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LA POSTA SOLAR RADIO MAPS (2ND QUARTER, 1979).(U)

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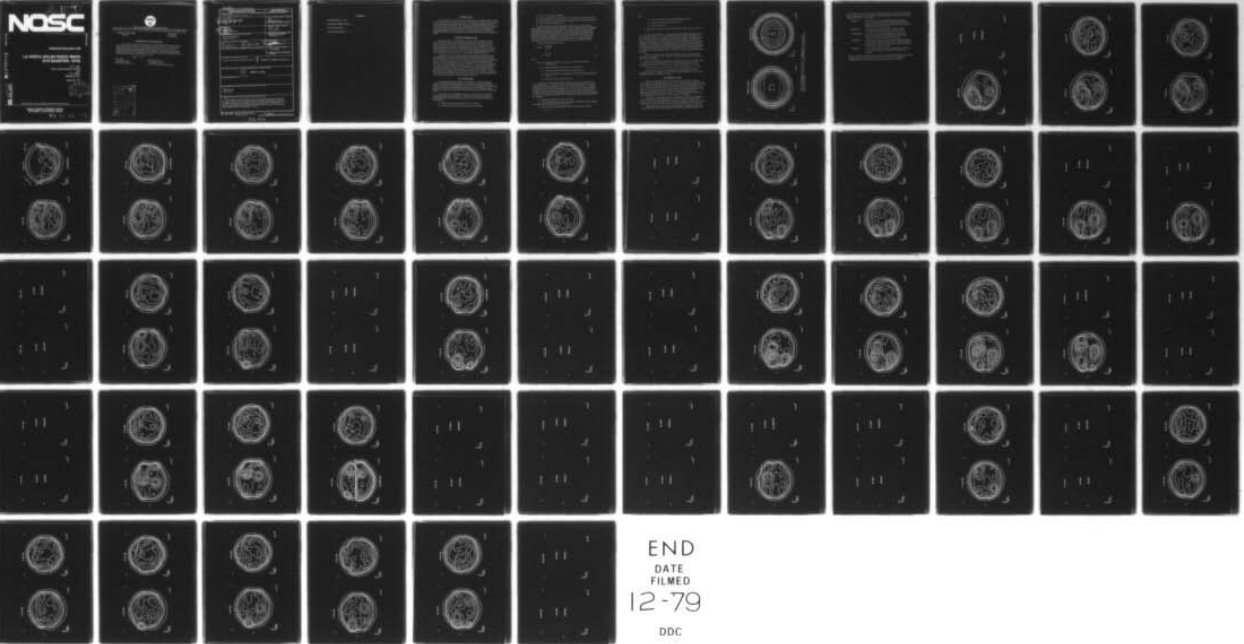
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Technical Document 283

LA POSTA SOLAR RADIO MAPS (2nd QUARTER, 1979)

P. E. Argo
Naval Ocean Systems Center
and
F. L. Wefer
Megatek Corp.

September 1979

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NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

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NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

SL GUILLE, CAPT, USN

Commander

HL BLOOD

Technical Director

ADMINISTRATIVE INFORMATION

The work reported herein was conducted for the Naval Material Command under the Independent Research and Exploratory Development Program (Project ZS 17) by the EM Propagation Division (Code 532), Naval Ocean Systems Center, as part of an effort to develop earth environmental disturbance forecast techniques. This work was accomplished during the period May 1979 to September 1979. The work performed by Megatek Corp. was conducted under contract number N00123-78-C-0043.

391 984

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J. H. Richter, Head
EM Propagation Division

Under Authority of
J. D. Hightower, Head
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NOSC Technical Document 283 (TD 283)	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LA POSTA SOLAR RADIO MAPS (2nd Quarter, 1979)		5. TYPE OF REPORT & PERIOD COVERED IRIED May-September 1979
7. AUTHOR(s) P. E. Argo, NOSC F. L. Wefel, Megatek Corp.		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Ocean Systems Center San Diego, CA 92152		8. CONTRACT OR GRANT NUMBER(s) 12 62
11. CONTROLLING OFFICE NAME AND ADDRESS 18 NOSC 19 TD-283 11		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS IRIED Project ZS 17
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE Sept 1979
		13. NUMBER OF PAGES 87
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited 9 Technical document, May-Sep 79,		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) 15 00123-78-C-0043		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Sun Solar Radio Maps Solar Activity		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The La Posta 18.3-m antenna has been used since 1972 to acquire radio maps of the solar disk at wavelengths of 0.86 and 2.0 cm. The NOSC in-house research program is supporting the continuation of this program through the peak of the present solar activity cycle (about 1981). During this period of operation, daily (5 days per week) radio maps at both wavelengths will be acquired. This report presents the radioheliogram data for the second quarter of 1979.		

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CONTENTS

INTRODUCTION . . .	page 1
METHOD OF OBSERVATION . . .	1
DATA REDUCTION . . .	1
DATA PRESENTATION . . .	3

INTRODUCTION

The La Posta 18.3-m antenna has been used since 1972 to acquire radio maps of the solar disk at wavelengths of 0.86 cm and 2.0 cm. The Naval Ocean Systems Center in-house research program is supporting the continuation of this program through the peak of the present solar activity cycle (about 1981). During this period of operation daily (5 days per week) radio maps at both wavelengths will be acquired. In addition, the detailed time development will be observed of specific active regions during the international Flare Buildup Study (FBS). This report presents the radioheliogram data for the third quarter of 1979.

METHOD OF OBSERVATION

The antenna used for the observations is an 18.3-m-(60 ft) diameter circular paraboloid on a computer-controlled altitude-azimuth mount. At 0.86 cm- λ the half-power beamwidth is 2.8 arc min; at 2.0 cm- λ it is 4.0 arc min. The central disk solar antenna temperatures are approximately 4000° K at 0.86 cm and 7300° K at 2.0 cm- λ . At both wavelengths the observations are made with Dicke radiometers, the antenna being switched against noise tubes. The rms noise in the solar antenna temperatures measured at the outputs of the radiometers with 1-s time constants is approximately 2° K.

The data for a map are collected by directing the telescope to perform a square boustrophedonic raster with lines perpendicular to heliographic N-S, filling a 35-by-35 grid of points with a 1.0 arc min spacing at 0.86 cm- λ . The antenna tracks each grid point for 2 s: 1 s for position attainment and 1 s for data acquisition, during which time the radiometer output is integrated. At 2.0 cm- λ the map grid is 19-by-19 with a spacing of 2.0 arc min, the antenna tracking each grid point for 3 s: 2 s for position attainment and 1 s for data acquisition, during which time the radiometer output is integrated. Both radiometers are operated with time constants of 0.1 s during solar mapping. The times taken to fill the map grids are 41 min and 18 min at 0.86 cm- λ and 2.0 cm- λ , respectively. The radiometers are calibrated before and after each map, using as calibration signals both noise tubes and the blank sky at the same elevation as the sun.

DATA REDUCTION

The integrated radiometer output at each grid point is converted to antenna temperature by linear interpolation between the blank sky and noise tube calibration readings. The maps are then normalized to correct for day-to-day changes in both the scale and zero level of the antenna temperature measurements. These changes are caused primarily by changes in atmospheric attenuation and changes in the noise tube calibration sources.

The first step in the normalization procedure is to determine the central disk background solar antenna temperature, T_c . This is done for each map by using the following algorithm, which is intended to minimize the effects of active regions of the determination.

- (1) Begin with the nine central points ($N = 9$) of the map.
- (2) Compute the mean and standard deviation of the N points.

- (3) If $N = 2$, go to step (6); otherwise,
- (4) If the standard deviation is less than 1% of the mean, go to step (6); otherwise,
- (5) Discard the largest temperature of the N points, ($N = N - 1$), and go to step (2).
- (6) Use the mean of the N points as T_c .

In order to normalize the maps for errors in both the scale and zero level, two known points are needed. From the second point we use the average of the four penultimate points along the map diagonals. These points lie at a distance of 22.627 arc min ($16\sqrt{2}$) from disk center, well beyond the solar limb. In the vicinity of these points the antenna temperature is small in comparison with T_c and varies nearly linearly with distance from disk center. This antenna temperature is denoted by T_o . Because of the motion of the Earth in its orbit, T_o is not constant, but varies during the year. We ignore this slight variation and denote by C the expected value of the ratio T_o/T_c averaged over the year.

Then the normalization can be written

$$B_n(i, j) = \frac{T(i, j) - D}{T_c - D} \quad (1)$$

$$D = \frac{T_o - CT_c}{1 - C} \quad (2)$$

where:

$B_n(i, j)$ = normalized temperature at position (i, j) of the solar radio map (dimensionless),

$T(i, j)$ = antenna temperature at position (i, j) of the map ($^{\circ}\text{K}$),

T_c = central disk background solar antenna temperature ($^{\circ}\text{K}$),

T_o = antenna temperature at the penultimate positions along the map diagonals ($^{\circ}\text{K}$), and

C = average value of T_o/T_c (dimensionless).

In the above normalization procedure a maximum of nine grid point values were used in determining T_c . For maps on which an active region occurs near the center of the solar disk, fewer than nine points are used. For some of these, the value of T_c is affected, even though the 1% criterion of the algorithm is met. There are also a few cases in which filaments near disk center cause the computed value of T_c to be small. An obvious way to reduce such effects is to increase the number of grid points of the map used in computing T_c . This is accomplished by the following re-normalization algorithm, which is first stated, then explained.

- (1) Divide an individual map by the "mode-map."
- (2) For the grid points on the solar disk, compute the distribution of the quotients. The median value of this distribution is denoted by Q .
- (3) Correct the central disk background solar antenna temperature thusly:

$$T_c' = T_c \times Q$$

where:

T_c = central disk background solar antenna temperature ($^{\circ}$ K),

Q = the above-described median quotient, and

T_c' = corrected value of T_c .

- (4) Normalize the map as described by Equations (1) and (2) using T_c' in place of T_c .

At step (1) the "mode-map" is a background-average-normalized map derived from the La Posta maps for 1972, 1973, and 1974 (444 maps at 0.86 cm- λ ; 418 maps at 2.0 cm- λ). The mode map at each wavelength was determined as follows. The individual maps were first made symmetric by computing the mean of corresponding points in the four quadrants. This produces north-south and east-west symmetry, but does not force circular symmetry. The distribution of the normalized temperature values was next computed for each grid point in the quadrant. The modal value of each distribution was then determined by constructing histograms with intervals of width 0.0025 (0.25% of T_c). These modal values determine a surface which is called the "mode-map." The two mode-maps are shown in Figure 1.

At step (2) of the procedure the solar disk is defined as the area over which the mode-map exceeds 0.85 (85% of T_c). At 0.86 cm this area encompasses 669 grid points, 169 at 2.0 cm wavelength.

At step (3) the correction factor Q gives an indication of the accuracy of the initial normalization. In re-normalizing the 1972, 1973, and 1974 maps by means of this procedure, approximately 75% of the correction factors Q were within $\pm 1\%$ of unity.

At step (4) the normalization is done as before, but a better value of T_c is used.

The final step in the data reduction procedure is the multiplication of the re-normalized antenna temperatures by a constant to reconvert the data to degrees Kelvin (4000 $^{\circ}$ K at 0.86 cm- λ ; 7300 $^{\circ}$ K at 2.0 cm- λ).

DATA PRESENTATION

The antenna temperatures measured at the grid points are used to construct a contour plot of the solar radio emission. The corners of the map grid are indicated on each plot. Note that the 0.86 cm- λ grid is 34 arc min square, while the 2.0 cm- λ grid is 36 arc min square. The scale of the map is shown at the lower left corner of the grid by short axes with 1-arc min tick marks. The Universal Time at which the map was begun is shown below these axes. Approximately 41 min are required to fill the 0.86 cm- λ grid, while approximately 18 min are required at 2.0 cm- λ . The radio wavelength is given below the lower right-hand corner of the grid. The date appears above the map.

The quantity being contoured is antenna temperature; all contours are labelled in units of 100 $^{\circ}$ K. The contour interval is not constant on a map, but is varied so as to provide a clear picture of the radio emission. Tick marks are placed on the low side of each contour line so that the direction of decreasing antenna temperature is readily apparent.

