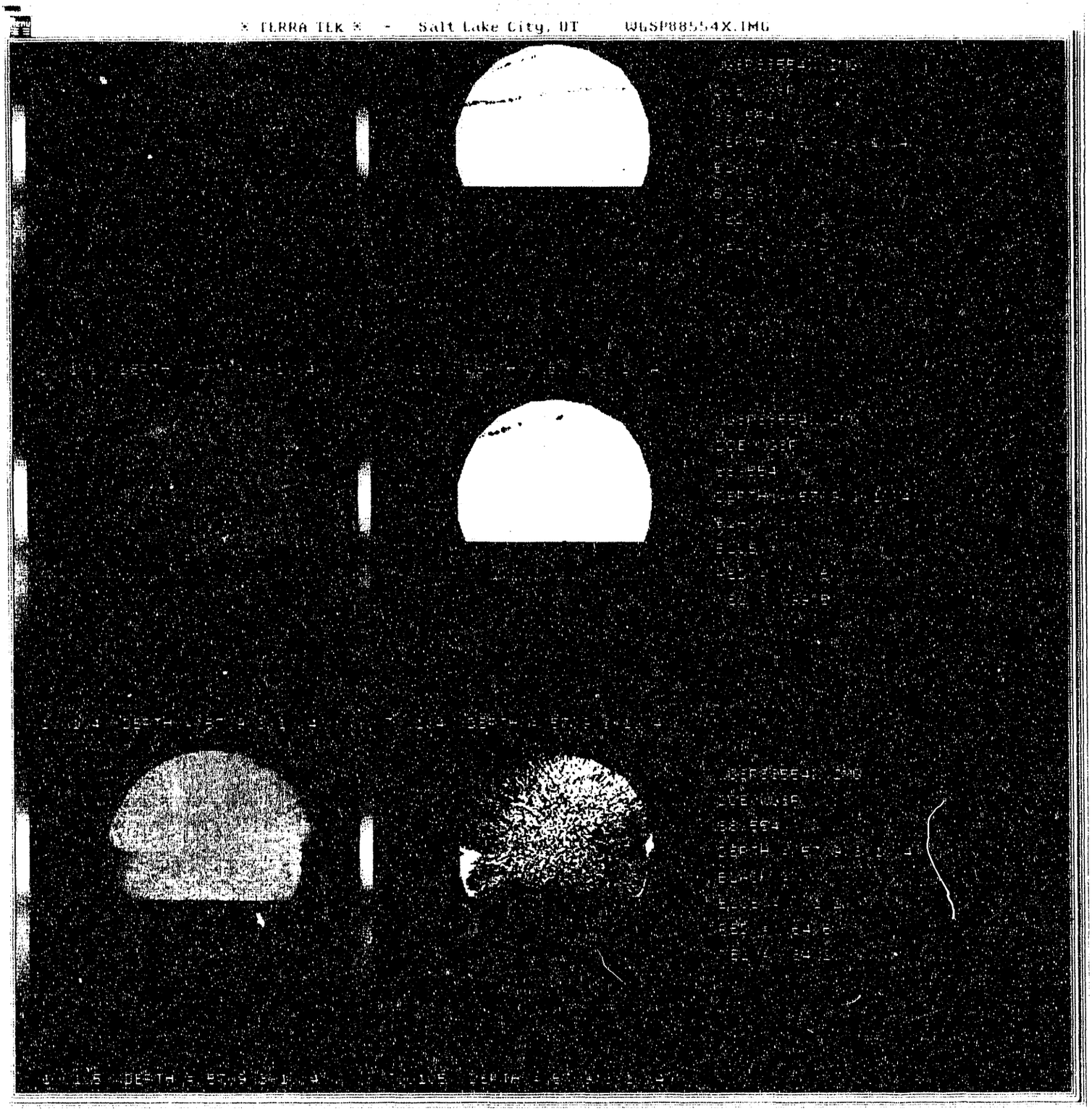


Figure 5C

Vertical Reconstruction and
Bulk Density Log of Sample 5

