TRAVERSE BRIEFINGS FOR APOLLO 16 CREW

THE TRAVERSE BRIEFING TEAM

INTRODUCTION

This document is a collection of materials handed out to the Apollo 16 surface crew during a series of traverse briefing sessions. It served as a guideline during these sessions to formulate and discuss in detail the general and specific scientific objectives of each EVA, of individual station stops and of each single task to be performed. Consequently, the document reflects the detailed background of the crew and therefore may be used by the members of the Science Support Team to familiarize themselves with the thinking to which the crew was exposed. Topics discussed in great detail and not summarized in this book are: (1) global and regional characteristics of the Cayley Formation, (2) global and regional characteristics of the Descartes Formation, and (3) detailed contingency planning.

It is not the purpose of this book to serve as an official guideline for traverse planning. It is hoped that it represents information for those readers who are interested in the crew's scientific background. The official traverse planning guidelines - among other documents - are contained in the "Science Contingency Plan" and "Lunar Surface Procedures".

The material contained in this book has been compiled from many scientific sources which are in most cases not identified, because we consider this book a working tool for the crew rather than a scientific document. Furthermore, the contents are the sole responsibility of the Traverse Briefing Team which realizes that there are many geologic details that are subject to alternative interpretation. However, the crew has been informed about such alternatives and it is believed that the crew had sufficient geologic field experience to identify and characterize deviations from premission interpretation.

The members of the Traverse Planning Team in alphabetical order are:

Anthony W. England, Chairman, MSC/CB

James W. Head, Bellcomm, Washington, D.C.

Friedrich Horz, MSC, S&AD

William R. Muehlberger, U.S.G.S., Flagstaff

John R. Sevier, MSC/ASPO

The contributions of Eugene Boudette, U.S.G.S., Flagstaff, Robert Kain, MSC and Roger Koppa, G.E. are greatly appreciated.

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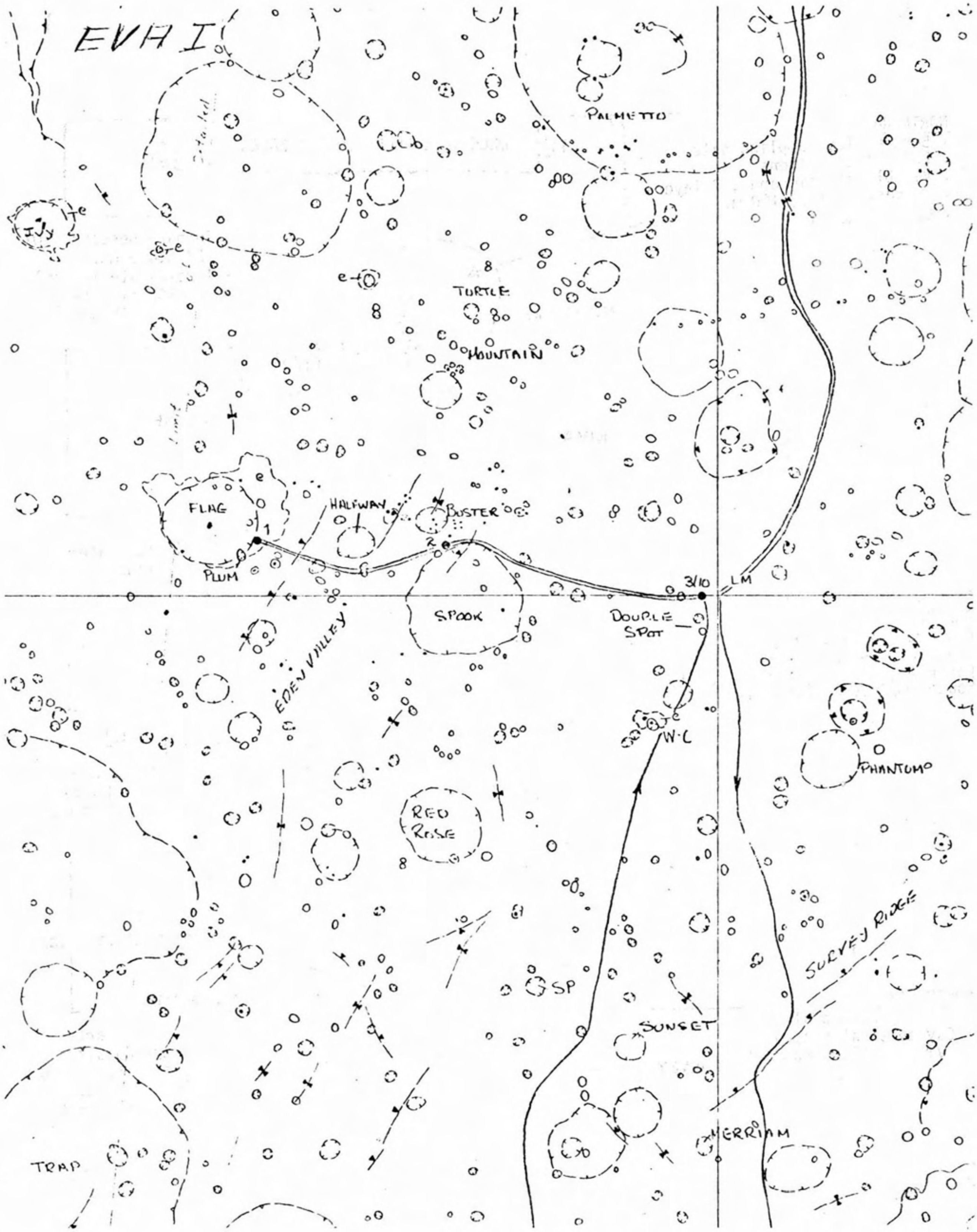
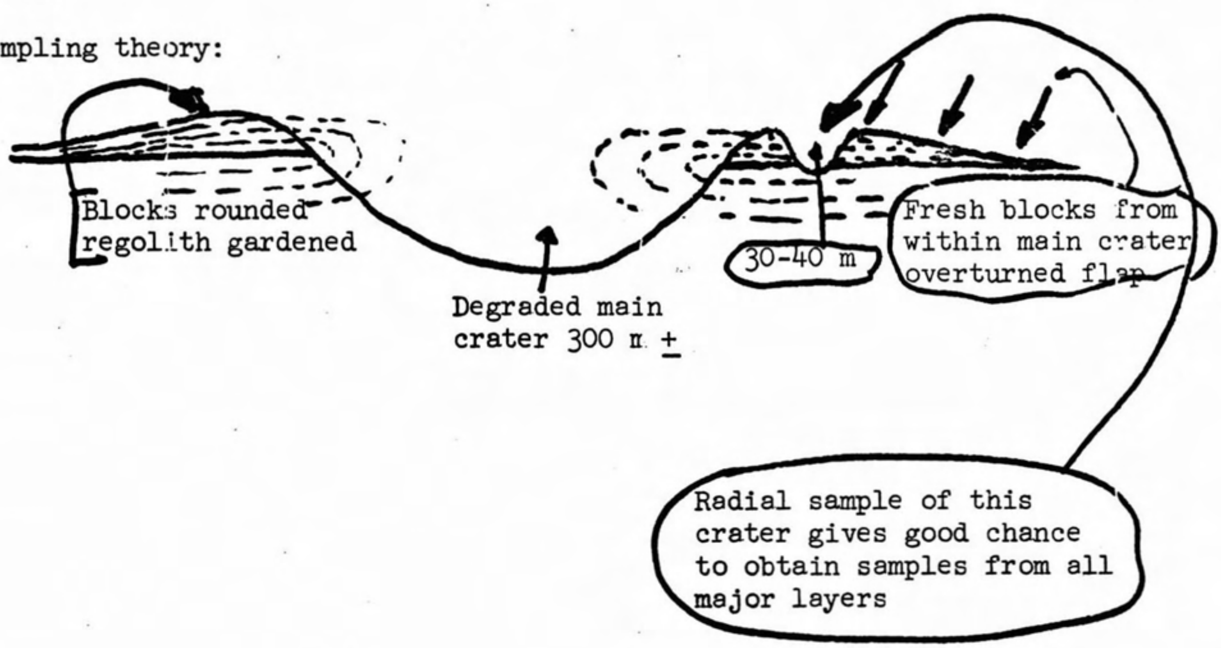

EVA I
PALMETTO
IVY
TURTLE
MOUNTAIN
FLAG
HALFWAY
BUSTER
1
2
3/10
LM
PLUM
SPOOK
DOUBLE SPOT
EDEN VALLEY
W.C
PHANTOM
RED ROSE
SP
SURVEY RIDGE
SUNSET
MERRIAM
TRAP

FLAG/SPOOK CRATER PAIR

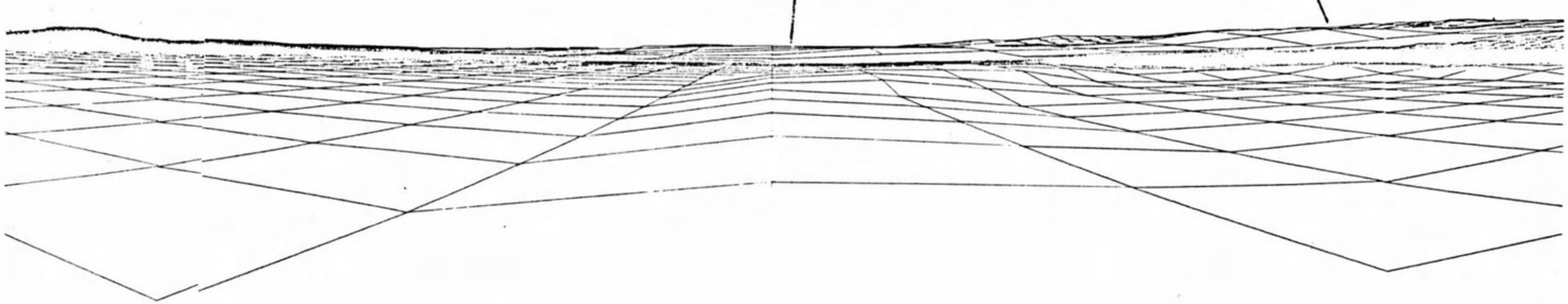
- Samples to 60 m depth
- Best opportunity to test lateral continuity of bedrock units over short (~1 km) distance
- Good stratigraphy from this pair will give a solid base to study ASE profile and to extend Cayley stratigraphy north to Palmetto - North Ray crater and south to South Ray crater
- Both craters are degraded and have ray material from South Ray crater obscuring local geology
- Both craters have fresh, young, 40-50 m craters on or near their rims which will be used to sample the overturned flap of the larger crater
- Sampling theory:

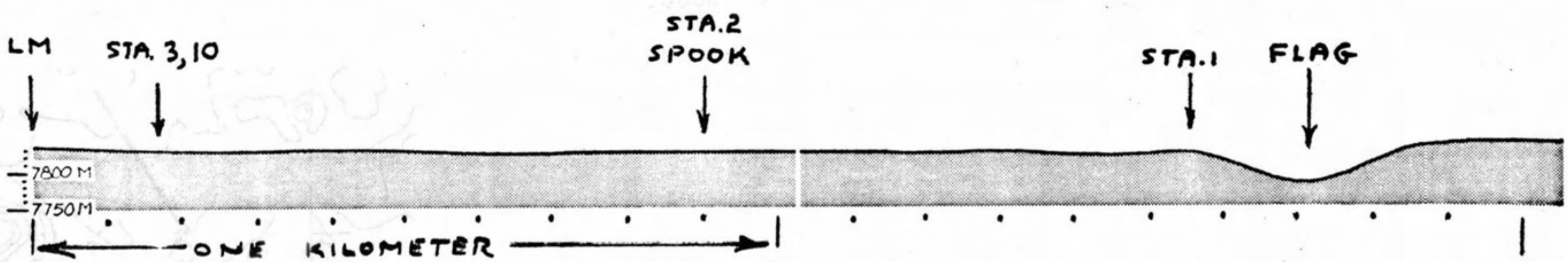


ALSEP - Station 1

- Small escarpment to climb at north edge of Spook
- Boulders in Buster region
- Large escarpment to climb between Halfway and Flag