Regular daily observations were begun on 9 May 1979. Starting on this date, the maps for each day of this second quarter of 1979 are shown on the following pages. On

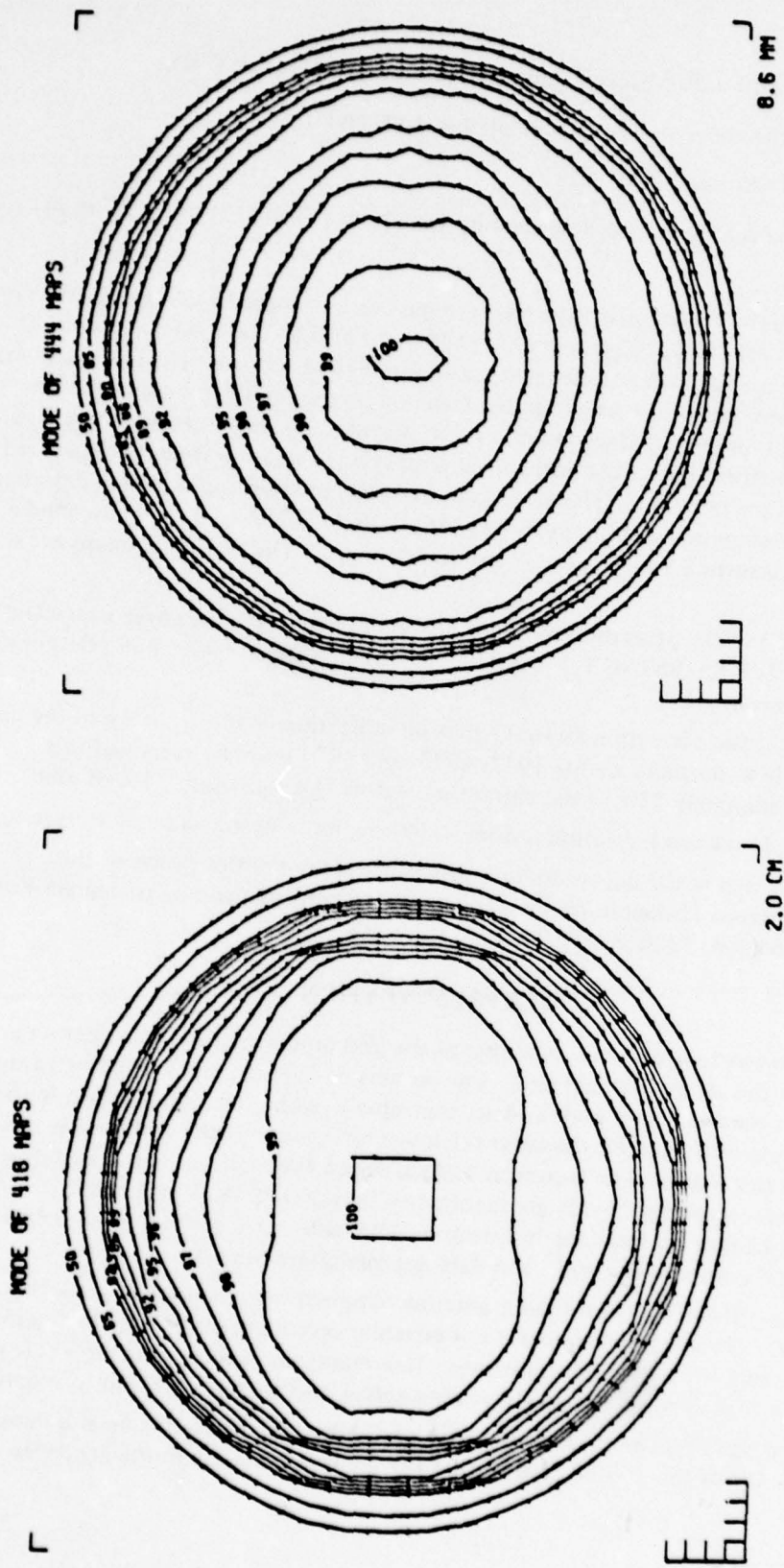


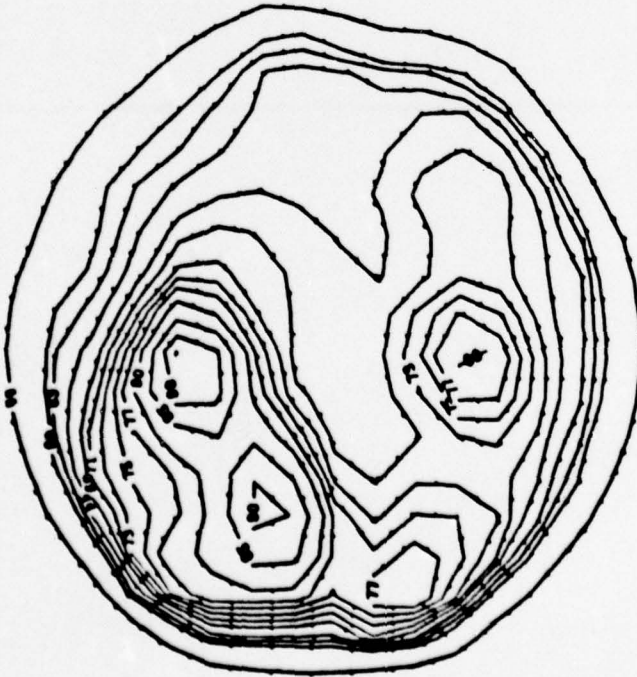
Figure 1. The mode maps at $2.0 \text{ cm-}\lambda$ and $0.86 \text{ cm-}\lambda$. A mode map results from averaging the corresponding points in the four quadrants of each map, then determining the modal value for each grid point in the quadrant.

days for which no map is presented the words NO DATA appear near the center of the grid. Below these appears a one-word indicator of why no map has been provided. These words have the following specific meanings:

- CLOUDY A map was made for the day beginning at the time shown; however, the data were so seriously affected by clouds that it was deemed unwise to publish it. Such maps will be provided to individual researchers upon request.
- WEATHER The weather at the observatory was so inclement that no observations were made. No time is given in the format.
- CALIBRATION A map was made for the day beginning at the time shown; however, the operation of the equipment was such that the reliability of the antenna temperatures is in doubt.
- EQUIPMENT The situation and condition of the equipment were such that no map was made. This includes such causes as receiver malfunction, mechanical and computer problems, and preventative maintenance. No start time is given in the format.
- SCHEDULE Except during special time periods, mapping is on a 5-days-per-week schedule. Maps are not scheduled on Saturdays and Sundays.

Sometimes a map is presented here which has not been published in Solar-Geophysical Data because of clouds or calibration problems. On such maps the word CLOUDY or CALIBRATION appears below the map between the time and the wavelength.

09 MAY 1979



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09 MAY 1979

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NO DATA

EQUIPMENT

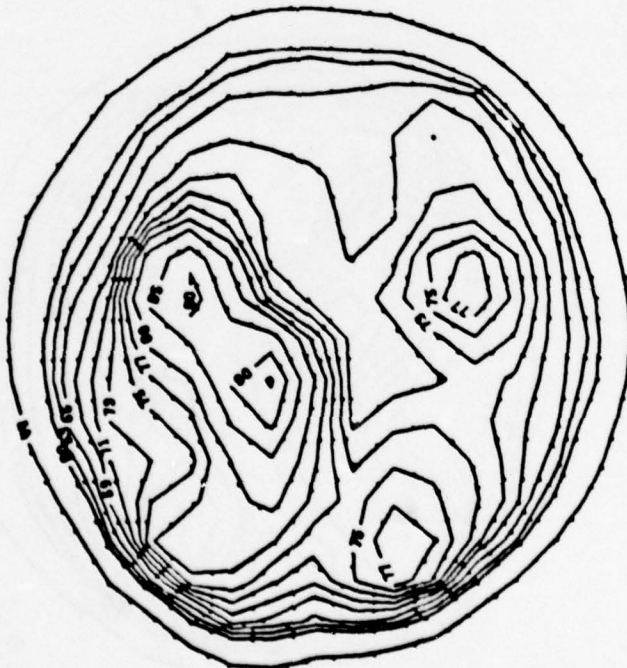
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2054

2.0 CM

UT

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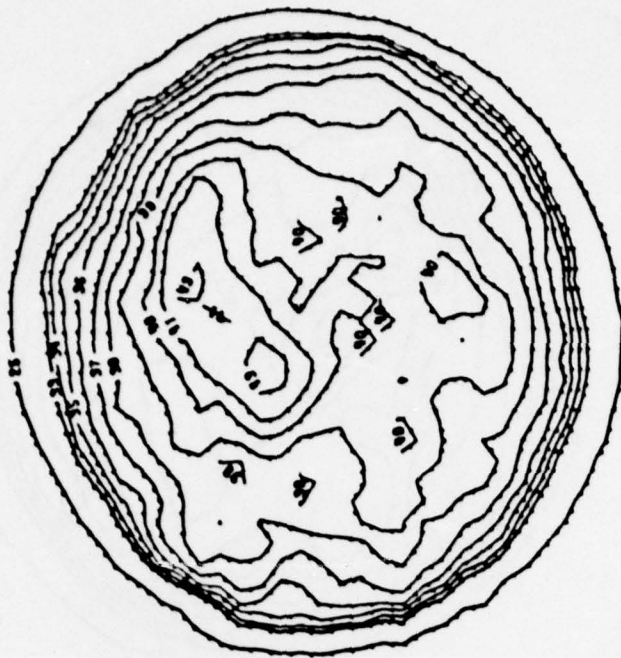
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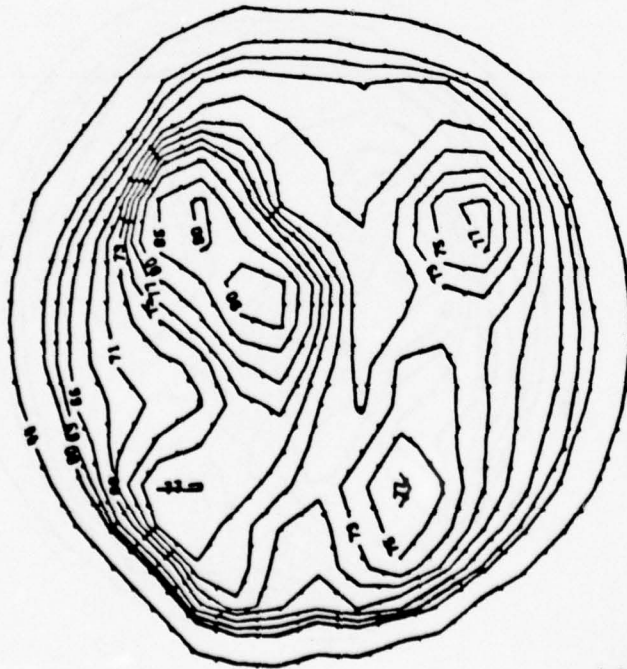
10 MAY 1979



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0.6 MHz

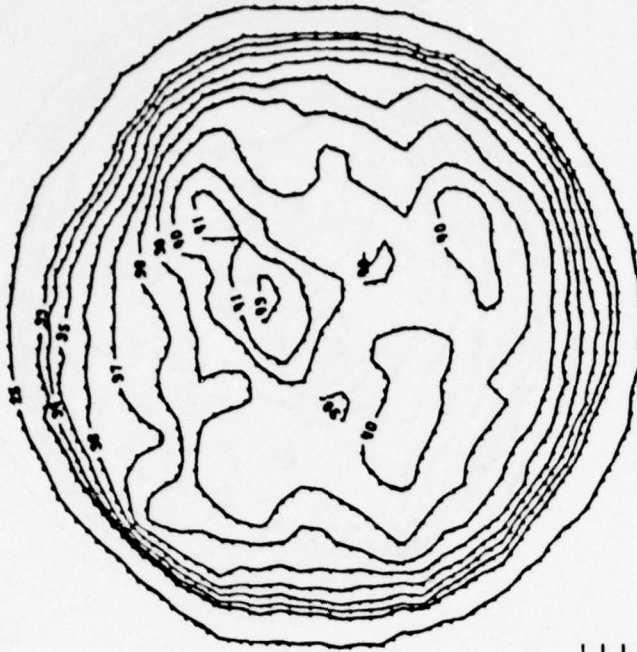
11 MAY 1979



1649 UT

2.0 CM

11 MAY 1979



1732 UT

8.6 MM

12 MAY 1979



12 MAY 1979

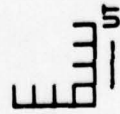


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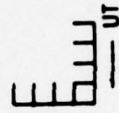
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WEATHER