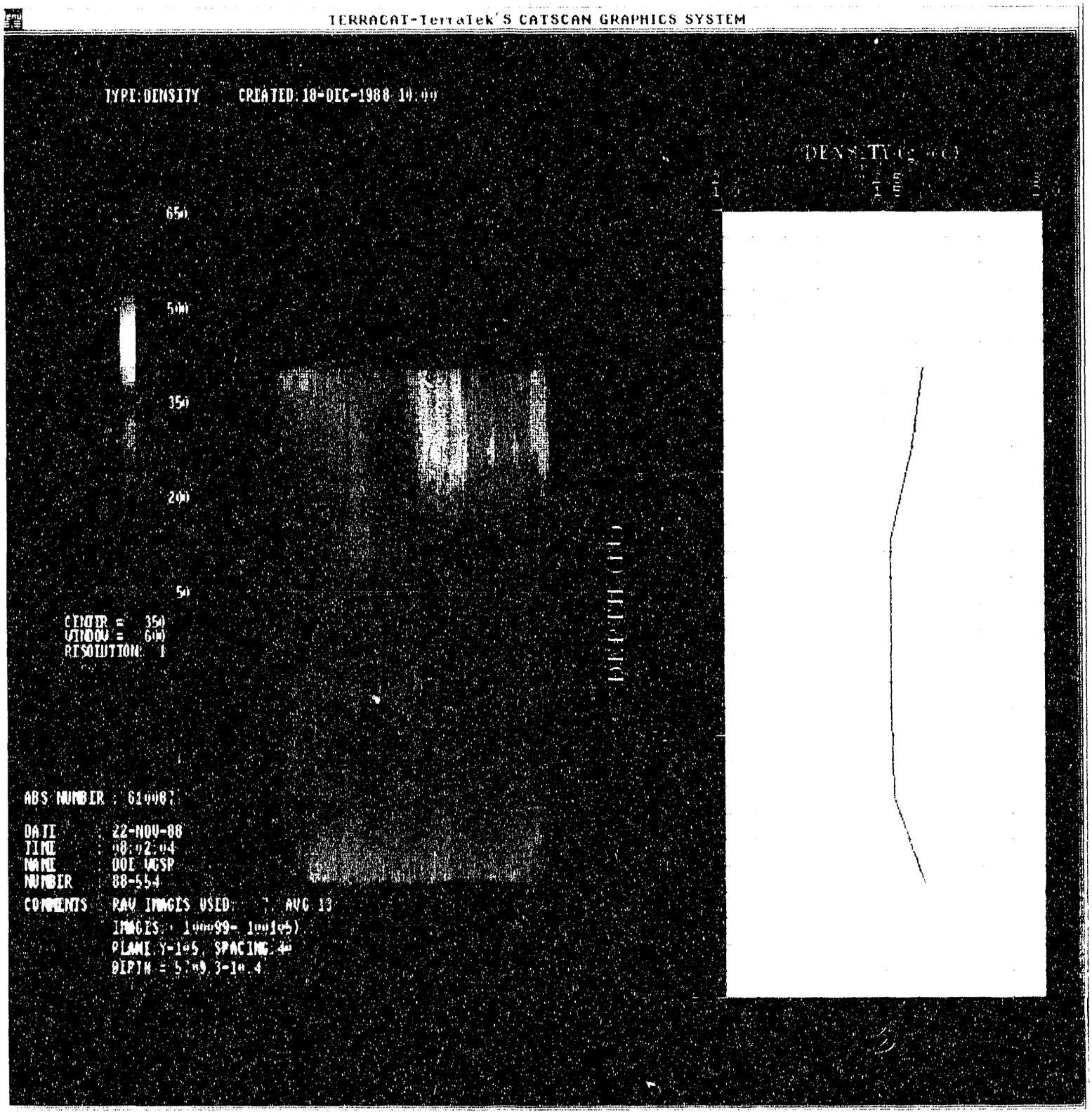


Figure 6A

Cross Sectional Images
of Sample 6