VIEW LOOKING WEST FROM LM LOCATION





TRAVERSE

LM TO STATION 1

STATION:

STATION 1 - FLAG CRATER (:43)

CDR	OVER-HEAD		DESCRIP-TION	RAKE/SOIL SAMPLE	SAMPLING*	O/H
	:03		:03	:08	:27	:02
LMP	O/H	PAN	DESCRIP-TION	RAKE/SOIL SAMPLE	SAMPLING	O/H

CUFF-CHECK LIST

TASKS

LOOK FOR:
- Rays from south ray | 99/0.8
- NE scarp on Spook rim
- Boulders at Buster
- NE scarp 95/1.4

STATION 1

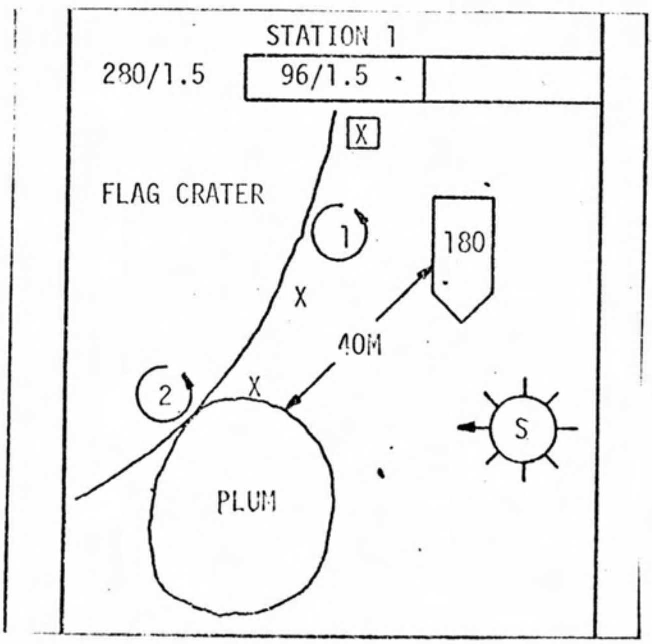
FLAG CRATER (PLUM) :43

CDR	LMP
MODE SW-2	DISPLAYS
HGA	PAN 1
DUST	

3: DESCRIPT
8:PAN 2 RAKE/SOIL
27: SAMPLING
(Flag ejecta-PLUM)
FRAME COUNT
MODE SW-1
POS TV HORIZ, CCW

CUFF-CHECK LIST

DRAWING

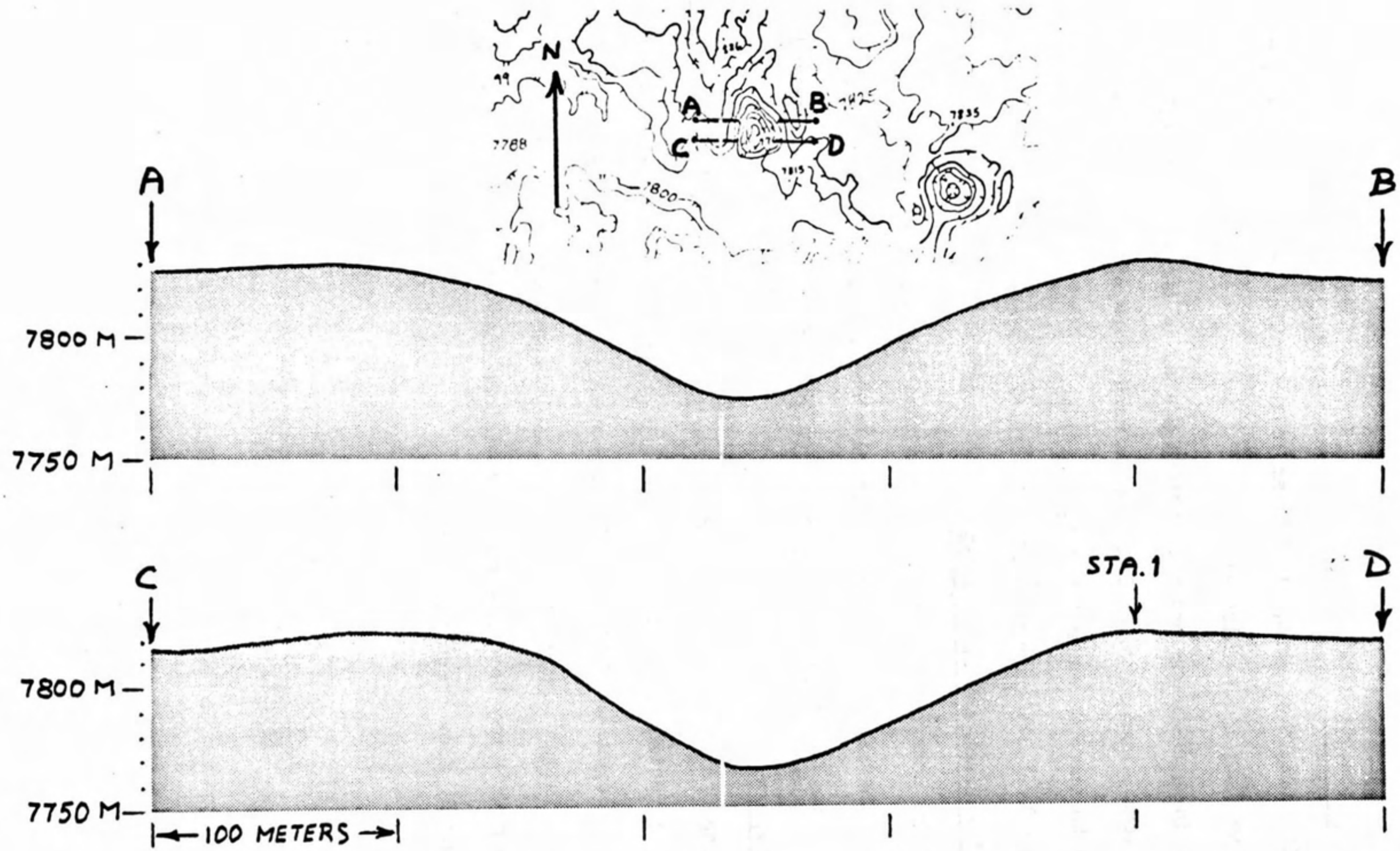


FLAG CRATER

280 m diameter

~50 m deep

- Plum crater (40 m diameter), at about 4 o'clock on the rim, is best bet to sample ejecta from Flag
- South Ray crater material is visible on photo to east. Note patterns of blocks, secondary craters, angularity of blocks, and sizes of fragments to distinguish between Plum, South Ray, and Flag crater primary ejecta. South Ray material appears to be youngest, therefore may be most angular and impact features from it will be superposed on all other craters the size of Plum or larger. Leave it there and concentrate on other material. Ray material may be mostly small rocks which made interlocking small craters.



SECTIONS
FLAG CRATER

1-1

Station 1 - Tasks

O Radial sample of Plum, should sample the entire sequence preserved in the Flag ejecta blanket

O Done in approximate order of priority - as is the case for all stations - except where 1 man tasks need to be paired or those tied to the LRV are related to save time

O Park LRV at 180°on rim of Flag Crater (TV coverage)

Pan 1 - Black and white - LMP:

To be done on Flag crater rim so that view of interior can be obtained as well as the potential/probable sampling area between the LRV and Plum Crater rim can be observed before being tracked

Description:

Flag Crater - We expect a regolith mantle. If bench (es) visible - be surprised - represent probable regolith thickness or discrete flow layers at depth. If benches easily identifiable will give the minimum number of rock units to be expected from Plum ejecta. Each unit may have several subdivisions however; example, vesicular, banded, flow brecciated, etc.

Plum Crater - if benched, means has penetrated to Cayley. Important point because means all layers in ejecta blanket from Flag will have been thrown to surface in Plum event; i.e., this would be ideal case.

Ray patches - best described when (and if) observed (or even during LRV traverse) - blockiness, general appearance, "gardening"

Rake-soil sample:

- To be taken off of Plum ejecta to maximize
  - (1) foreign components
  - (2) collect deepest material from Flag
- To be taken on Flag Crater rim

Pan 2 - (Color)

- To be taken from common rim of Plum and Flag crater so that the interiors of both can be studied

1-3

Sampling -

- Start on Plum Crater rim
- Then 1/2 D out
- Will give partial radial sample
- If time permits sample at 1 D
- At each station collect variety of rocks identifiable plus scoop of soil

Station 1 - Station 2

- Stone and Smoky Mountains observations: preparatory to 500 mm photos at station 2
- Escarpments, etc., will have totally opposite sun angle on return leg and will thus appear different. Might make a set of new observations or features visible in this orientation
- Sun angle will be low and visibility might be poor

STATION:

STATION 2 - SPOOK CRATER (:56)

CDR	O/H		DESC.	LPM SITE MEAS.			SAMPLING*	O/H
		:03	:03	:05	:11	:02	:30	:02
LMP	O/H	PAN	DESC.	500mm PHOTOS	SAMPLING	PAN	SAMPLING	O/H