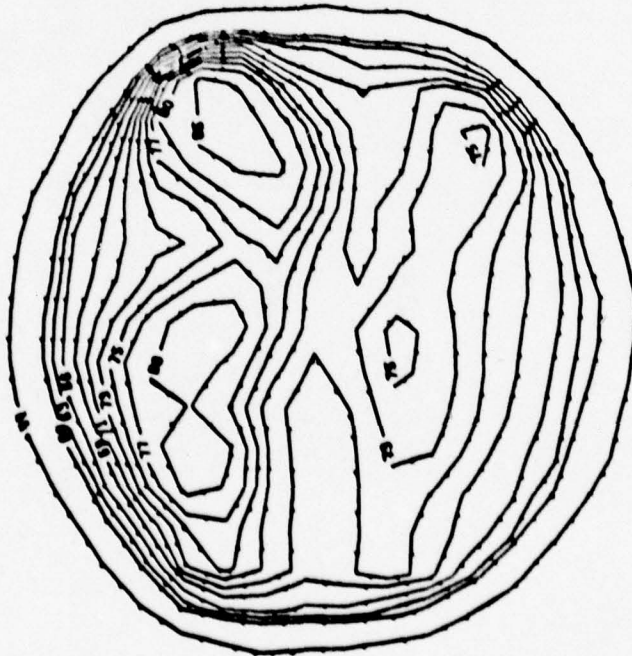


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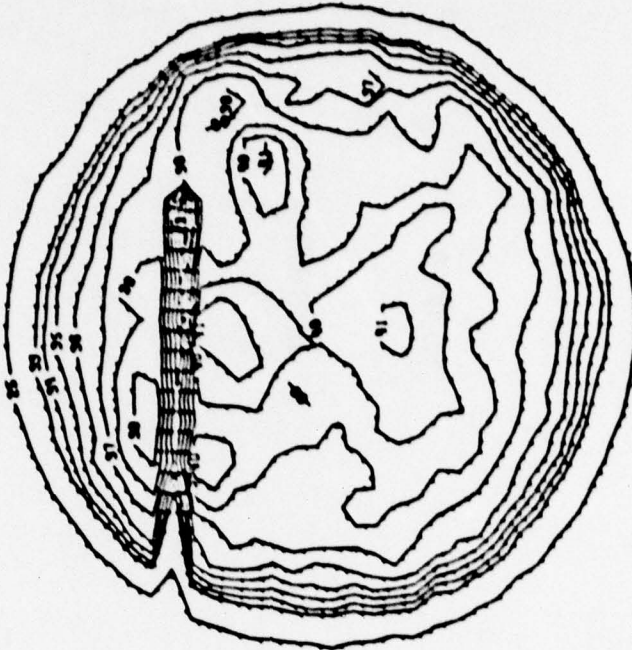
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13 MAY 1979



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13 MAY 1979

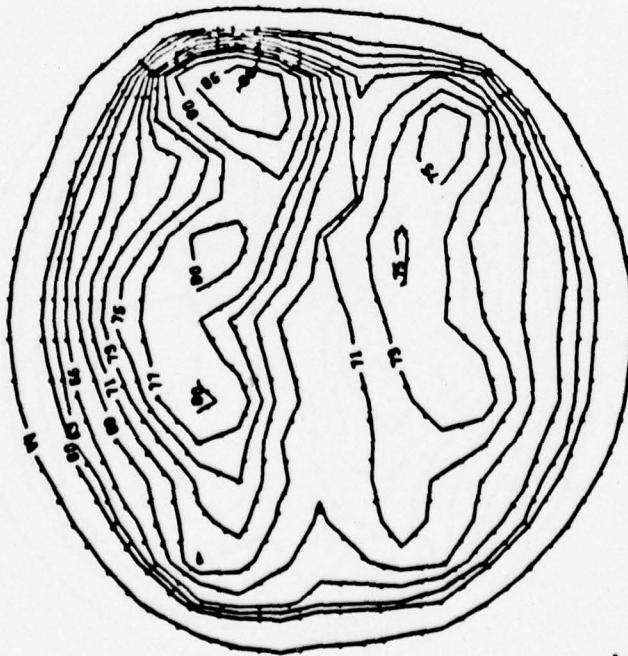


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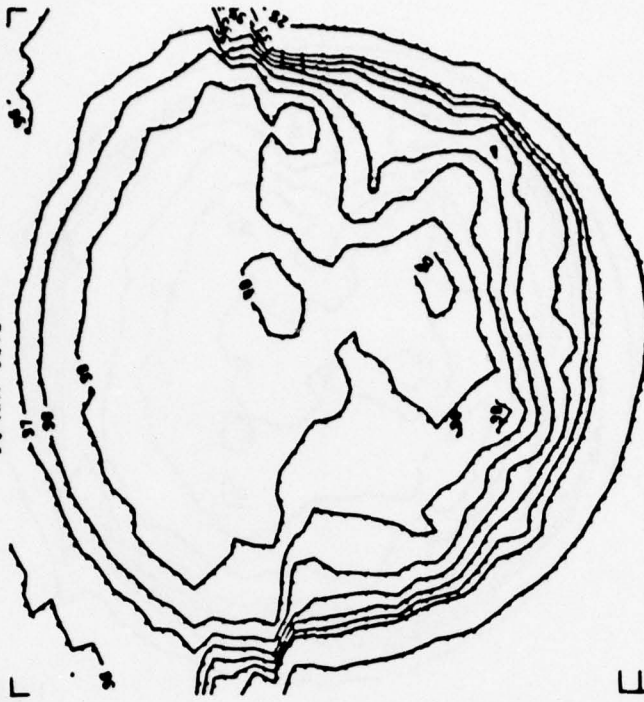
14 MAY 1979



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14 MAY 1979

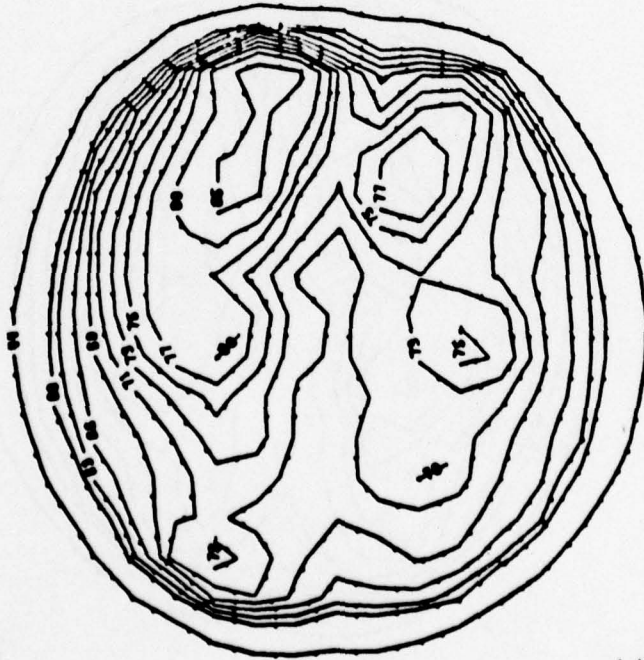


1818 UT

CALIBRATION

0.6 MM

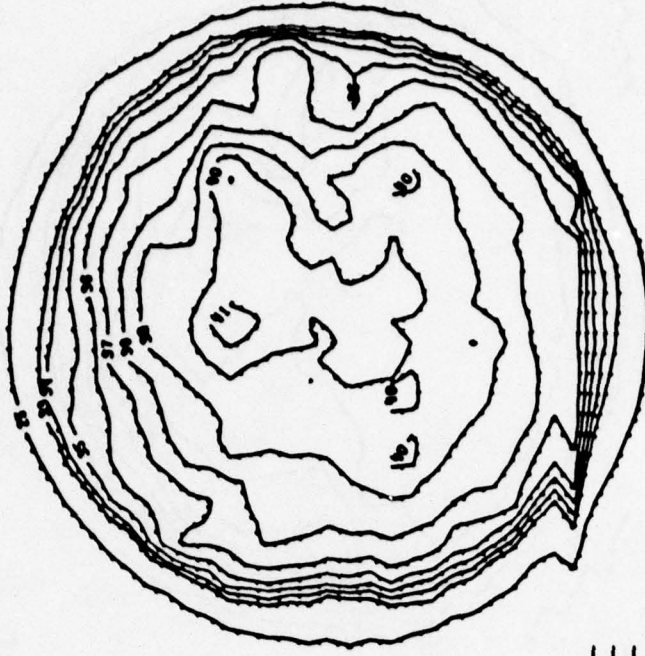
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15 MAY 1979

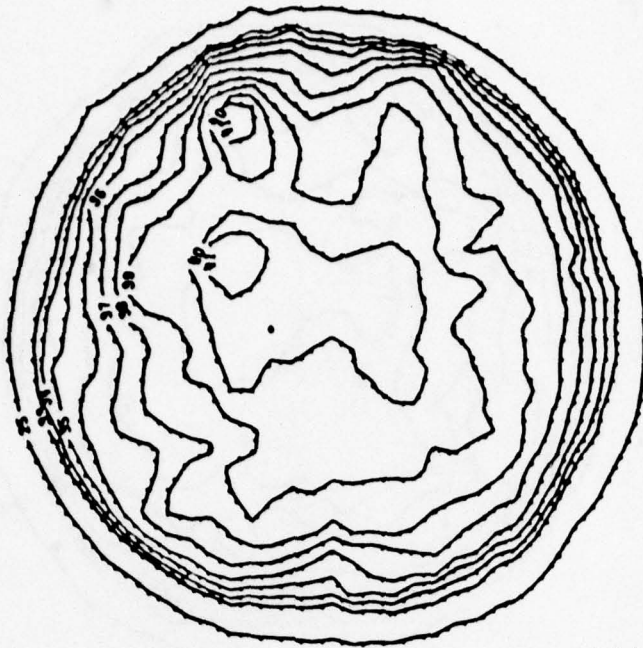


1642 UT

CALIBRATION

0.6 CM

16 MAY 1979



0.5 MM

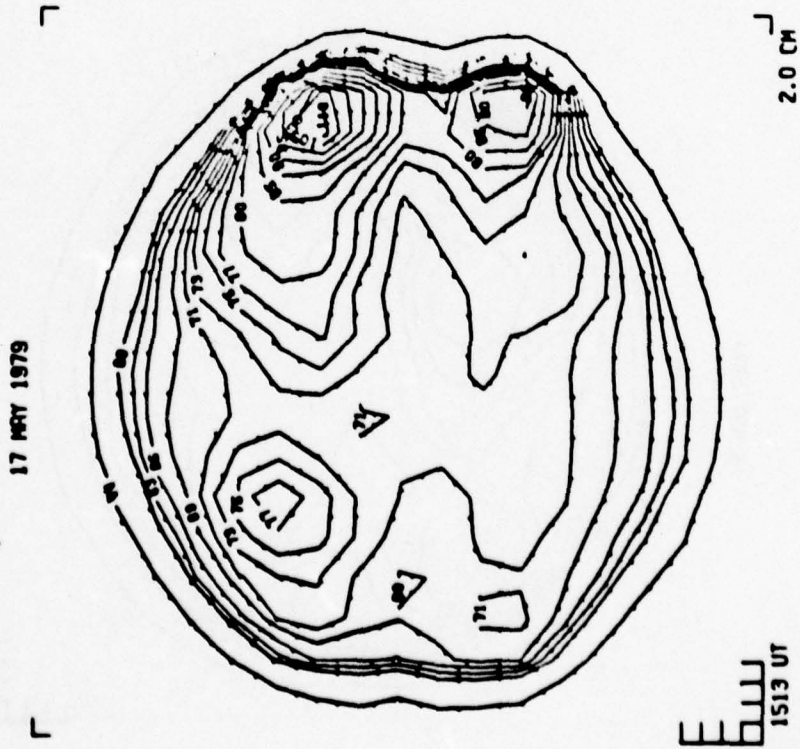
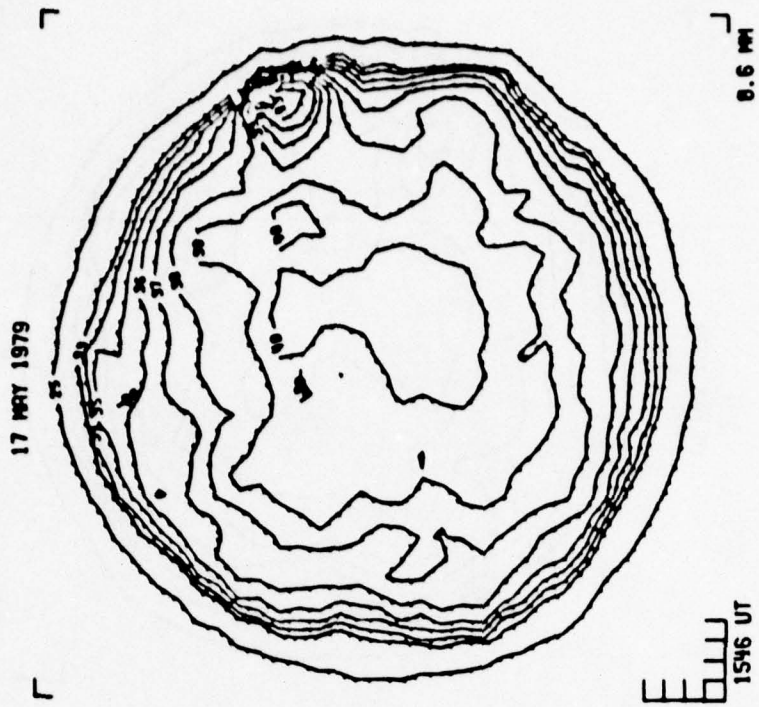
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16 MAY 1979