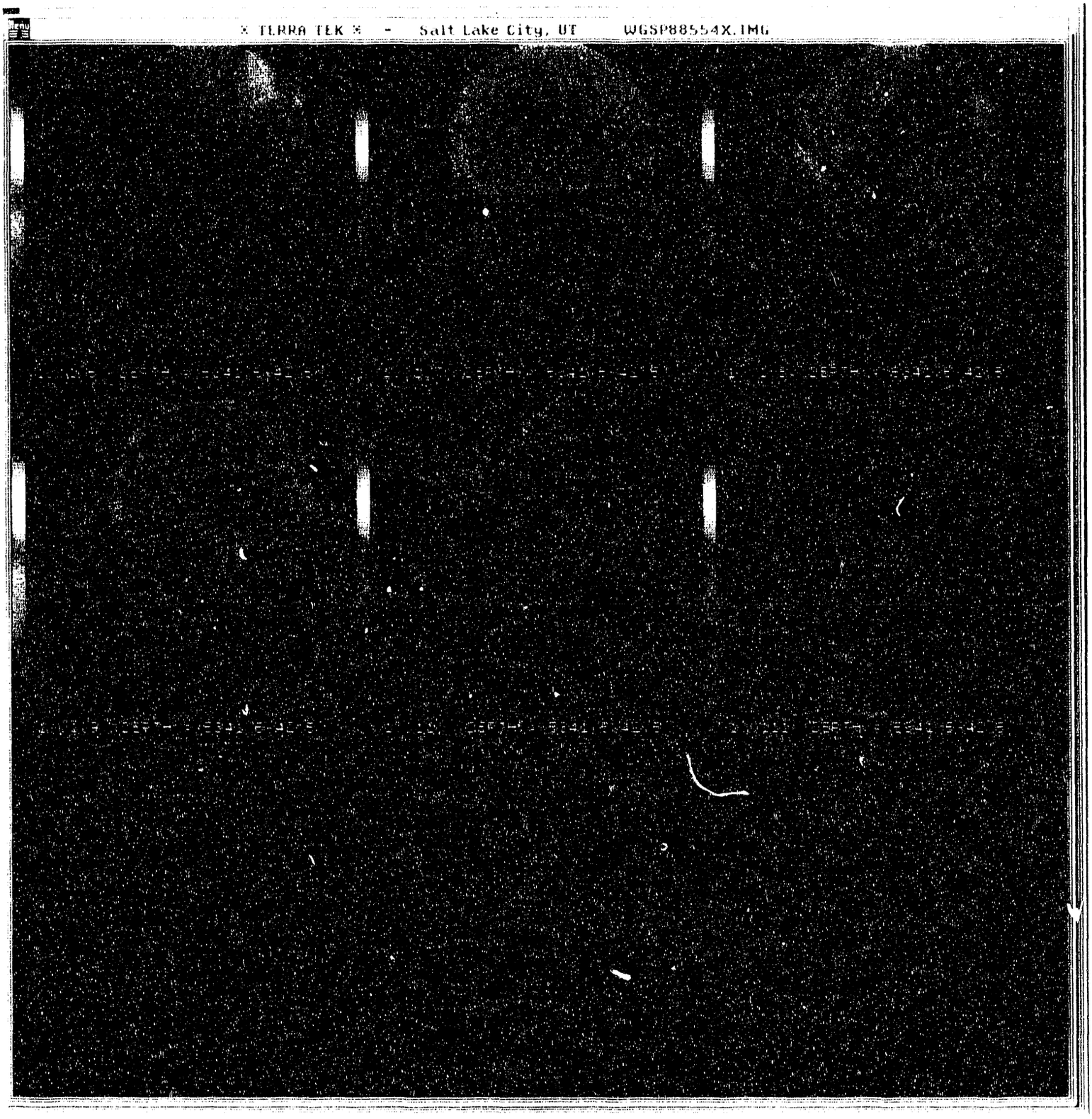
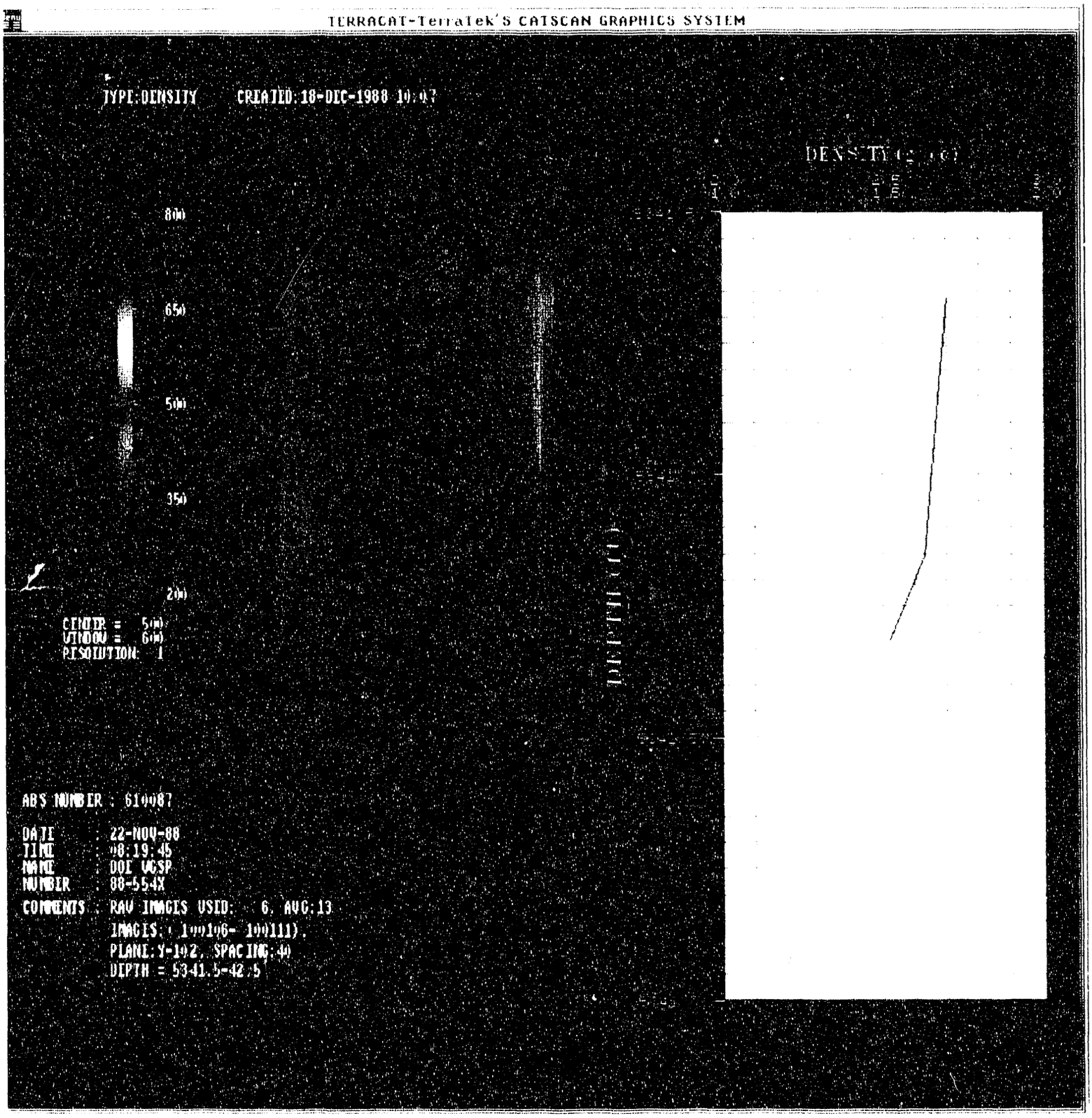


Figure 6B

Vertical Reconstruction and
Bulk Density Log for Sample 6



END

DATE FILMED

9/16/92

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