CUFF-CHECK LIST

TASKS

```
STATION 2
            SPOOK CRATER :56

    CDR                     LMP
    MODE SW-2               DISPLAYS
    HGA                     PAN 1
    DUST
 3:          DESCRIPT
         (Note ray patterns)
18: LPM SITE                500 Stone30
         (Sensor posi-      SAMPLING
          tion 1,2,3)       (Buster
             SAMPLING        PAN 2)
30:
              (Spook)

             FRAME COUNT
    MODE SW-1
    POS TV HORIZ, CCW
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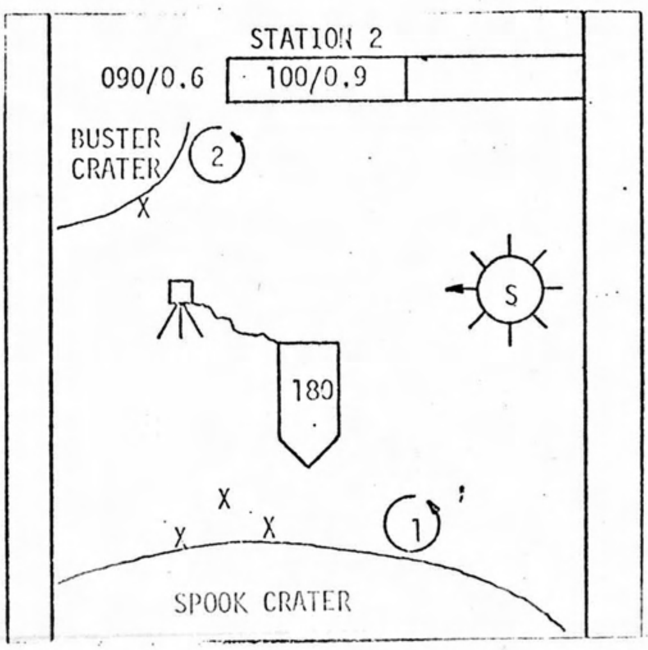
CUFF-CHECK LIST

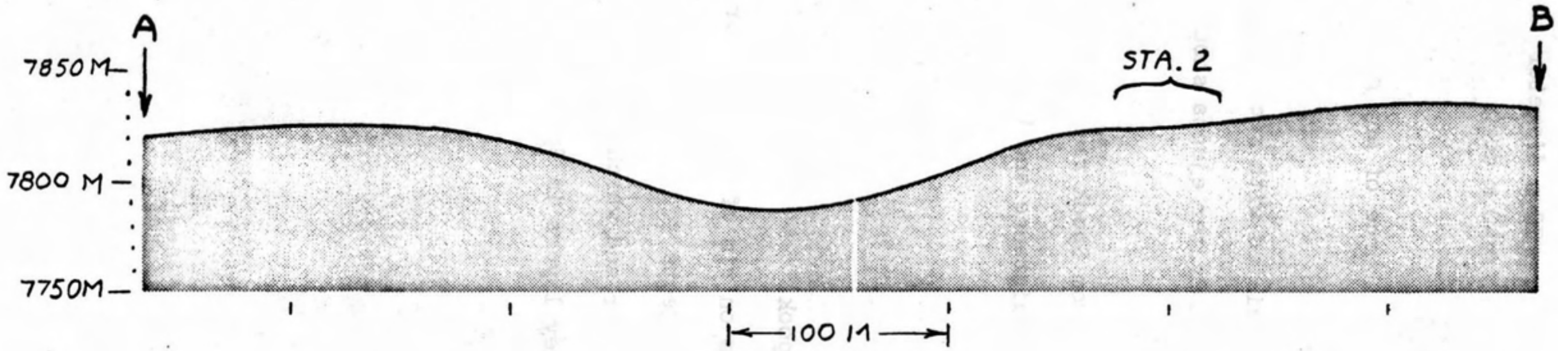
DRAWING

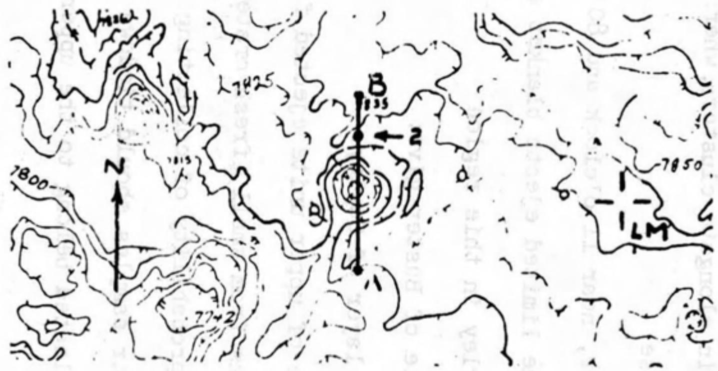


Spook Crater - Station 2

370 m diameter
~40 m deep

- Ray material from South Ray crater abundant
- Therefore be difficult to be certain as to the source of any given sample
- South Ray blocks should be more angular, associated with secondary craters and in elongate clusters, whereas Spook Crater ejecta should be the reverse
- Buster Crater, near 11 o'clock and 80-100 m from Spook rim should penetrate the limited ejecta blanket at that distance and the top layer of Cayley in this region
    - Rim sample of Buster give:
        (1) Top layer of Cayley
        (2) Some of upper units ejected from Spook
- Sample blocks from small, fresh crater rims on rim of Spook Crater to enhance probability of collecting Spook ejecta
- Buster crater samples should tiedown top layer and which of other samples collected belong to the upper Cayley layers in Spook





SECTION
SPOOK CRATER

1-1

Station 2 - Tasks

- Park LRV at 180 on Spook rim for view into Spook

Pan 1 - (Black and white)

- Take on rim of Spook. Will give view of Spook interior and area to Buster that will be sampled

Description:

- Spook - should be regolith-covered, non-benched crater
- Buster - should be blocky with blocky floor. If so, means has penetrated to Cayley
- Ray patterns - Need to identify so that it can be avoided where possible so that most samples will be Spook ejecta. Patterns of boulders, craters, lighter material
- Stone Mountain - Part of 500 mm photography

500 mm Photographs

- Stone Mountain - 30 photographs: Make a complete panorama of visible part, photographs centered on mountain will cover all of it

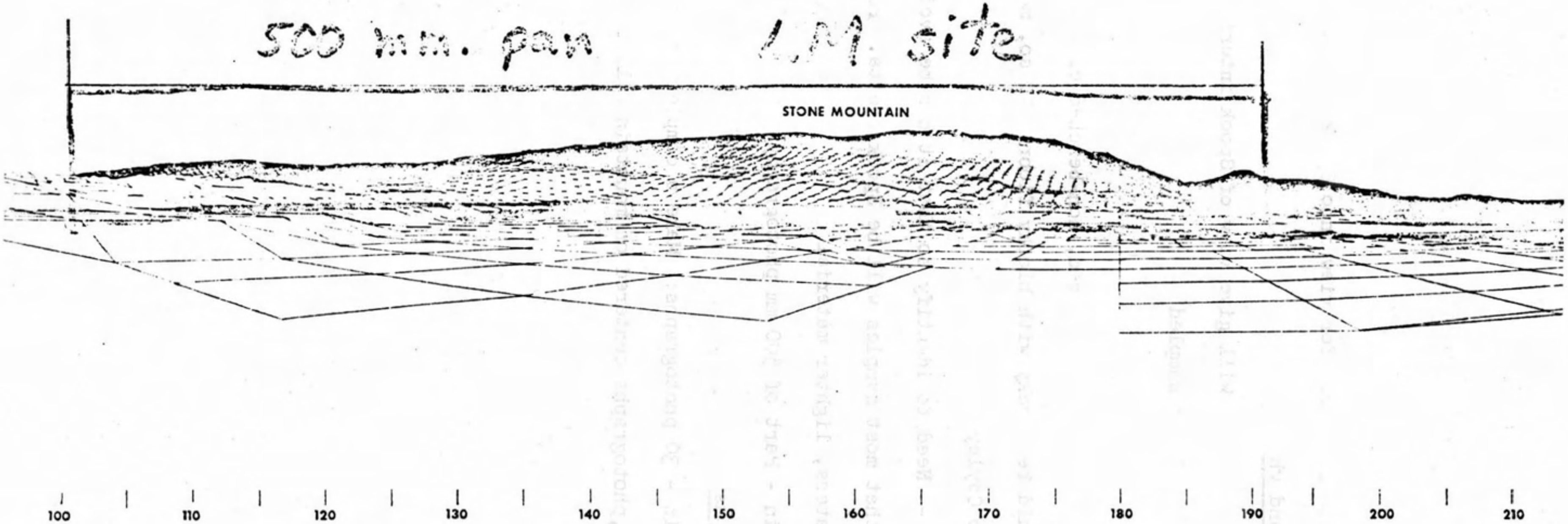


FIGURE 1 - VIEW FROM LANDING SITE

1-2

- Is one leg of stereoscopic coverage - other to be taken at LM during closeout; lineations might be visible on stripe of the mountain
- How many benches are recognizable? Gives clues as to number of stratigraphic divisions and how (where) to explore on EVA 2

LMP site measurement:

- Basic measurement needed to calibrate instrument
- In comparison with LSM, should give an estimate of the anomaly produced by Spook Crater
- Be useful then for prediction as to probable values to be obtained on the Palmetto Crater study at stations 15, 16, 17

Sampling:

- One man sampling - while LMP measurement is being taken: go to Buster crater rim for block samples and photo pan of interior. These samples should characterize top layer of Cayley in the area and thus be important for sorting samples from Flag and Spook and determining lateral continuity of units.

1-3

- Two man sampling should concentrate on fresh crater rims along Spook rim to maximize return from Spook crater
- A few samples from identifiable South Ray secondary craters should be collected to

  (1) give age of South Ray

  (2) A minimum sample of South Ray if station 8 cannot be occupied

<u>Possible operation:</u>

- Exploratory trench - If ray material is a blanket, this might give thickness. Samples from both ray and underlying soil would be extremely valuable to characterize a ray, what it is, when it was derived, history of buried regolith

STATION:

STATION 3 - ALSEP/LM AREA (:14)

CDR	O/H	GRAND PRIX	ARM MP RETRIEVE 2.6m CORE
	:01	:08	:05
LMP	O/H	GRAND PRIX	ARM MP RETRIEVE 2.6m CORE

CUFF-CHECK LIST

TASKS

STATION 3
BACK AT ALSEP :14

GRAND PRIX
Drop off LMP w/DAC

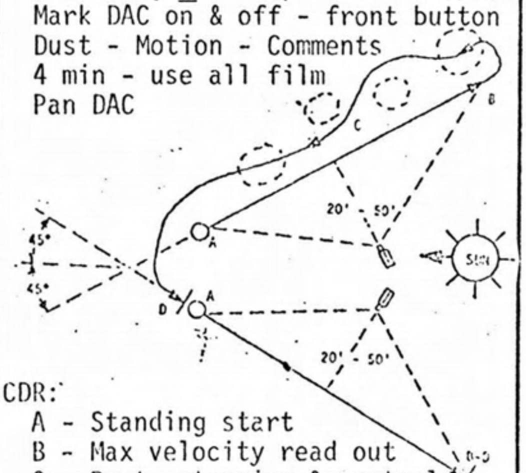
CDR	LMP
8: GRAND PRIX	
5: ARM M/P SW 5-CCW	PICK UP STEM STRINGS

BACK TO LM FOR CLOSE

CUFF-CHECK LIST

DRAWING