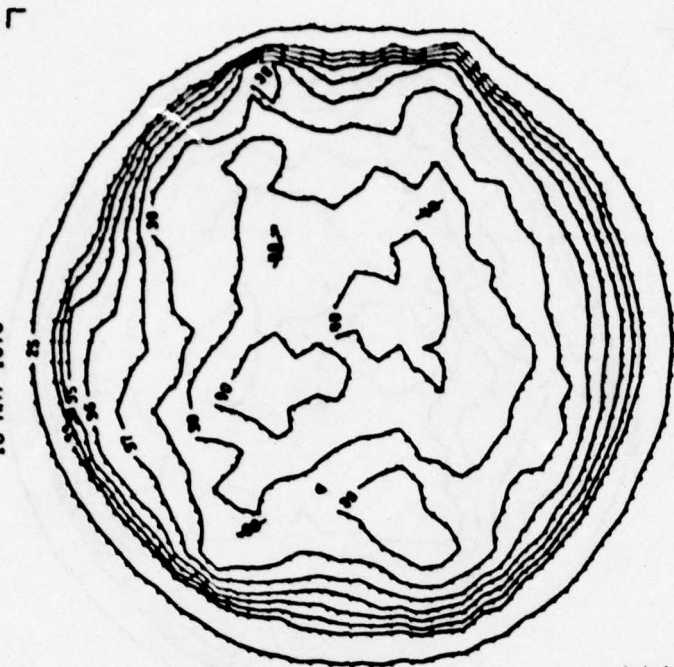


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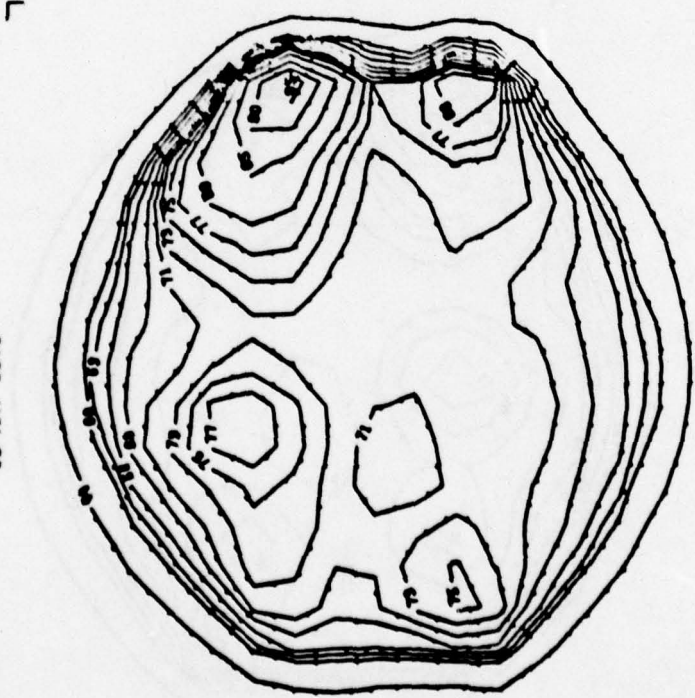
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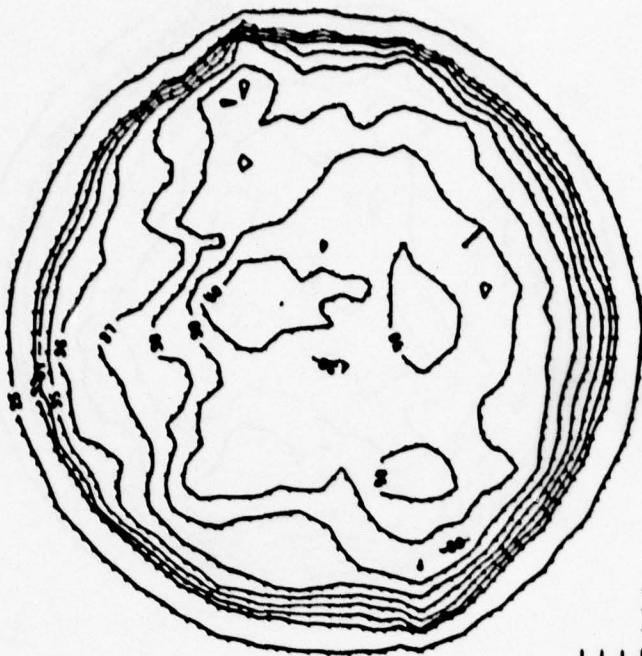
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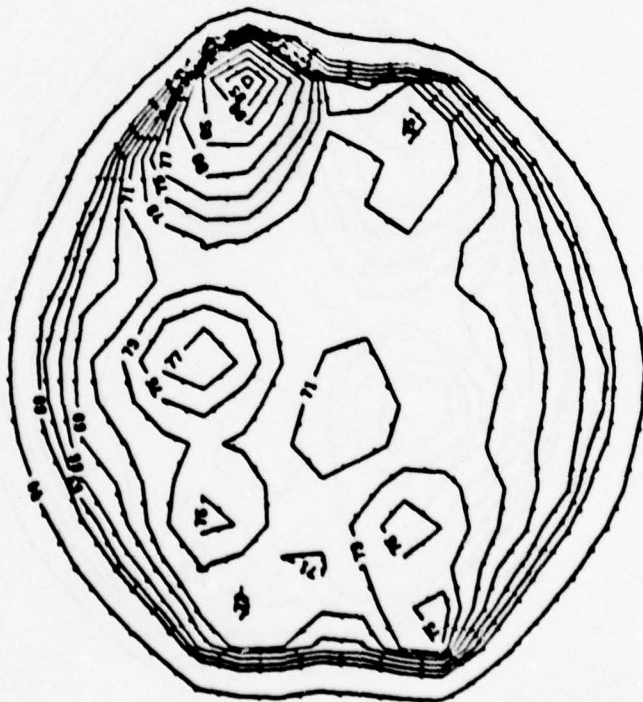
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19 MAY 1979



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E 1551 UT

28 MAY 1979

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WEATHER

8.6 MI

UT

28 MAY 1979

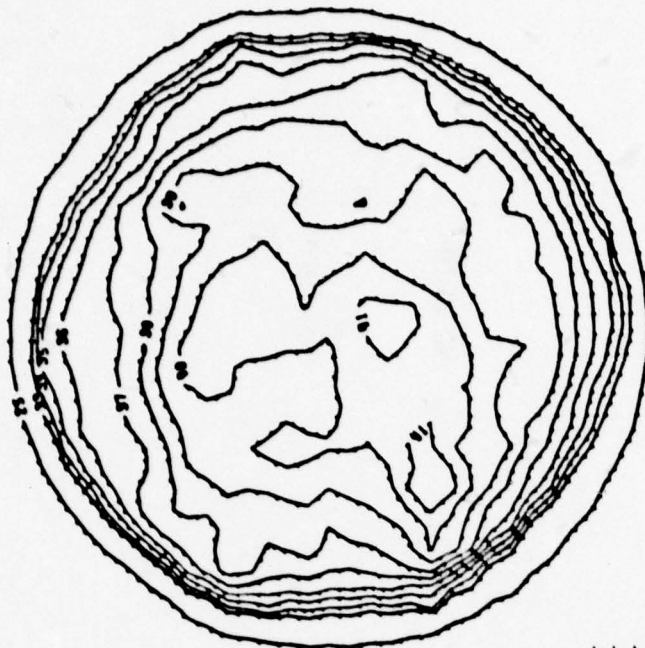
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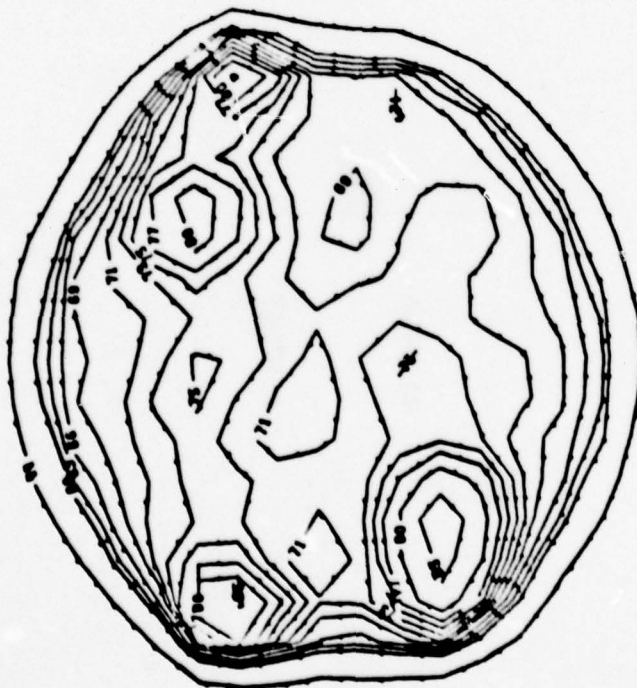
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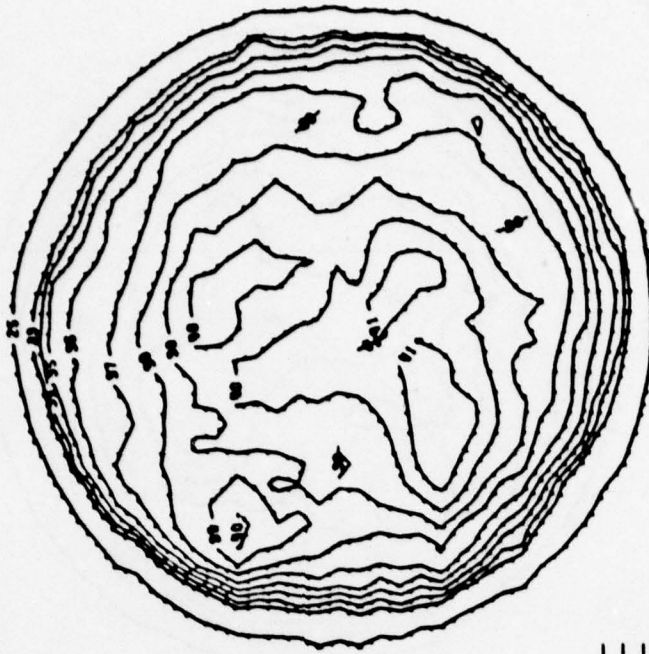
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22 MAY 1979



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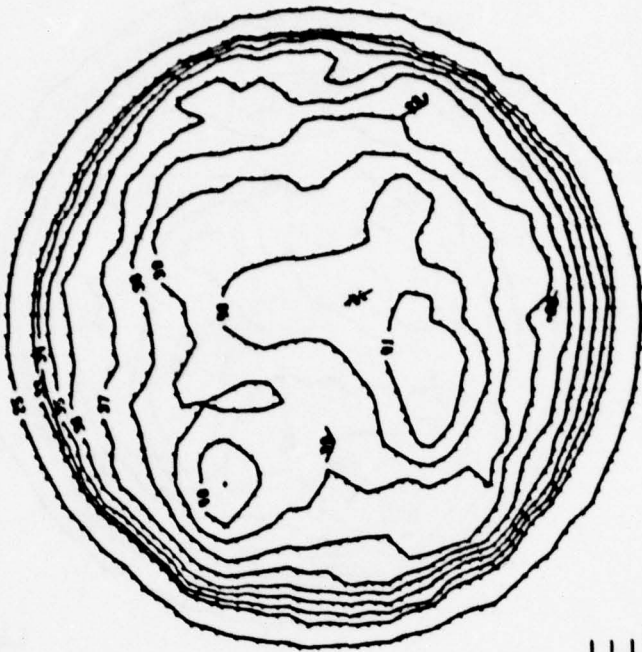
23 MAY 1979