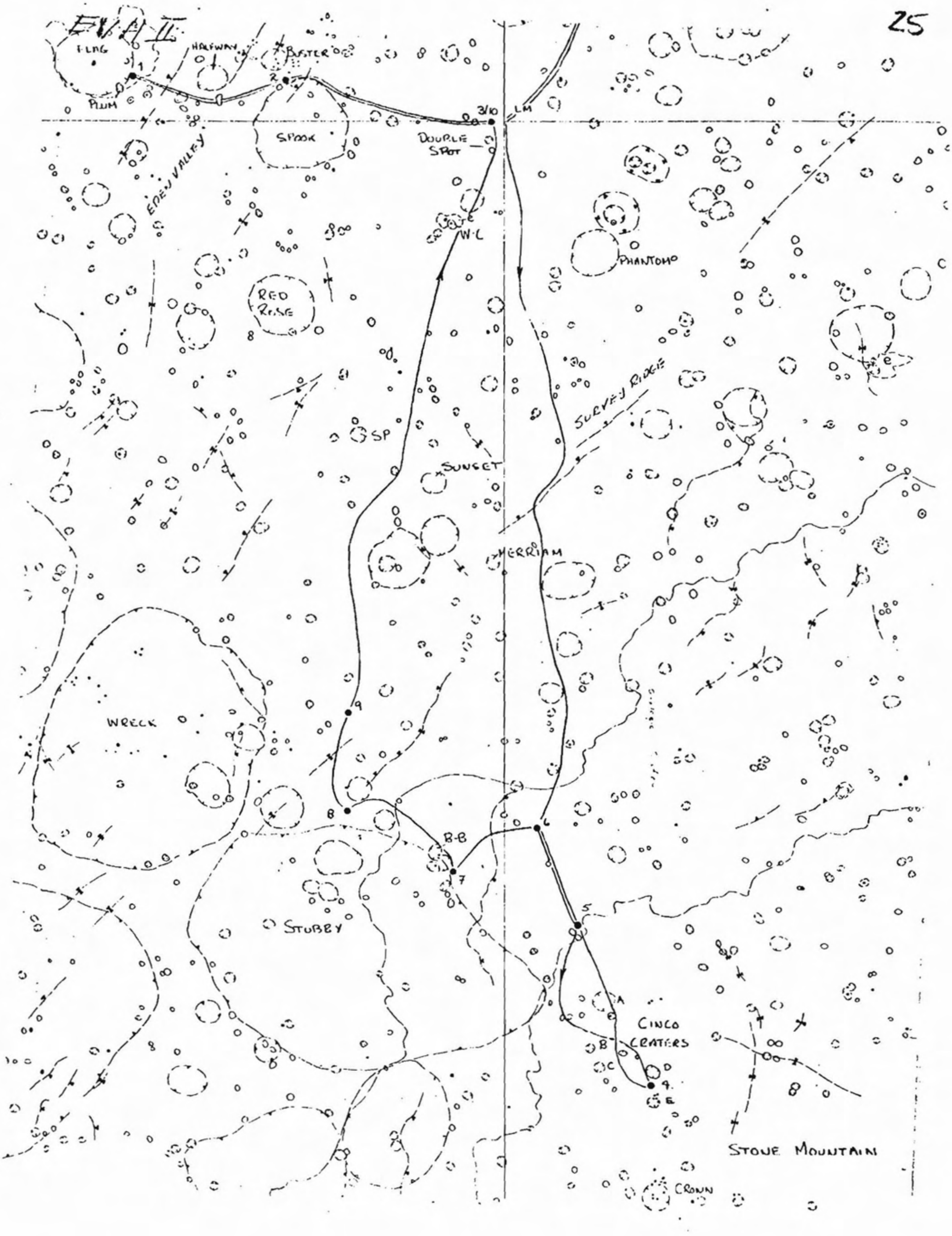
LMP:
DAC - Mag _ - 24fps - f:8 - 1/250
Mark DAC on & off - front button
Dust - Motion - Comments
4 min - use all film
Pan DAC



CDR:
A - Standing start
B - Max velocity read out
C - Dust, steering & control - Comments
D - Braking comments

Station 3 - ALSEP Area

- Grand Prix (Don't dust the ALSEP)
- Arm mortar package on ASE
- Pickup drill stems and go to LM
- This station will be reoccupied at end of EVA 2 to do a series of tests and sampling for regolith analysis


EVA II
FLAG
1
HALFWAY
BUSTER
2
PLUM
SPOOK
3/10
LM
DOUBLE SPOT
EDEN VALLEY
W.C
PHANTOM
RED ROSE
SURVEY RIDGE
SP
SUNSET
MERRIAM
WRECK
9
8
B-B
7
6
5
STUBBY
A
B
C
D
E
4
CINCO CRATERS
STONE MOUNTAIN
CROWN

EXPLORATION OF STONE MOUNTAIN

Importance: Only accessible part of a physically continuous unit of Descartes materials that extends for over 100 km to the south and 60 km to the east.

DESCARTES MATERIALS
(Adapted from 1:5M Geologic Map of Moon)

Topographic form: Aggregates of closely spaced subdued hills and ridges 3 to 15 km long and 2 to 6 km wide capped by distinctive sinuous furrows. Hills mostly steep, with short furrows. Brighter and topographically sharper examples (therefore younger) occur about 30-40 km south of Stone Mountain.

Geologic interpretation: Mixed volcanic deposits erupted from fissures. Includes pyroclastic or composite cones in densely packed arrays.

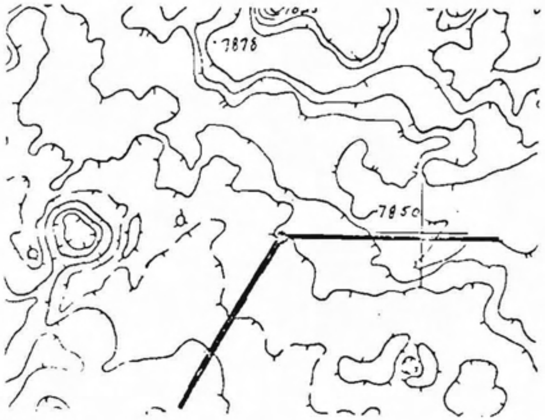
STONE MOUNTAIN

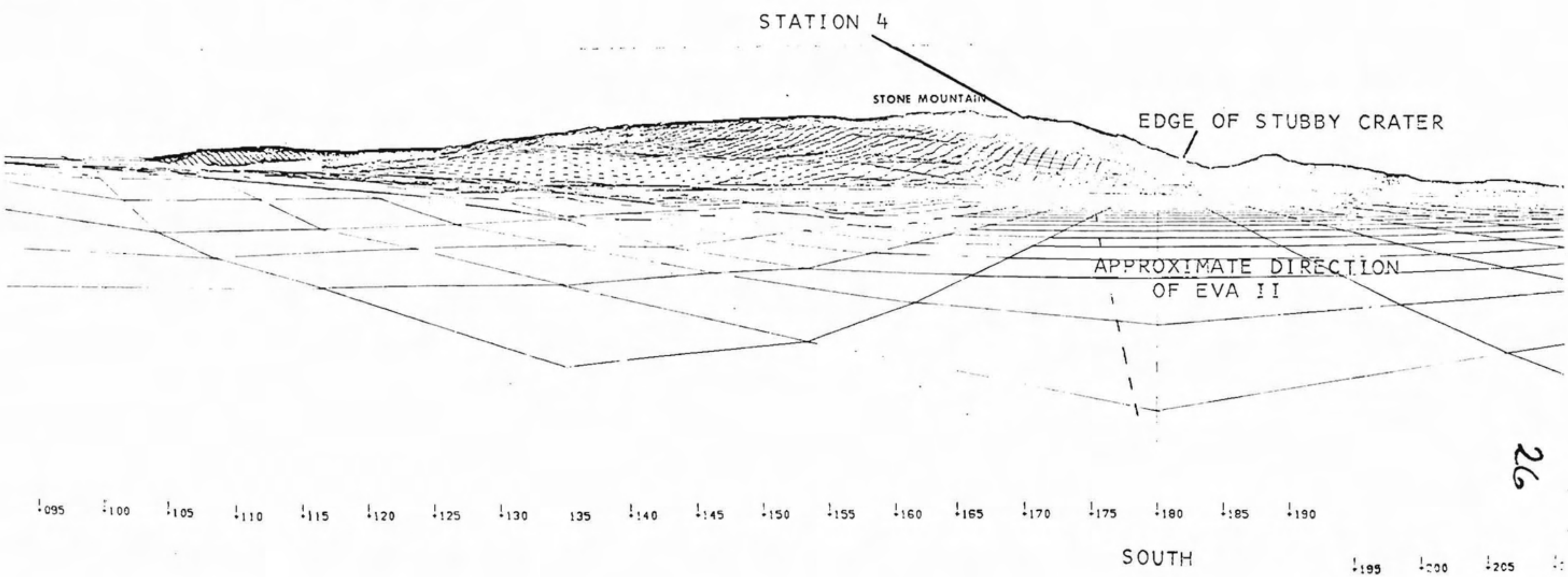
Topographic form: Rounded, nearly flat-topped ridges.
North faces - crudely terraced with steep segments ranging from 40-80 m each.
West faces - nearly continuous steep slopes with very narrow to non-existent terraces.
Above 8050 contour - many 10-20 m escarpments with narrow to broad benches.
Mountain capped with elongate hills, 2 out of 3 with crater near summit.

Geologic interpretation: Superposed pile of volcanic rocks. Individual flows averaging 10-20 m in thickness. Ridge tops might be the volcanic vents - examples: two craters at crest of Stone Mountain itself.
Zone of "paired" contours (band of topography along the north and northwest face of Stone Mountain between 8050 and 8150 m) probably represent flow fronts.
Alternate explanation: break away scars of multiple landslide entities. If slides then are probably controlled by bedrock units because of the topographic continuity of the zone.

West-facing (north-trending) steep escarpments might be faulted.

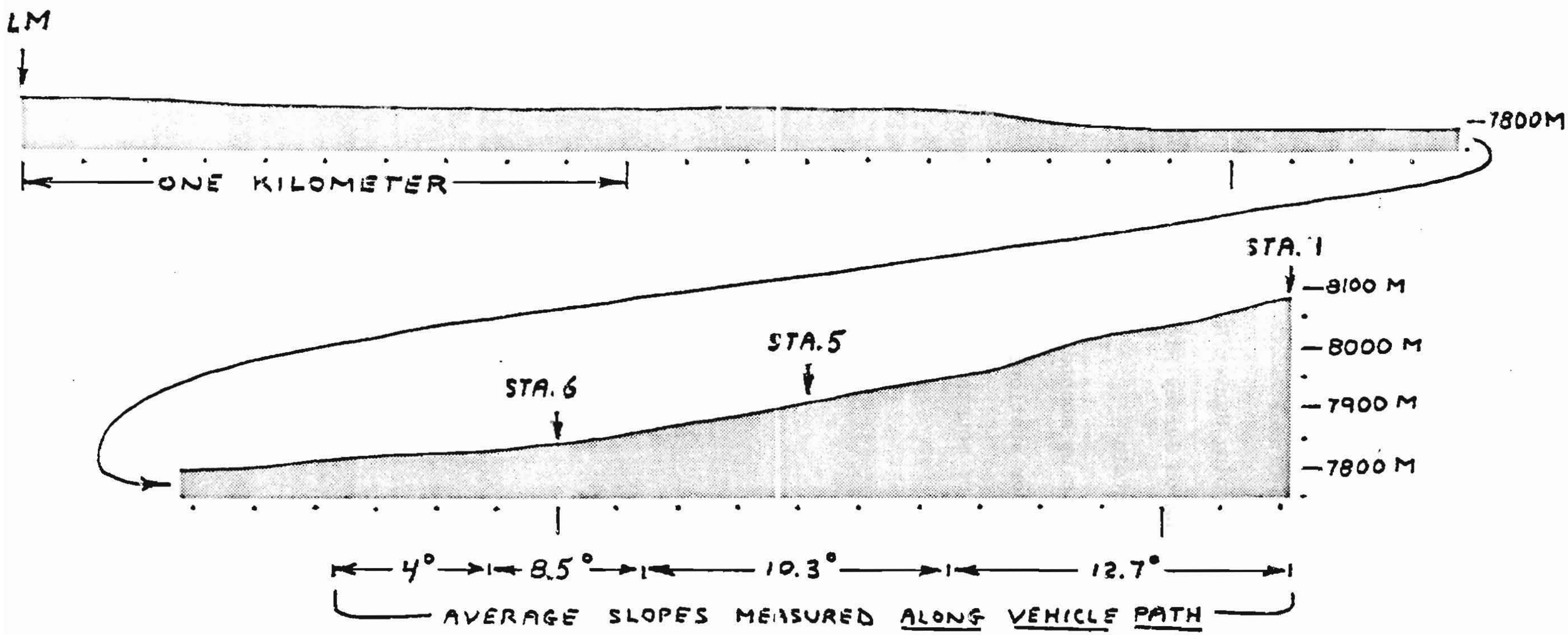
VIEW LOOKING SOUTHEAST FROM LM LOCATION





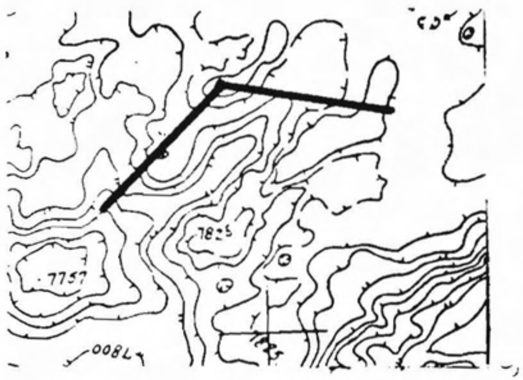
EVA II - Traverse LM - Stone Mountain

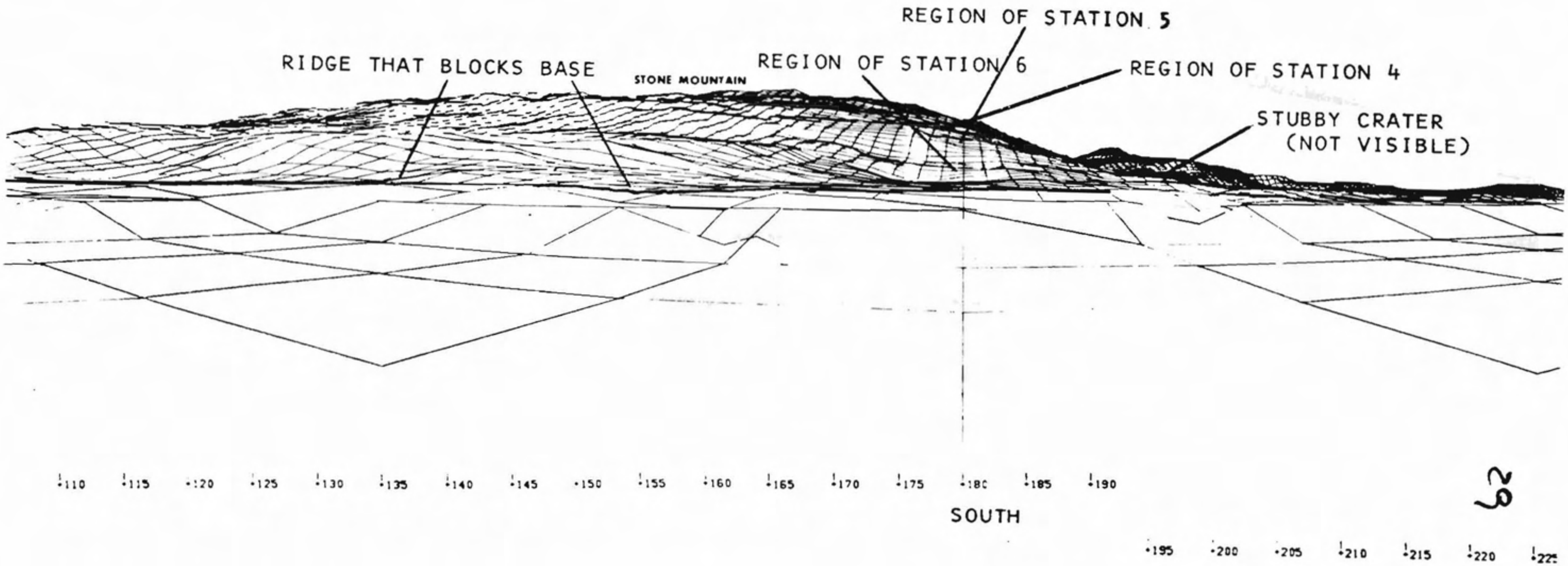
- Lineations on Stone Mountain
- Low mound NE of Phantom Crater
- Major South Ray ray capping Survey Ridge
- Change to 227° heading on Survey Ridge to make an end run on 30 m scarp
- Good view of Stone Mountain
    - Assess traverse route up mountain
    - Possible locations for stations 4 and 5
- Break in slope at base of mountain might not be easy to spot



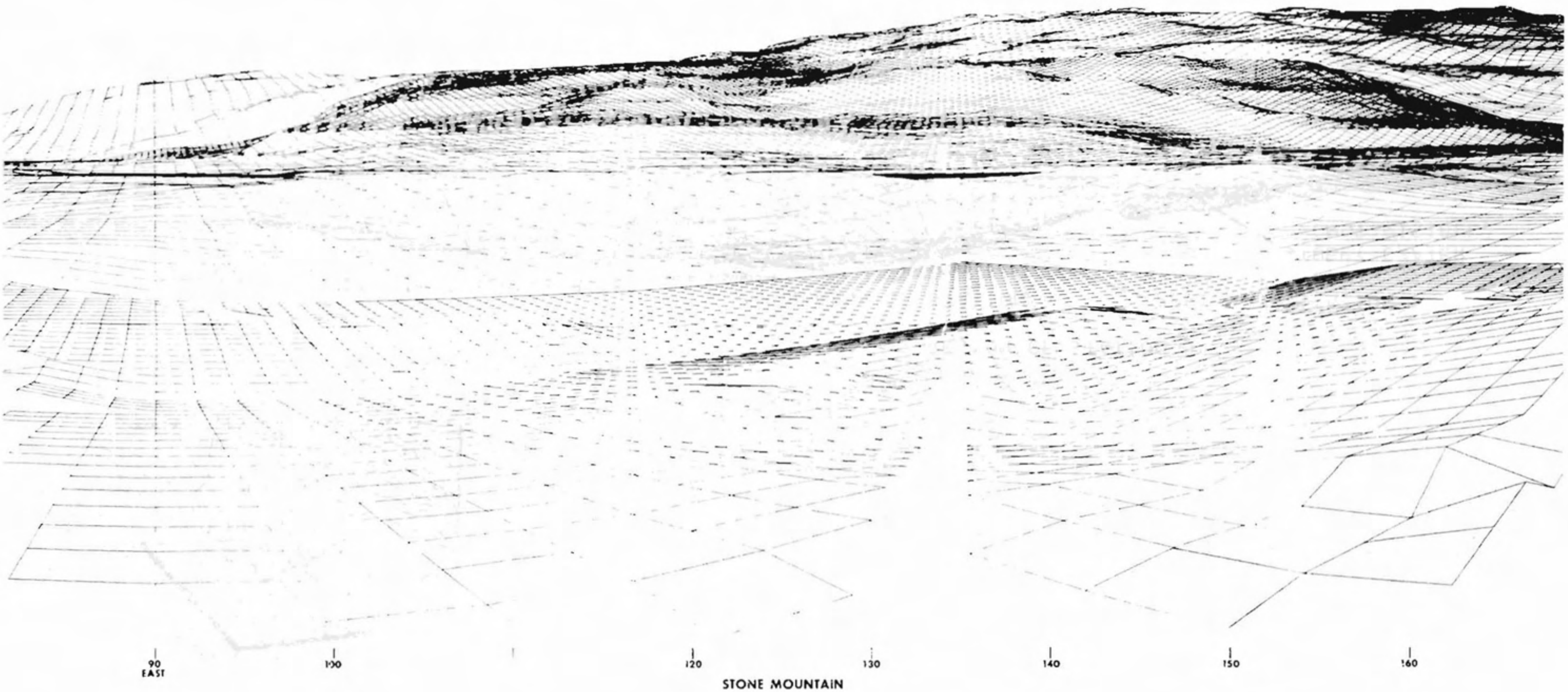
TRAVERSE
LM TO STATION 4

OUTBOUND TRAVERSE LEG (EVA II)
WHERE BASE OF STONE MOUNTAIN
IS NOT VISIBLE





VIEW JUST PAST SURVEY RIDGE



Stone Mountain

512 m high

- North facing slope is crudely terraced
  - Probably result of volcanic layering
- Outcrops possible on steepest terrace edges
  - Sample, if observed and can be reached
- Stations 4 and 5 should be on separate benches - if accessible. Each bench should be the break between major volcanic units (at least geo-morphic unit)
- In general, find blockiest crater or outcrop you can find; and to go it
  - Park on contour with it and sample along contour

Possible surprises:

- Can't find crater - use blocky area
- No blocks - use rake
- Fantastic variety of rocks - get one each-if time gets short, use rake
- Driving is easy, may want to go to Crown

STATION:

STATION 4 - STONE MOUNTAIN (:58)

CDR	O/H	DESC	RAKE/SOIL SAMPLE	SAMPLING	PAN	DOUBLE CORE	SAMPLING		O/H
	:03	:05	:08	:06	:02	:08	:22	:02	:02
LMP	O/H & DESC	500 mm	RAKE/SOIL SAMPLE	PENETROMETER MEASUREMENTS		DOUBLE CORE	SAMPLING	PAN	O/H

CUFF-CHECK LIST

TASKS