1518 UT

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23 MAY 1979



1546 UT

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24 MAY 1979



24 MAY 1979

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UT

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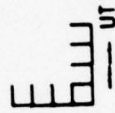
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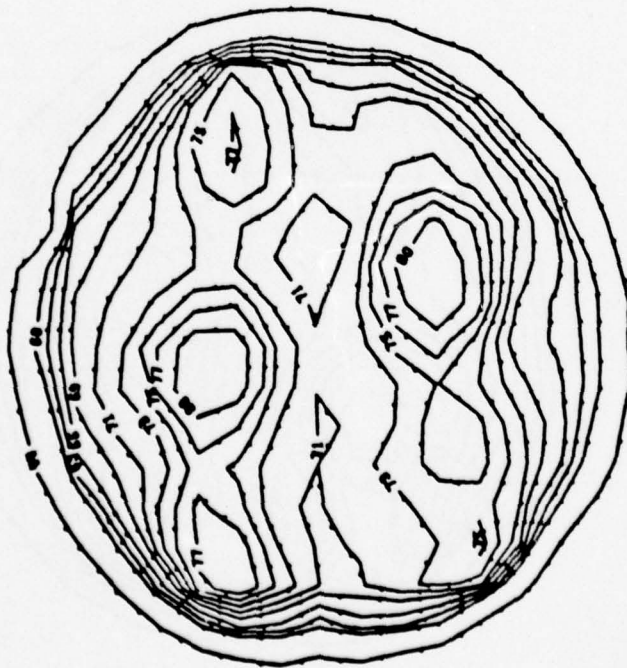
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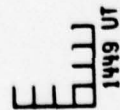
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25 MAY 1979



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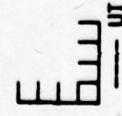


26 MAY 1979

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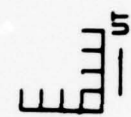
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26 MAY 1979

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27 MAY 1978

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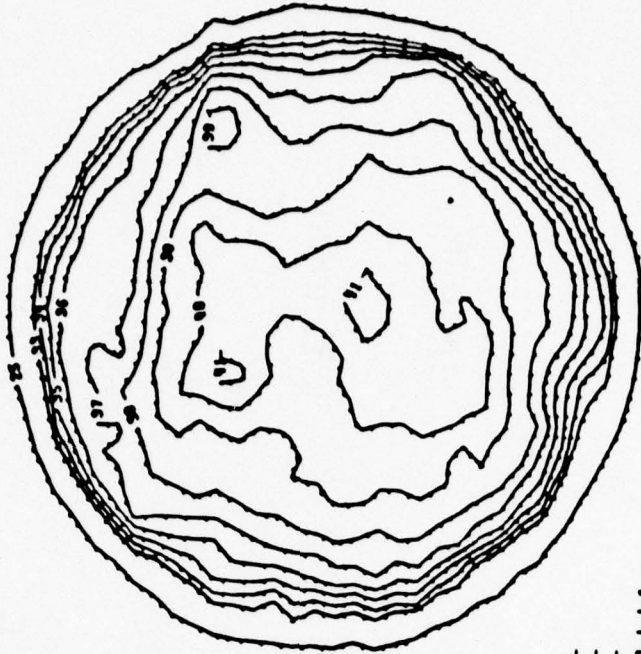
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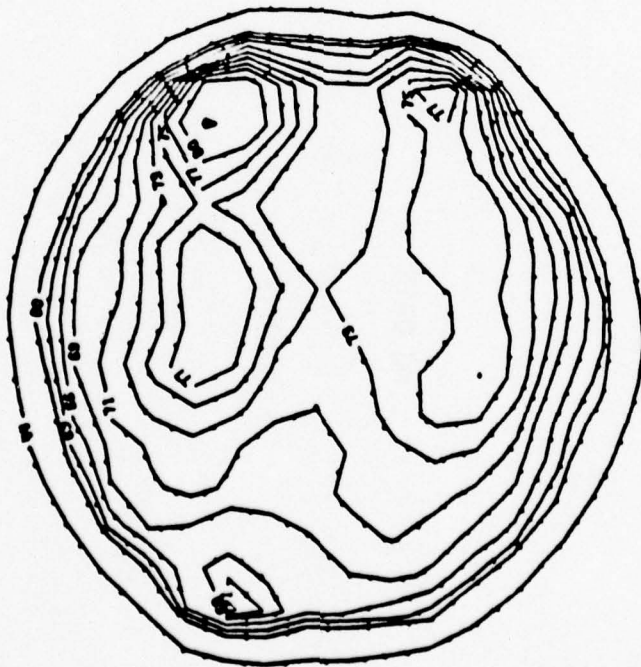
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0.6 MM

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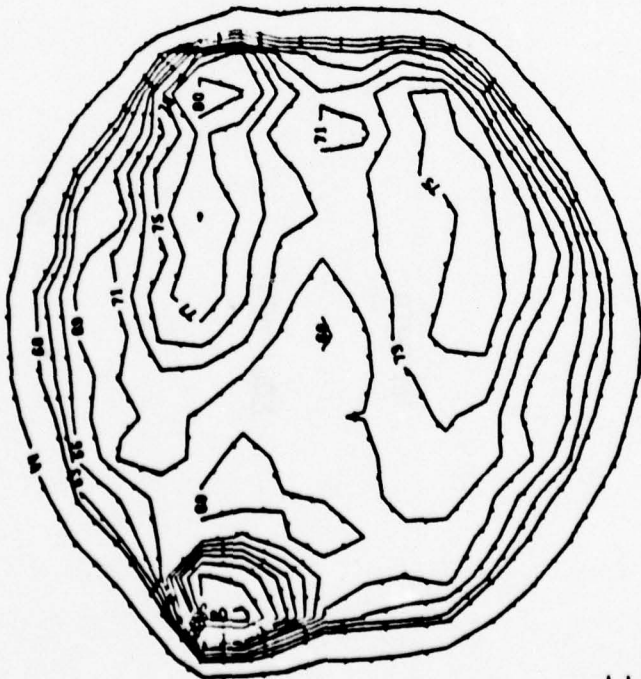
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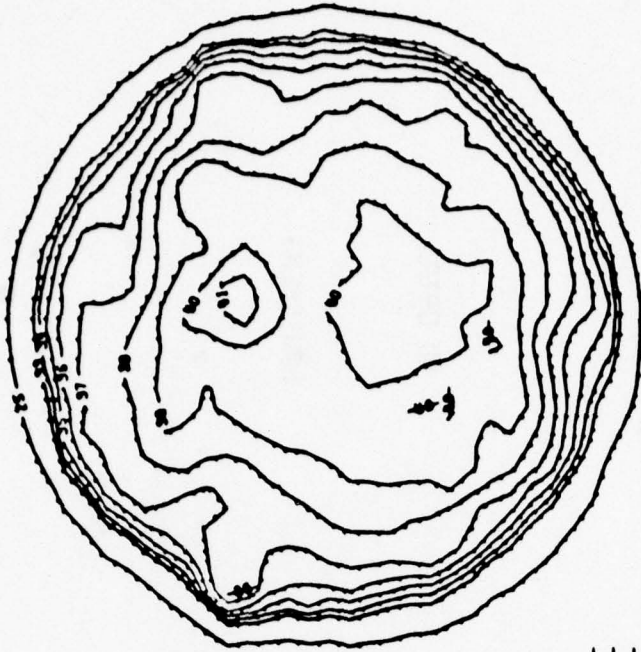
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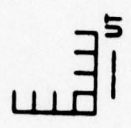
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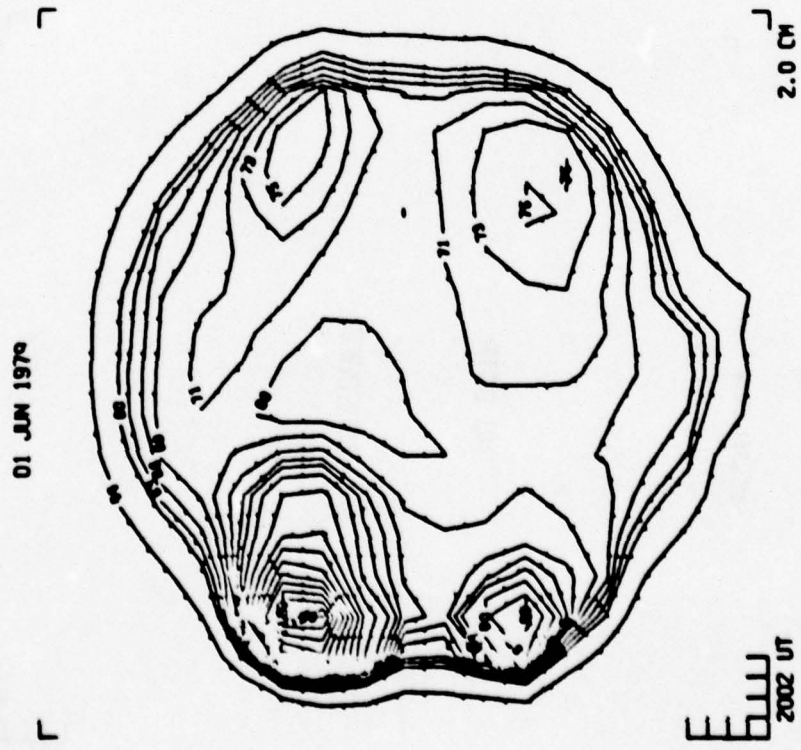
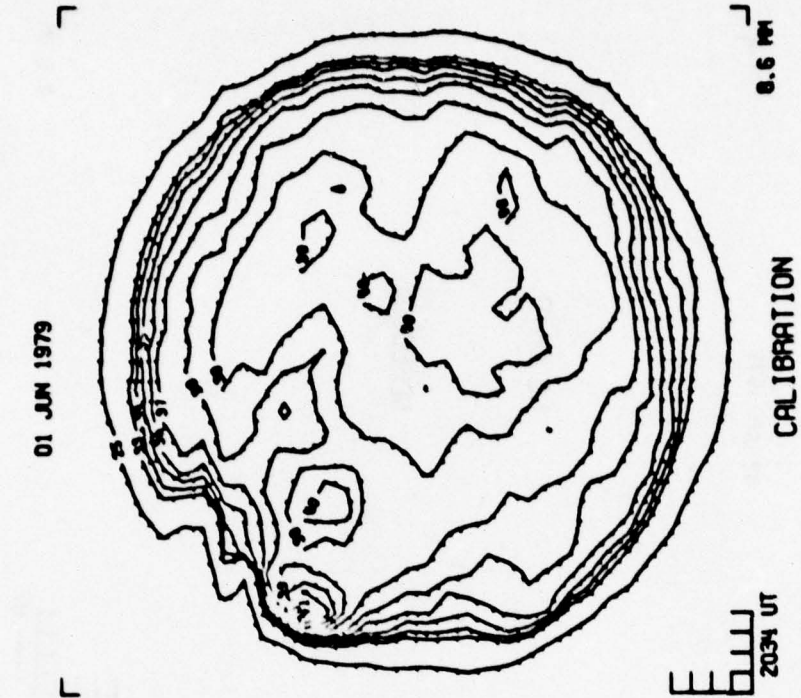
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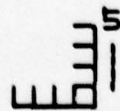


82 JUN 1979



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SCHEDULE

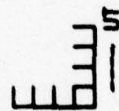


82 JUN 1979



NO DATA

SCHEDULE



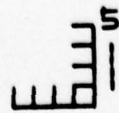
0.6 MI

2.0 CH

03 JUN 1979

NO DATA

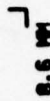
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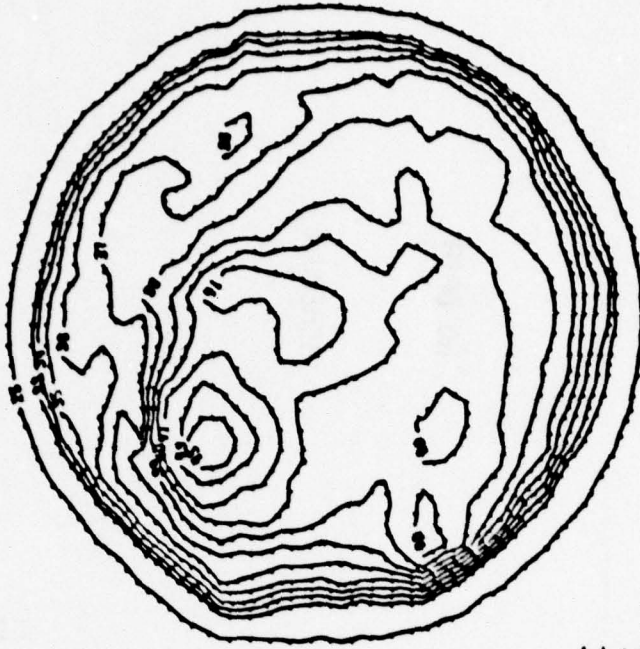
03 JUN 1979