```
LOOK FOR:
•Scarp at survey; DES/CAY contact
STATION 4   A BLOCKY CRATER :58
(>40 M)          DAC OFF
  CDR            LMP
  MODE SW-2      DISPLAYS
  HGA            500•Trap/Stubby-15
  DUST              •Smoky-15
                    •S.Ray/B.Ray-5
 3:     DESCRIPT
 8:     RAKE/SOIL
 8:SAMPLING      PENETROMETER
  PAN 1 (after penetrations)
 8:     DOUBLE CORE
24:     SAMPLING PAN 2
  (Padded bags-2 rocks-dense,
    hard, igneous)
        FRAME COUNT
  MODE SW-1      CHANGE DAC; MAG-R
  POS TV HORIZ, CCW
DAC ON; f8/250/1fps
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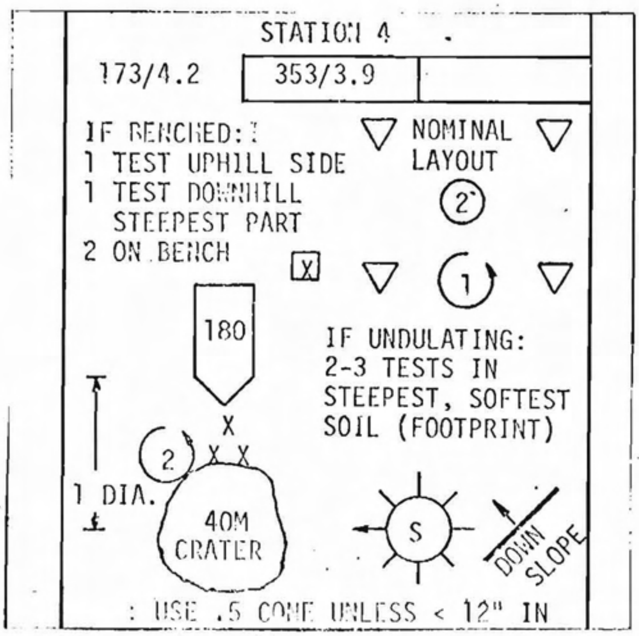
CUFF-CHECK LIST

DRAWING



Station 4 - Highest point reached on Stone Mountain

- Proposed stop between Cinco D and E (biased toward E)
- 500 mm photographs
  - One leg of stereo base to Smoky Mountain - 15
  - Views into Trap/Stubby - 15

    South Ray/Baby Ray - 5
  - Targets of opportunity
    - To ranges to E and NE of landing site = lineaments?

Description:

- Regolith appearance: "softness", slump/slope shapes
- Crater rims = blockiness = very blocky has penetrated to underlying Descartes
- Distant objects -
  - Smoky Mountains - lineations, terraces
  - Stubby interior - prevue to station 7
  - Ray patterns - prevue to station 8
  - South Ray - jagged apperance on photographs

Rake/Soil - between craters and off ejecta blankets - should characterize the materials from higher upslope on Stone Mountain - as well as foreign materials

- Penetrometer readings used to give idea of ease of double core penetration
- Sampling
  - Rocks from blockiest crater
  - Soil and rocks (minicomp) in radial sampling mode
  - Collect a large quantity of material - this is the "purest" Descartes material that will be obtained

- Should avoid areas affected by "recent" cratering events
- Pan 1 taken to show penetrometer holes and if possible with double core in ground

Double Core

- Centered within penetrometer readings -- provided they have gone fairly deep
- If depth of penetrometer was asymmetrical bias core toward deepest penetrometer reading(s)

Pan 2 - to be taken from rim of fresh crater that is to be sampled radially from rim outward (within time available)

Padded Bags

- Proposed to use here because
  - most remote from LM
  - first good chance to use the bags
  - Want dense (non-vesicular), hard, igneous rocks
- Close tightly on sample