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SCHEDULE



01 JUN 1979



0.6 MM

1522 UT

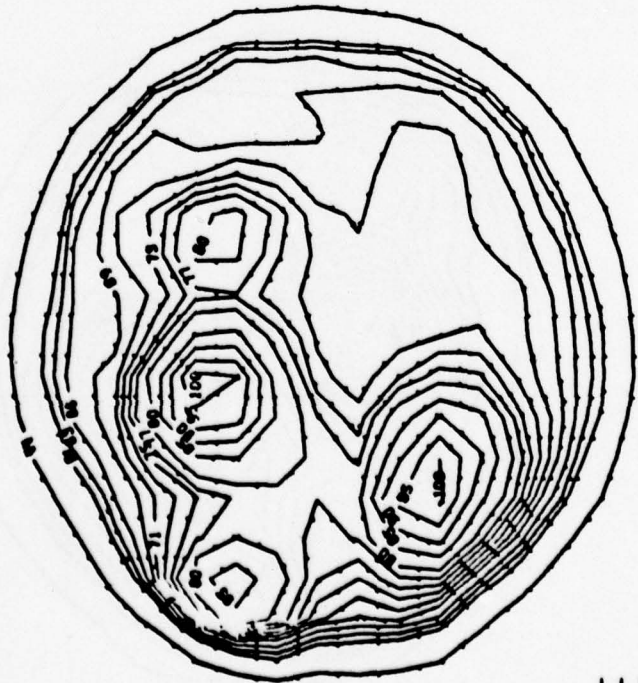
01 JUN 1979



2.0 CM

1454 UT

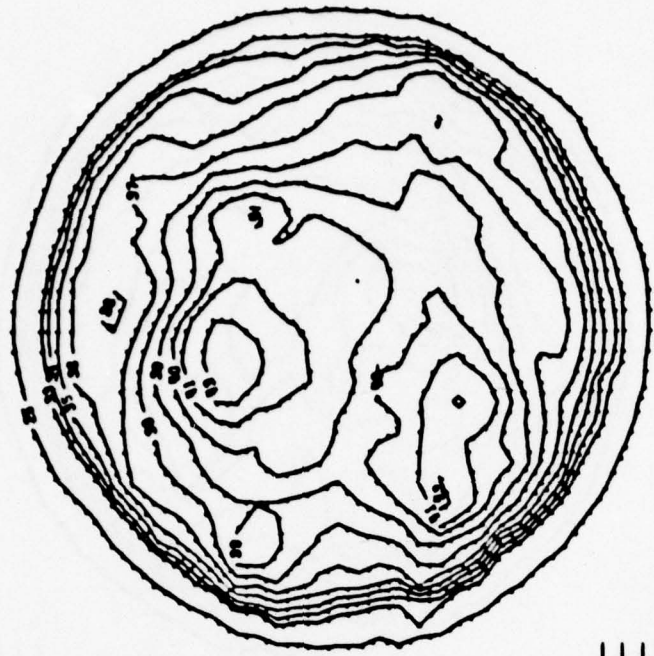
05 JUN 1979



2.0 CM

1500 UT

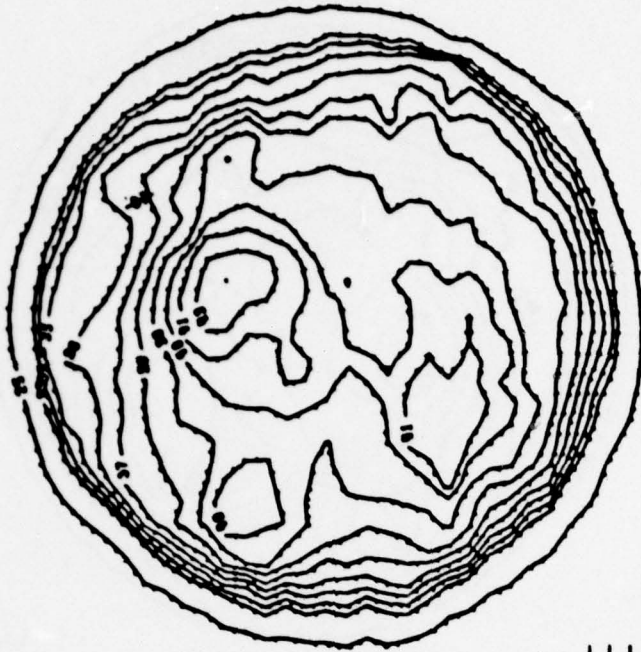
05 JUN 1979



0.6 MM

1530 UT

06 JUN 1979



1540 UT

0.6 NM

06 JUN 1979



1507 UT

2.0 CM

07 JUN 1979



1508 UT

2.0 CM

07 JUN 1979

NO DATA
CALIBRATION

1541 UT

0.6 MM

00 JUN 1979

7

7

00 JUN 1979

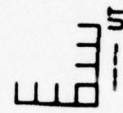
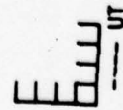
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NO DATA

WEATHER

NO DATA

WEATHER



2.0 CH

8.6 MM

10 JUN 1979

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NO DATA

SCHEDULE

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10 JUN 1979

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NO DATA

SCHEDULE

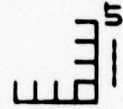
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11 JUN 1979

NO DATA

EQUIPMENT

0.6 MI

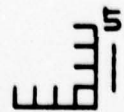


11 JUN 1979

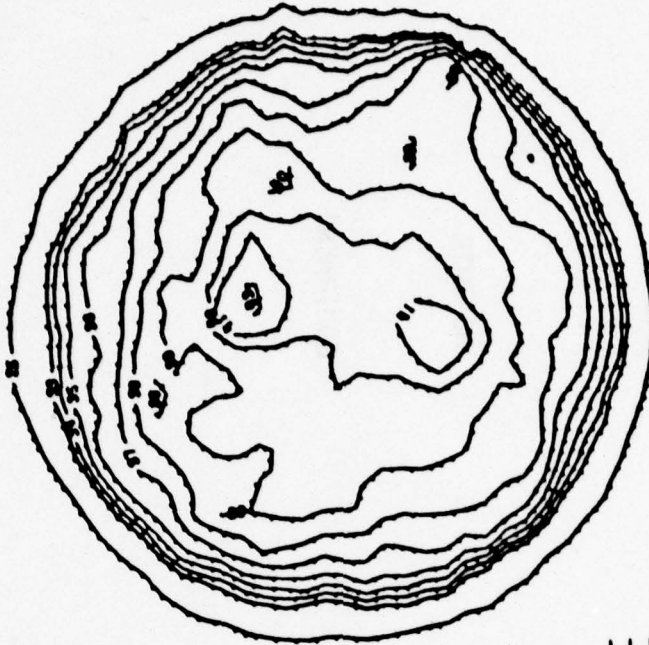
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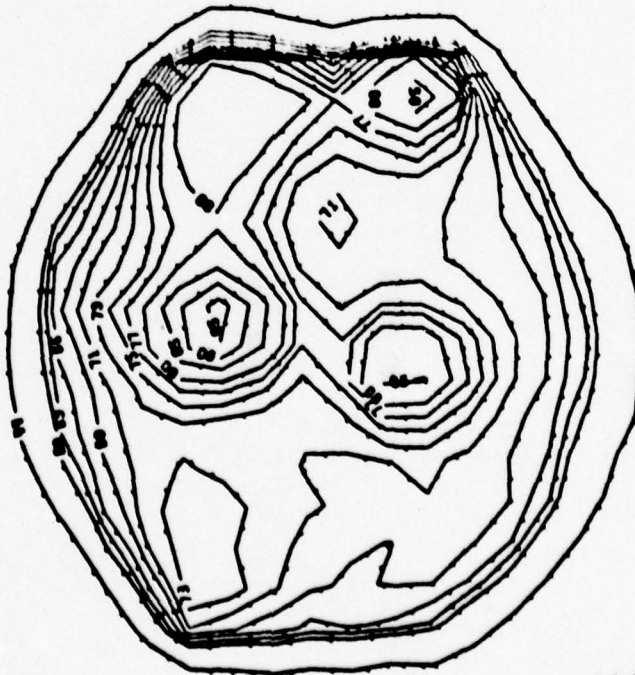