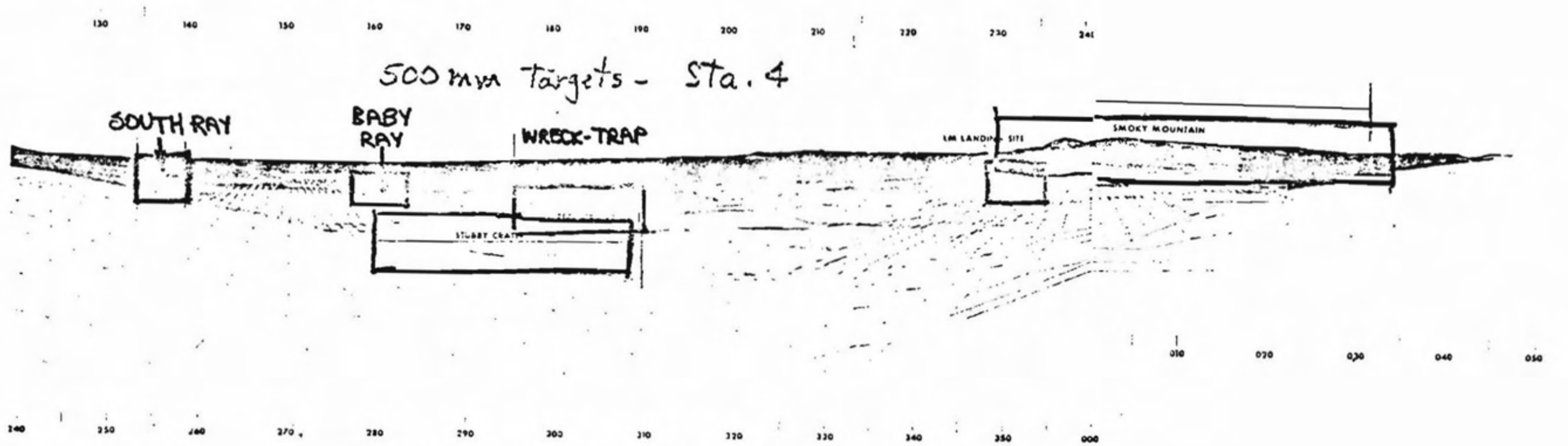
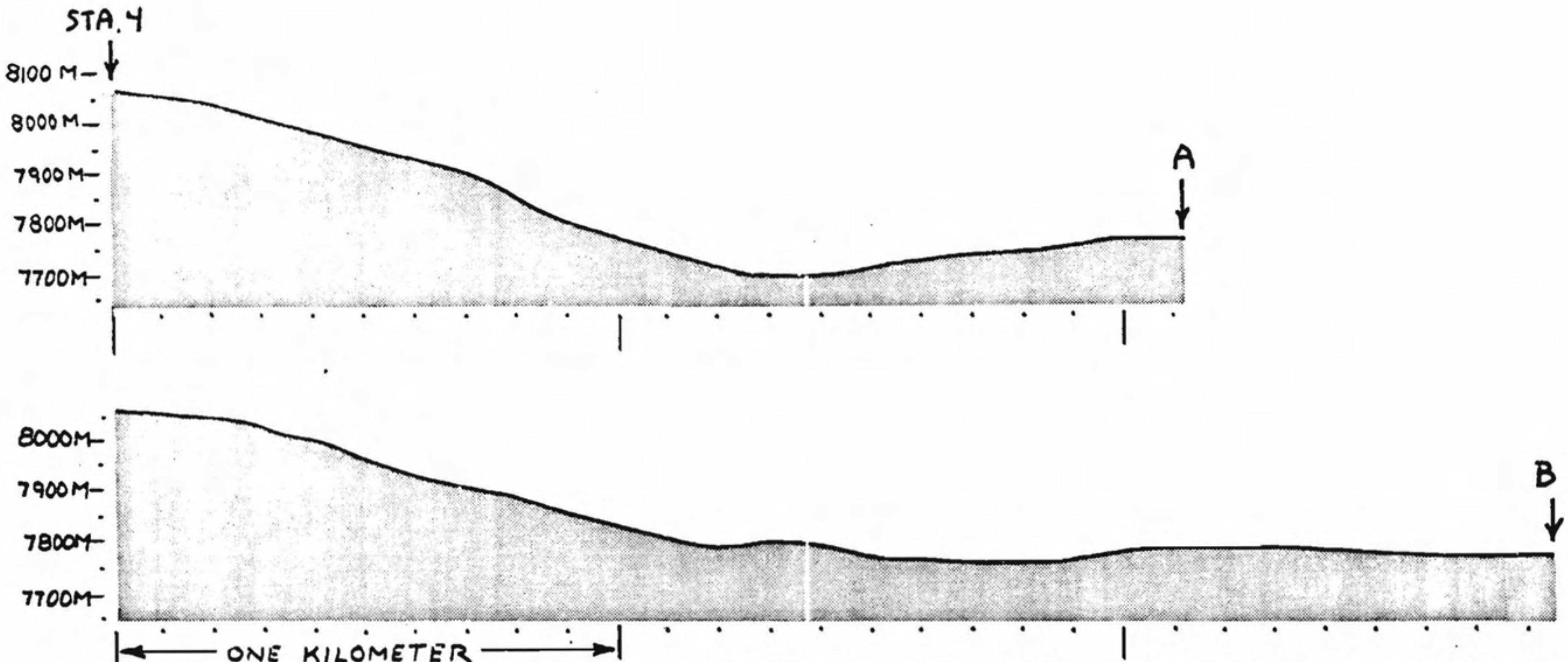
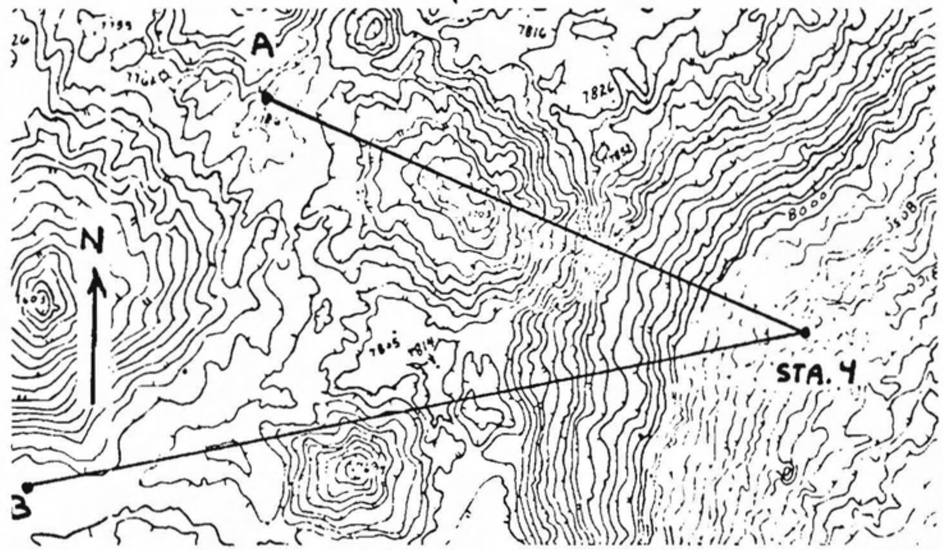
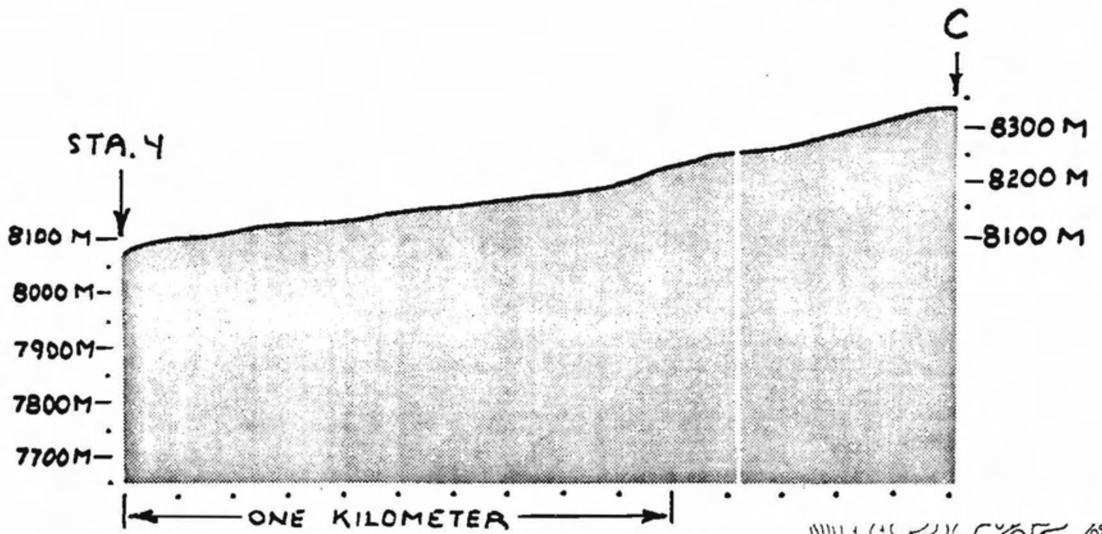


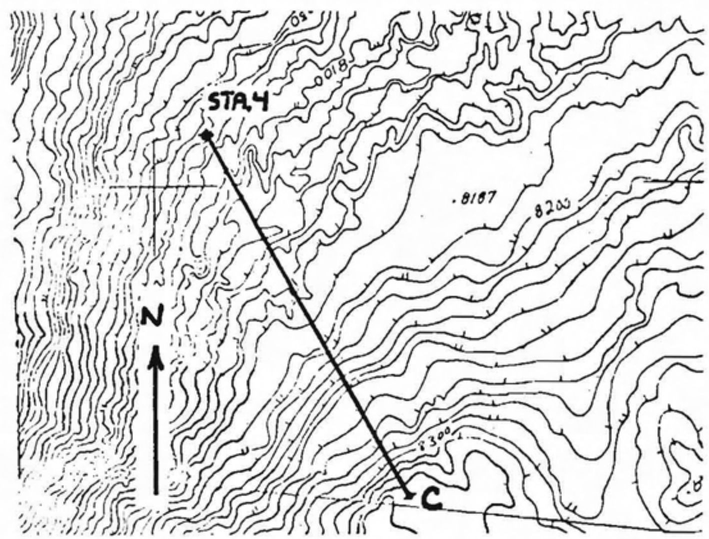
FIGURE 2 - VIEW FROM THE SIDE OF STONE MOUNTAIN (STATION 4





SECTIONS
FROM STATION 4

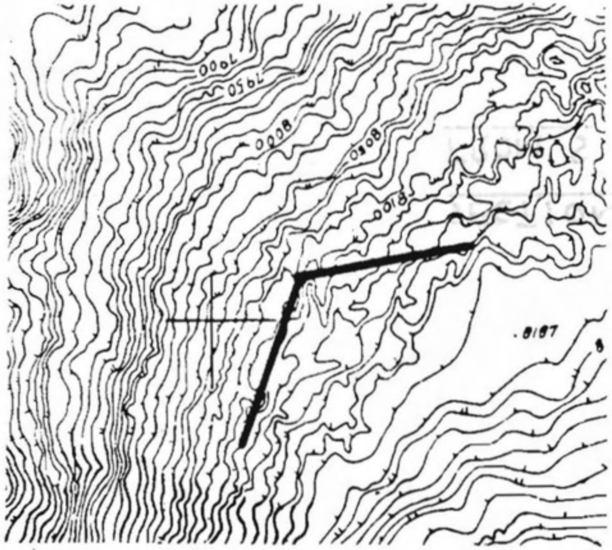


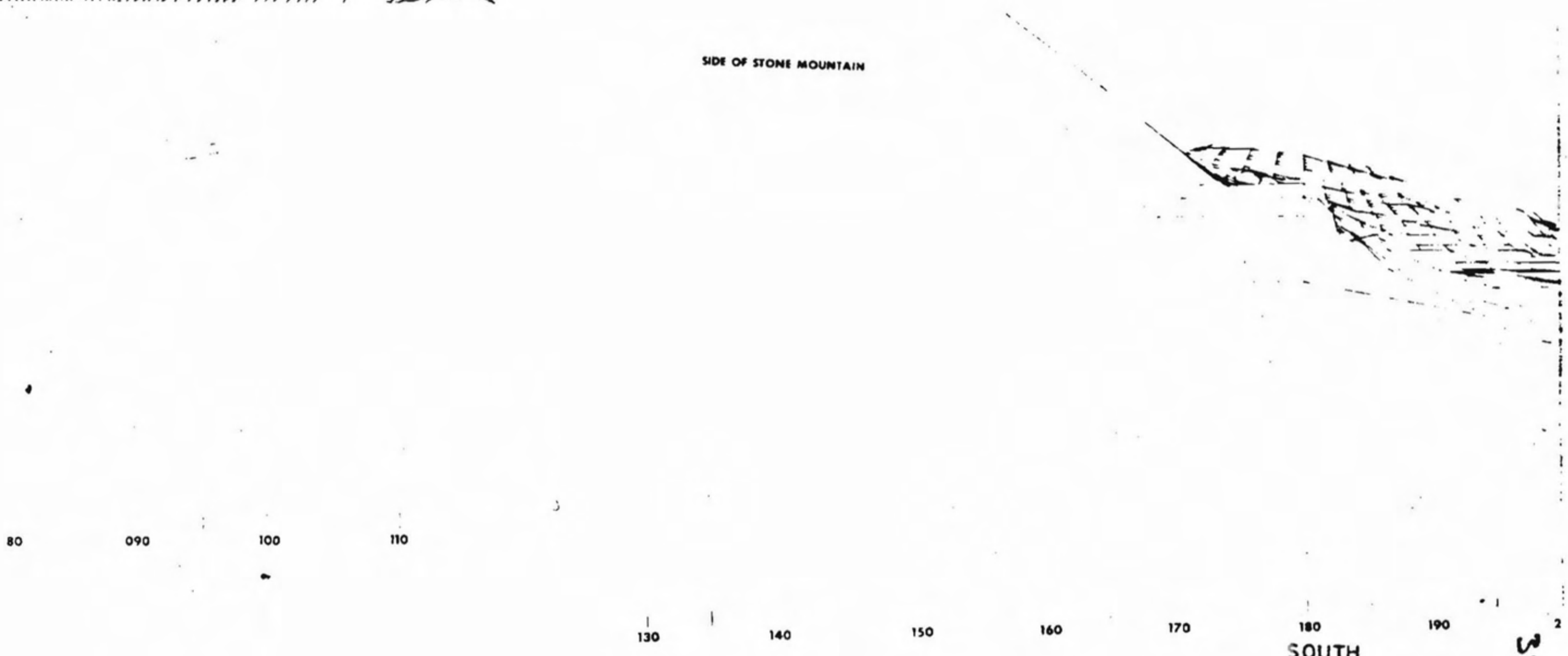


SECTION

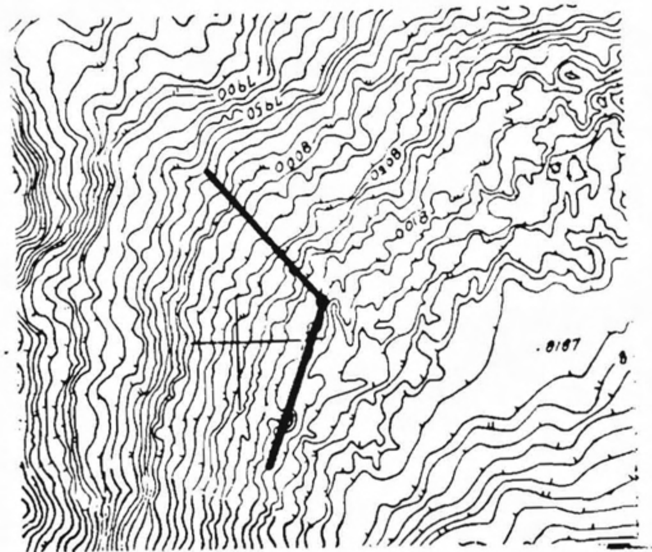
FROM STATION 4

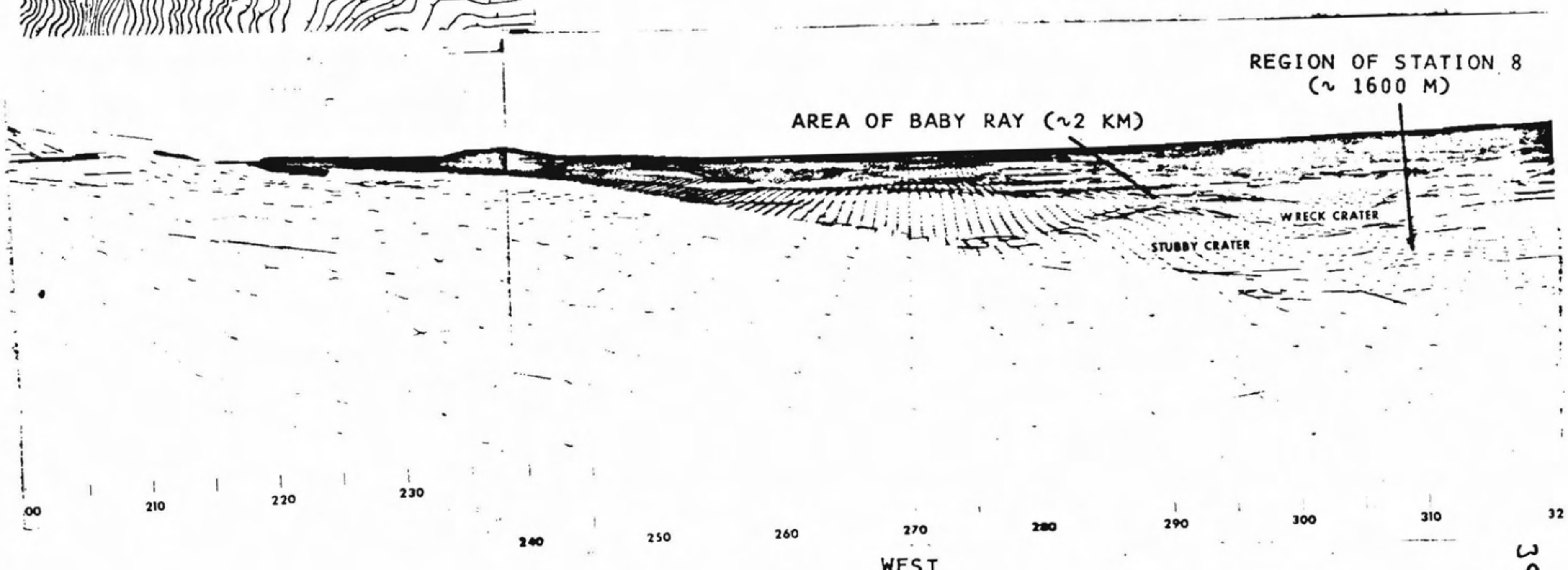
VIEW LOOK'NG SOUTH' 'ST FROM STAT'ON 4



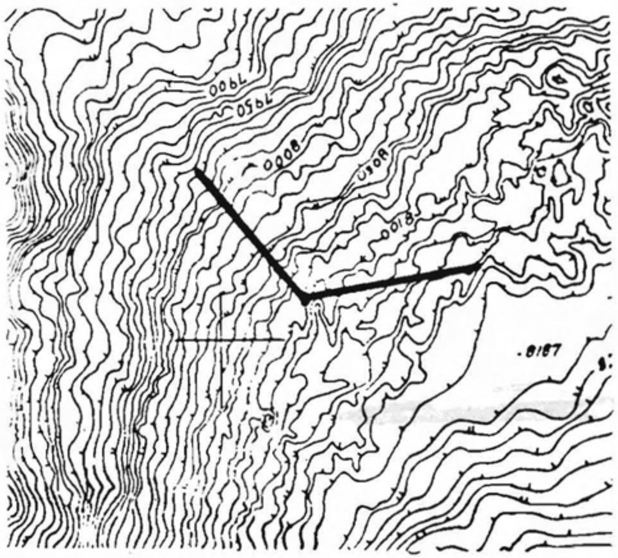


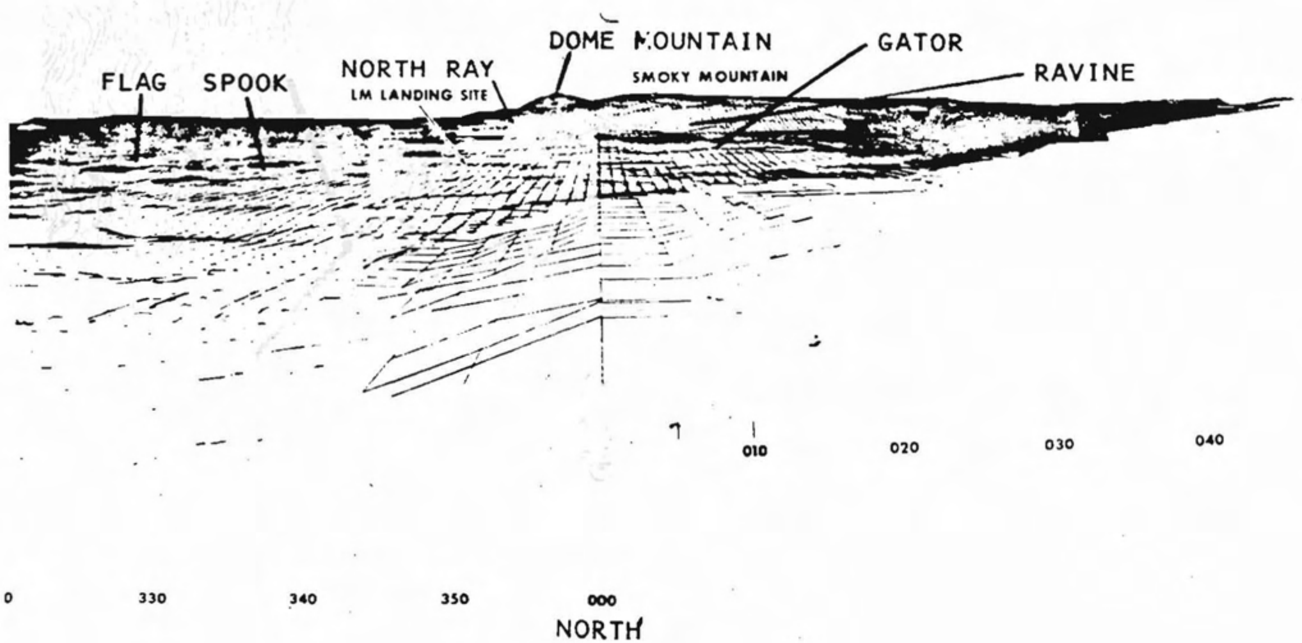
VIEW LOOKING WEST FROM
STATION 4



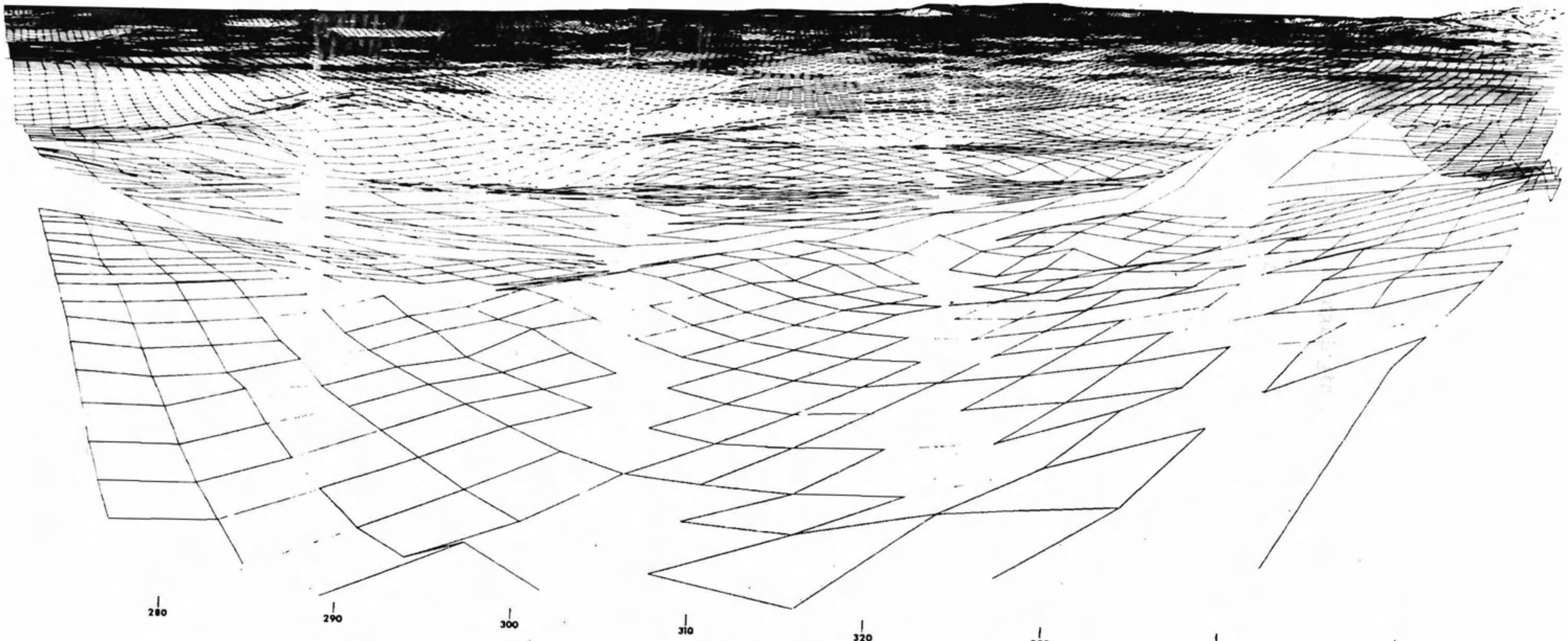


VIEW LOOKING NORTH FROM
STATION 4





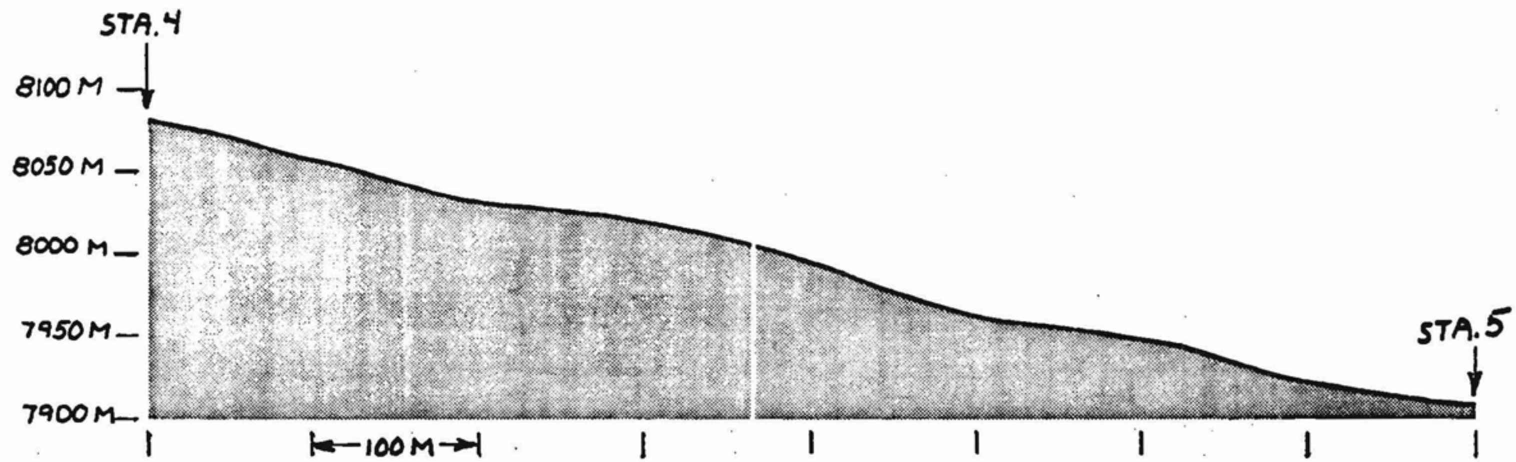
4G



VIEW FROM STATION 4

Travel Station 4 - Station 5

- Travel in opposite direction
- Different sun angle might highlight features not observed while driving up



AVERAGE SLOPE IS 12.7 DEGREES ALONG VEHICLE PATH

TRAVERSE

STA. 4 TO STA. 5

STATION:

STATION 5 - STONE MOUNTAIN (:40)

CDR	O/H		DESCRIPTION AND SAMPLING *	O/H
	:03		:35	:02
LMP	O/H	PAN	DESCRIPTION AND SAMPLING	O/H

CUFF-CHECK LIST

TASKS

STATION 5

STONE MOUNTAIN :40

331/0.8 | 358/3.3 |

LRV=180°

DAC OFF

CDR

MODE SW-2

HGA

DUST

LMP

DISPLAYS

PAN

35: SAMPLING

Observe terraces & bedrock/regolith changes at contact

FRAME COUNT

MODE SW-1

POS TV HORIZ, CCW

DAC ON

f8/250/1fps

CUFF-CHECK LIST

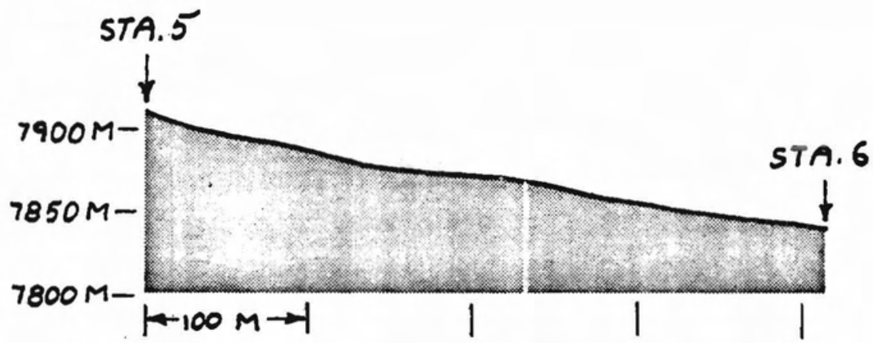
DRAWING

Stop 5

- Stop at major break in slope
  - Top of lower geomorphic unit
- Stop at blocky rimmed crater, if possible
- Pan - should show sampling area (optional pan of sample area at end)
  - If blocky crater
    - Documented sampling of variety of rocks
    - Large soil scoop
  - If bedrock ledge
    - Samples
    - Closeup stereo photographs
    - Flight line stereo photographs
  - If only regolith
    - Collect blocks
    - Rake/soil
    - Photographs of lineations
  - Photograph targets of opportunity
    - Outcrop bands
    - Lineations in regolith
    - 500 mm on distant features not previously identified (not too likely)

Travel Station 5 - Station 6

- Same as for last leg
- Locate probable base of slope for station 6