12 JUN 1979



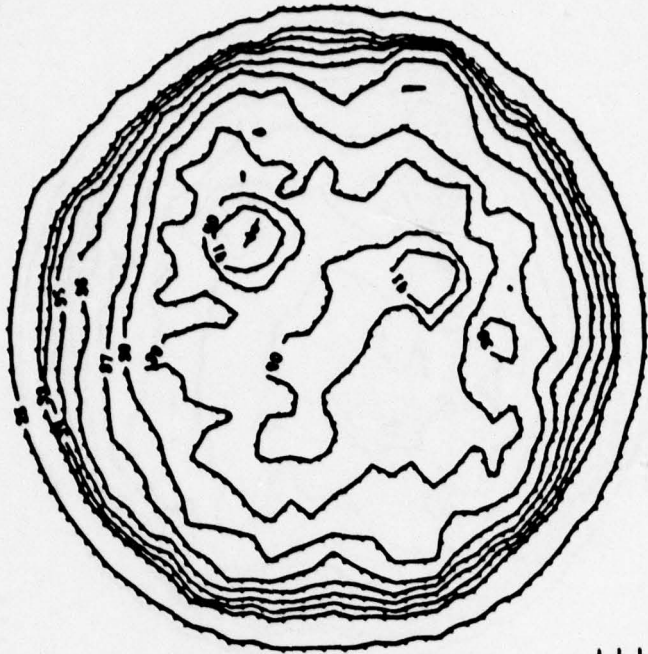
0.6 NM

12 JUN 1979



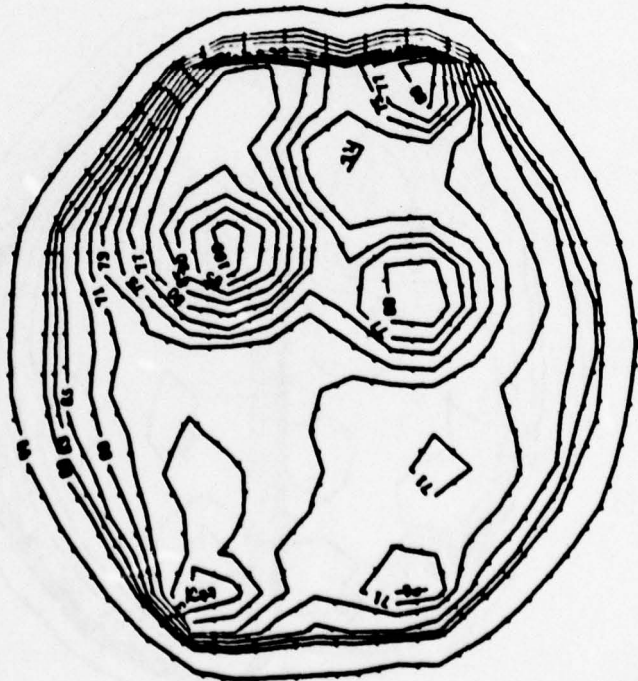
2.0 CM

13 JUN 1979



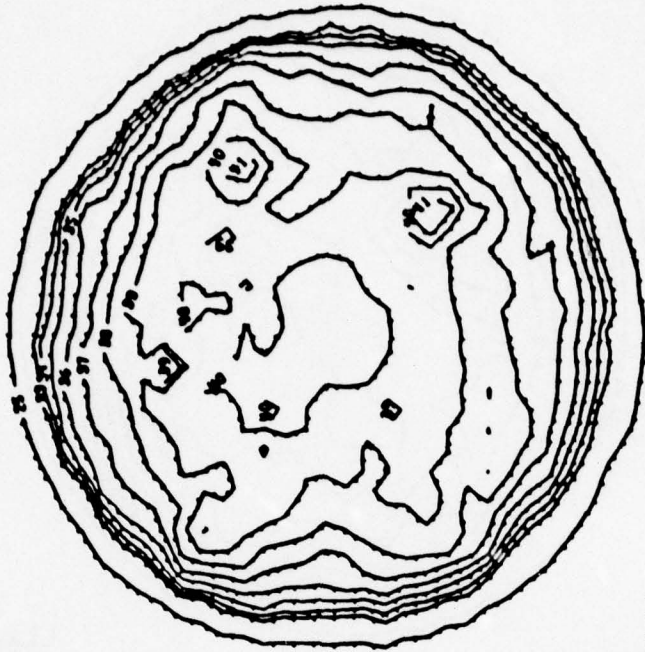
8.6 MI

13 JUN 1979



2.0 CM

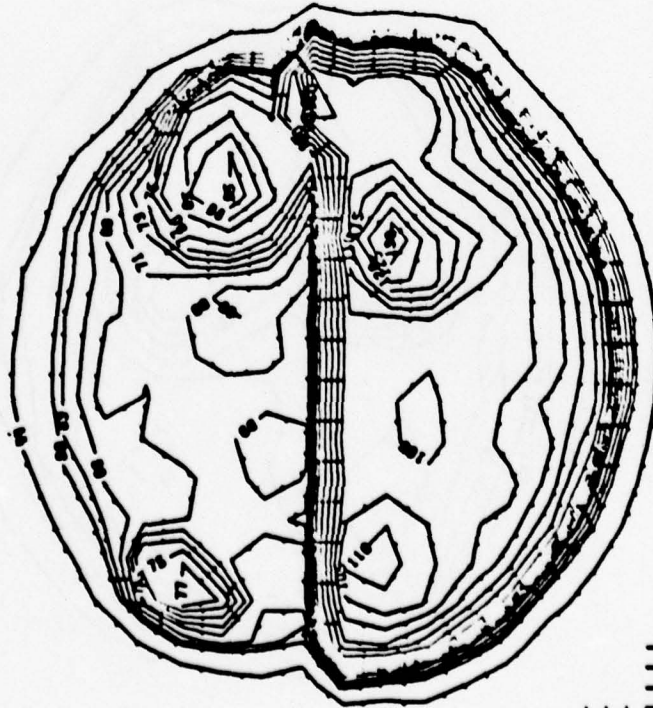
14 JUN 1979



0.6 MP

1559 UT

14 JUN 1979



2.0 CM

CALIBRATION

1514 UT

15 JUN 1979

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NO DATA

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15 JUN 1979

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NO DATA

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15 JUN 1979

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NO DATA

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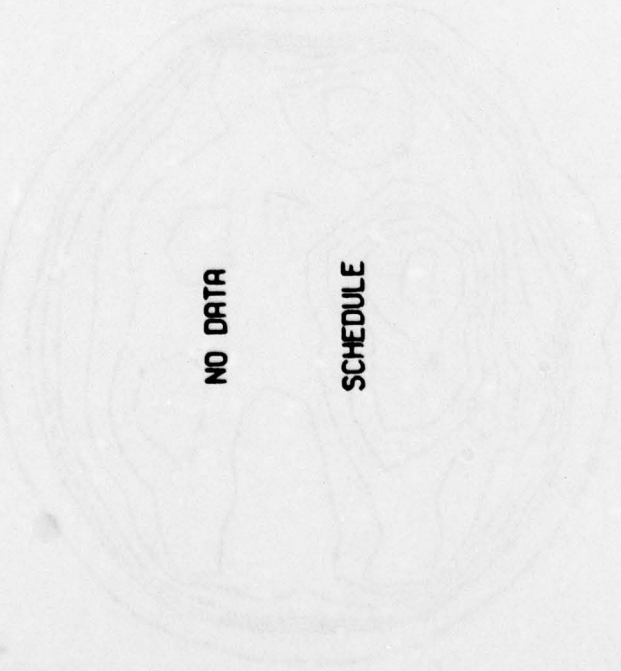
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17 JUN 1979



17 JUN 1979

17 JUN 1979

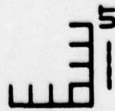


NO DATA

SCHEDULE

NO DATA

SCHEDULE



2.0 CH



0.6 MM

18 JUN 1979



1625 UT

18 JUN 1979

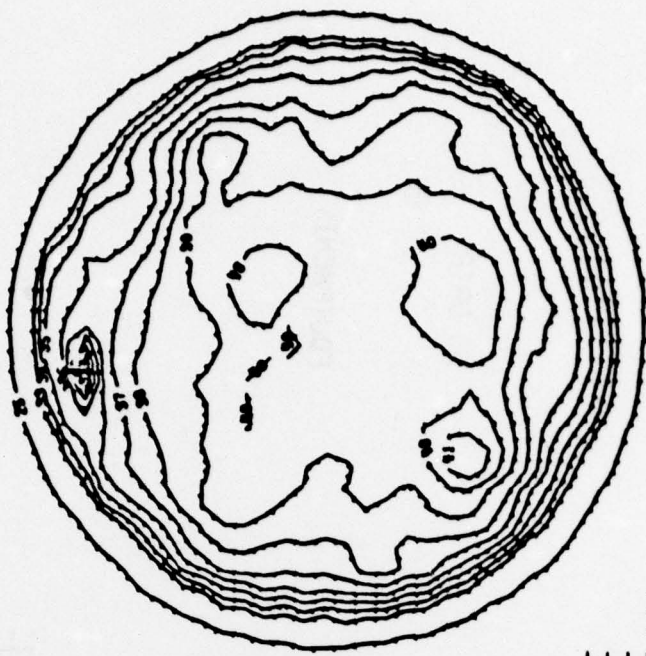
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CALIBRATION

1656 UT

2.0 CM

8.6 MM

20 JUN 1979



1519 UT

8.6 MI

20 JUN 1979



1448 UT

2.0 CH

21 JUN 1979



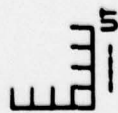
21 JUN 1979

NO DATA

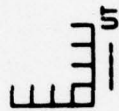
WEATHER

NO DATA

EQUIPMENT

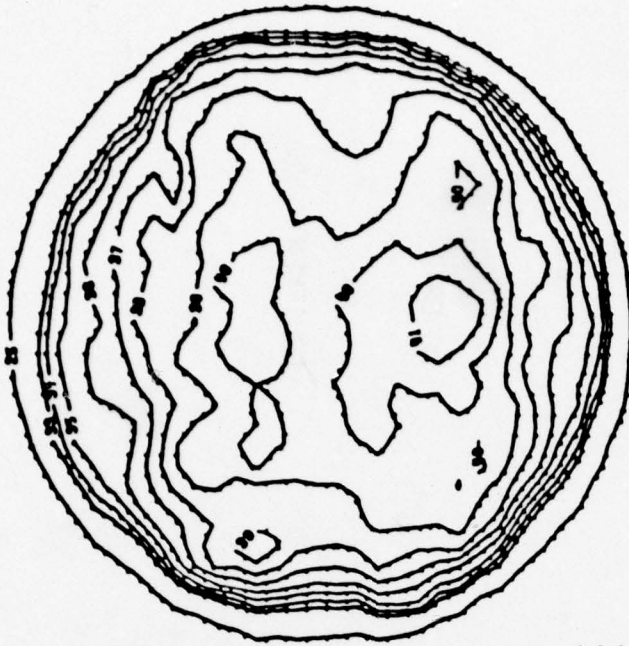


2.0 CH



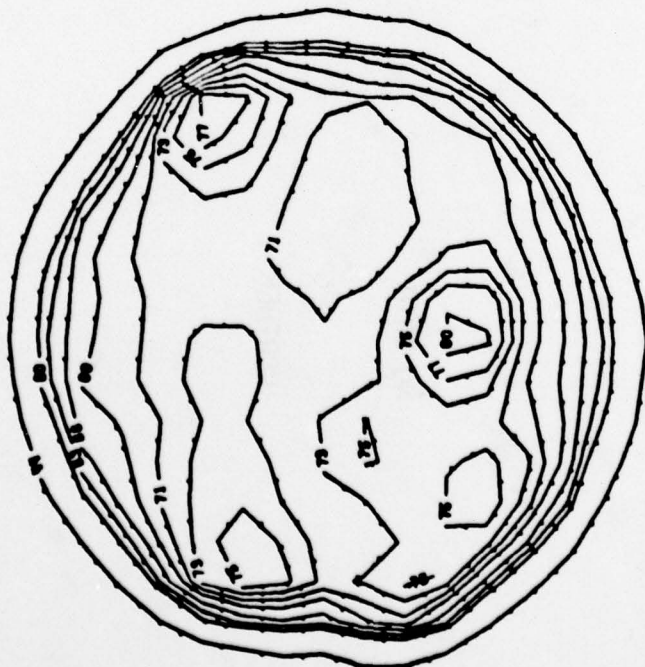
0.6 MH

22 JUN 1979



1047 UT

22 JUN 1979



1018 UT

23 JUN 1979

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NO DATA

SCHEDULE

0.6 MI

23 JUN 1979

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NO DATA

SCHEDULE

2.0 MI

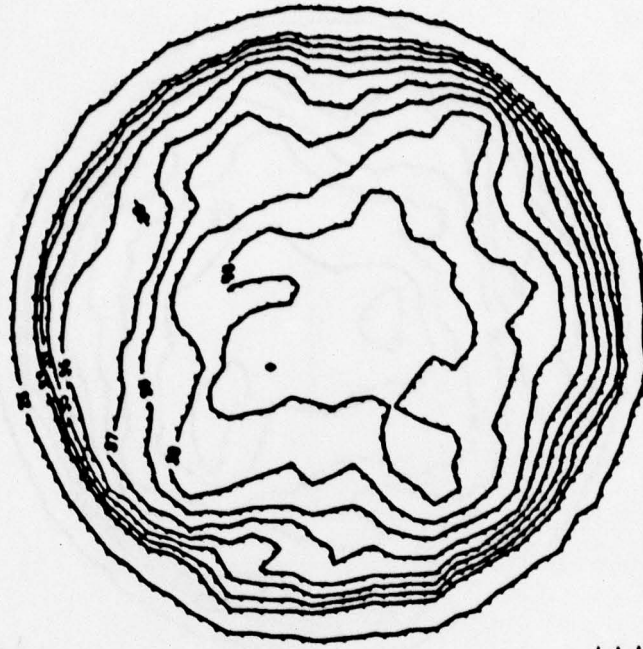
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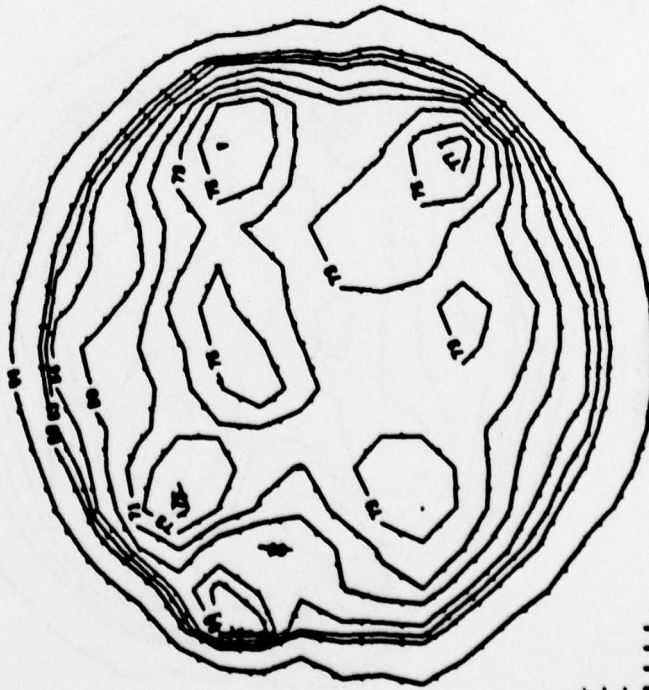
25 JUN 1979



0.6 M

1642 UT

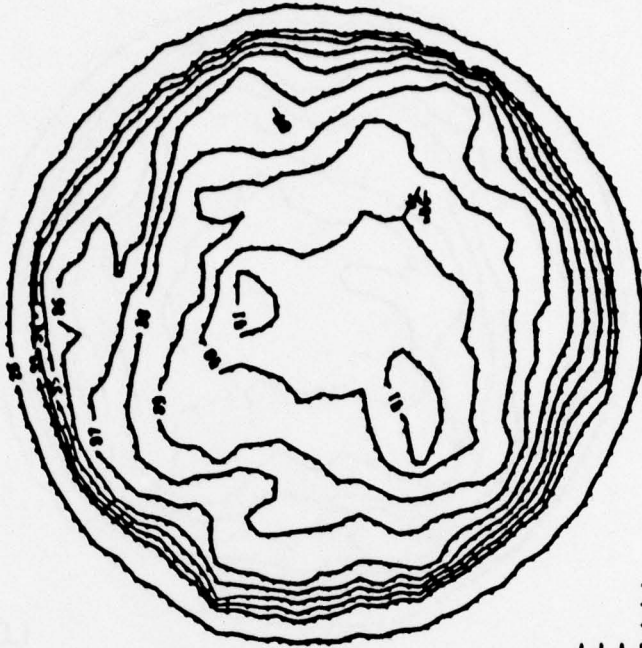
25 JUN 1979



2.0 CM

1606 UT

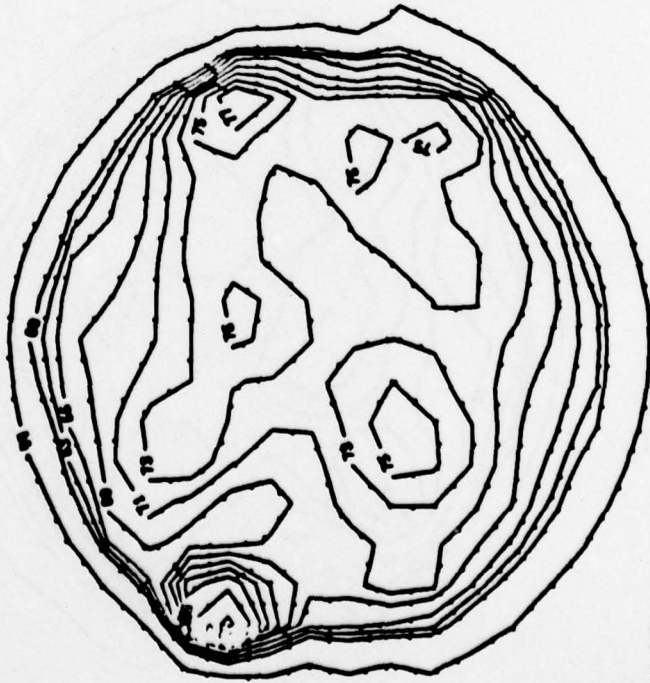
26 JUN 1979



0.6 MI

E
1539 UT

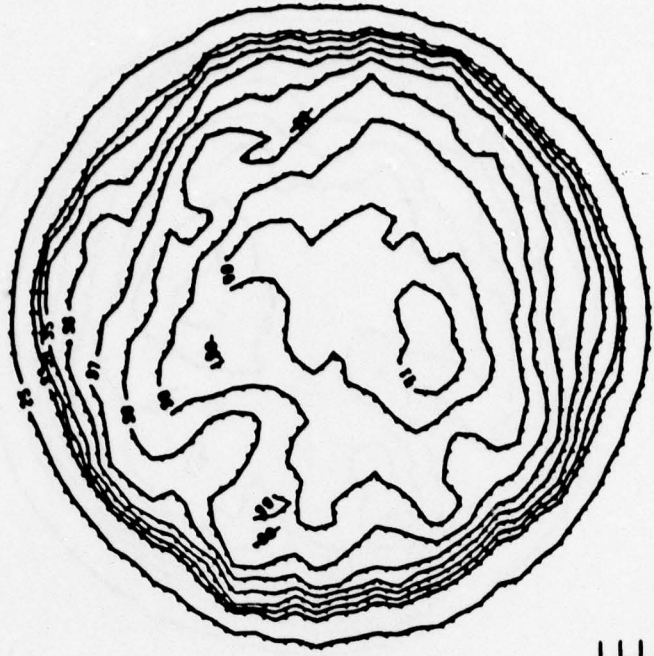
26 JUN 1979



2.0 CM

E
1511 UT

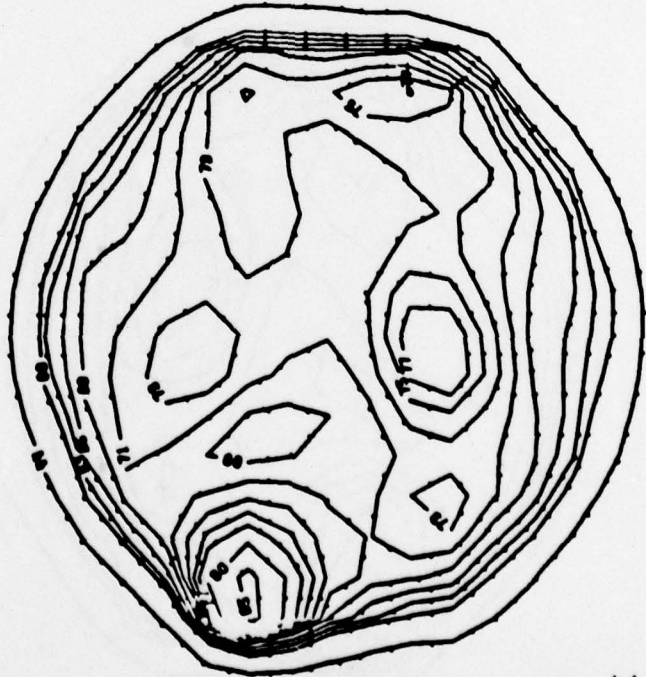
27 JUN 1979



0.6 MI

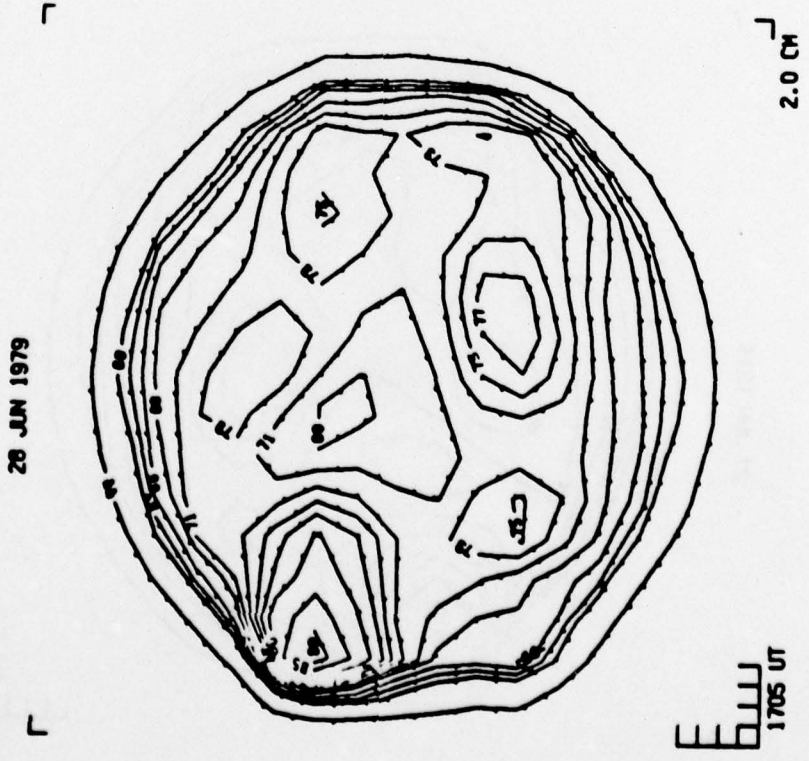
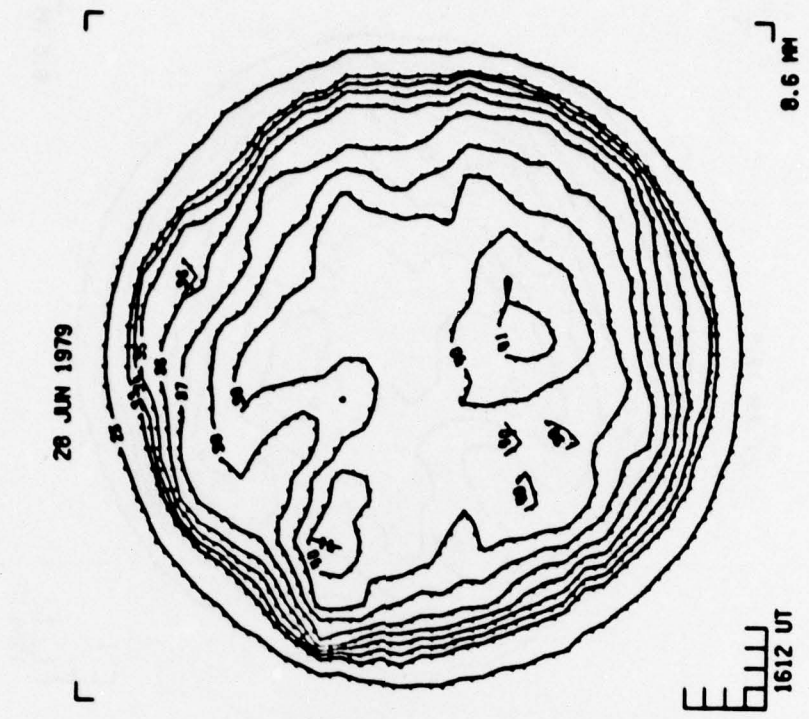
1656 UT

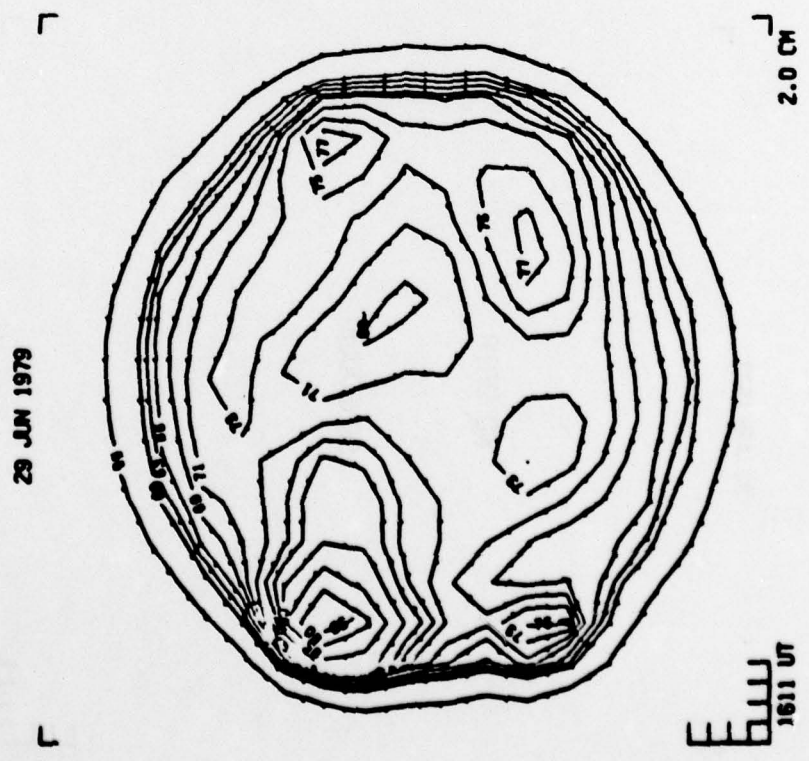
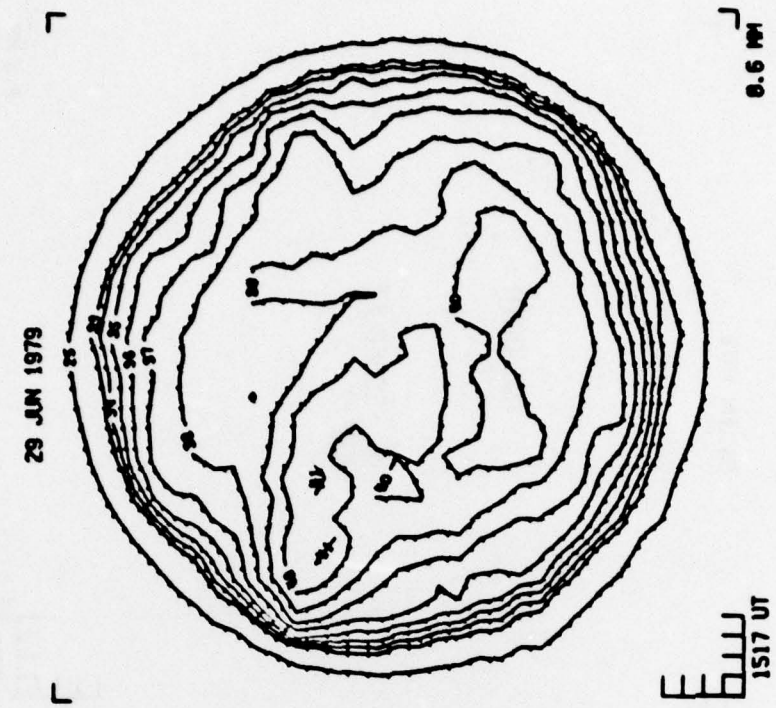
27 JUN 1979



2.0 CM

1749 UT





30 JUN 1979

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30 JUN 1979

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NO DATA

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NO DATA

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0.6 MI