AVERAGE SLOPE IS 9.6 DEGREES
ALONG VEHICLE PATH

TRAVERSE
STA. 5 TO STA. 6

STATION:

STATION 6 - BASE OF STONE MOUNTAIN (:20)

CDR	O/H		DESCRIPTION AND SAMPLING	O/H
	:03		:15	:02
LMP	O/H	PAN	DESCRIPTION AND SAMPLING	O/H

CUFF-CHECK LIST

TASKS

STATION 6
FOOT OF STONE MT. :20

341/0.4 | 360/2.9

LRV=180°
DAC OFF

CDR
MODE SW-2
HGA
DUST

LMP
DISPLAYS
PAN

15: SAMPLING
FRAME COUNT

MODE SW-1
POS TV HORIZ, CCW

DAC ON
f8/250/1fps

CUFF-CHECK LIST

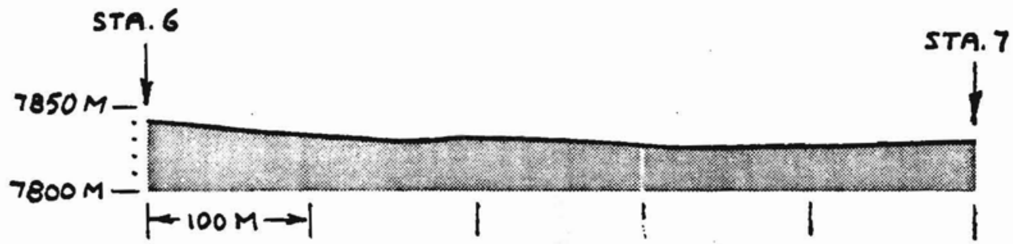
DRAWING

Station 6

- Base of Descartes units = Stone Mountain
- Pan should document break in slope, if one is visible
- Collect samples of
  - Downhill accumulation
  - Cayley for contrast
- Appearance of regolith surface on both types of units

Travel Station 6 - Station 7

- Ridges and craters to avoid
- Escarpment to go down
- Go around set of 60-100 m craters that flank B-B



TRAVERSE

STA. 6 TO STA. 7

STATION:

STATION 7 - STUBBY CRATER (:15)

CDR	O/H		DESCRIPTION	SAMPLING	O/H
	:03		:03	:07	:02
LMP	O/H	PAN	500mm PHOTOS	SAMPLING	O/H

CUFF-CHECK LIST

TASKS

LOOK FOR:
●N scarp | 001/2.9 |
STATION 7
NEAR STUBBY :15

CDR	DAC OFF LMP
MODE SW-2	DISPLAYS
HGA	PAN
DUST	
3: DESCRIPT	500●Stubby-20 ●Smoky-15

7: SAMPLING (BB)
Note any differences between Cayley & Descartes and any flow on E. side of Stubby

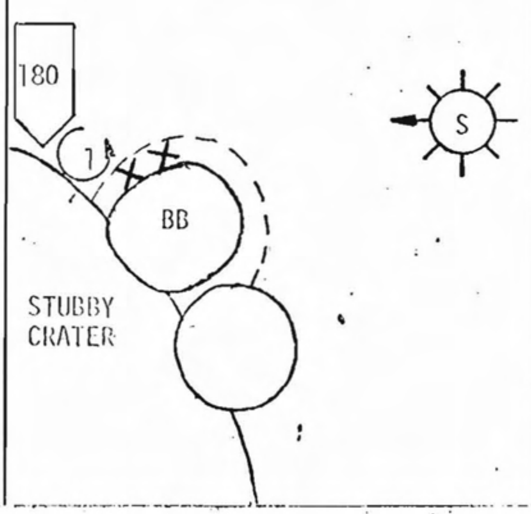
FRAME COUNT
MODE SW-1
POS TV HORIZ, CCW
DAC ON
18/250/1fps

CUFF-CHECK LIST

DRAWING

STATION 7

239/0.4 | 006/3.1 |



Station 7 - B-B Crater - edge of Stubby

- Near Descartes/Cayley boundary

Pan = on rim of B-B so can also see into Stubby

Description:

- Stone Mountain flow into Stubby? or landslide?

South Ray ejecta patterns: Stubby is elongate, no or low rims, may be internal

500 mm origin?

- Stubby interior - 20 (south)
  - Irregularities
  - Flow (?) into east sode
- Smoky Mountain - 15 (north)
  - 2nd leg for stereo coverage

Samples:

- B-B crater rim
  - Hopefully it punched Descartes - Cayley contact

Terminal Pan - if have moved a considerable distance, it would give a limited stereo base to features in the middle distance

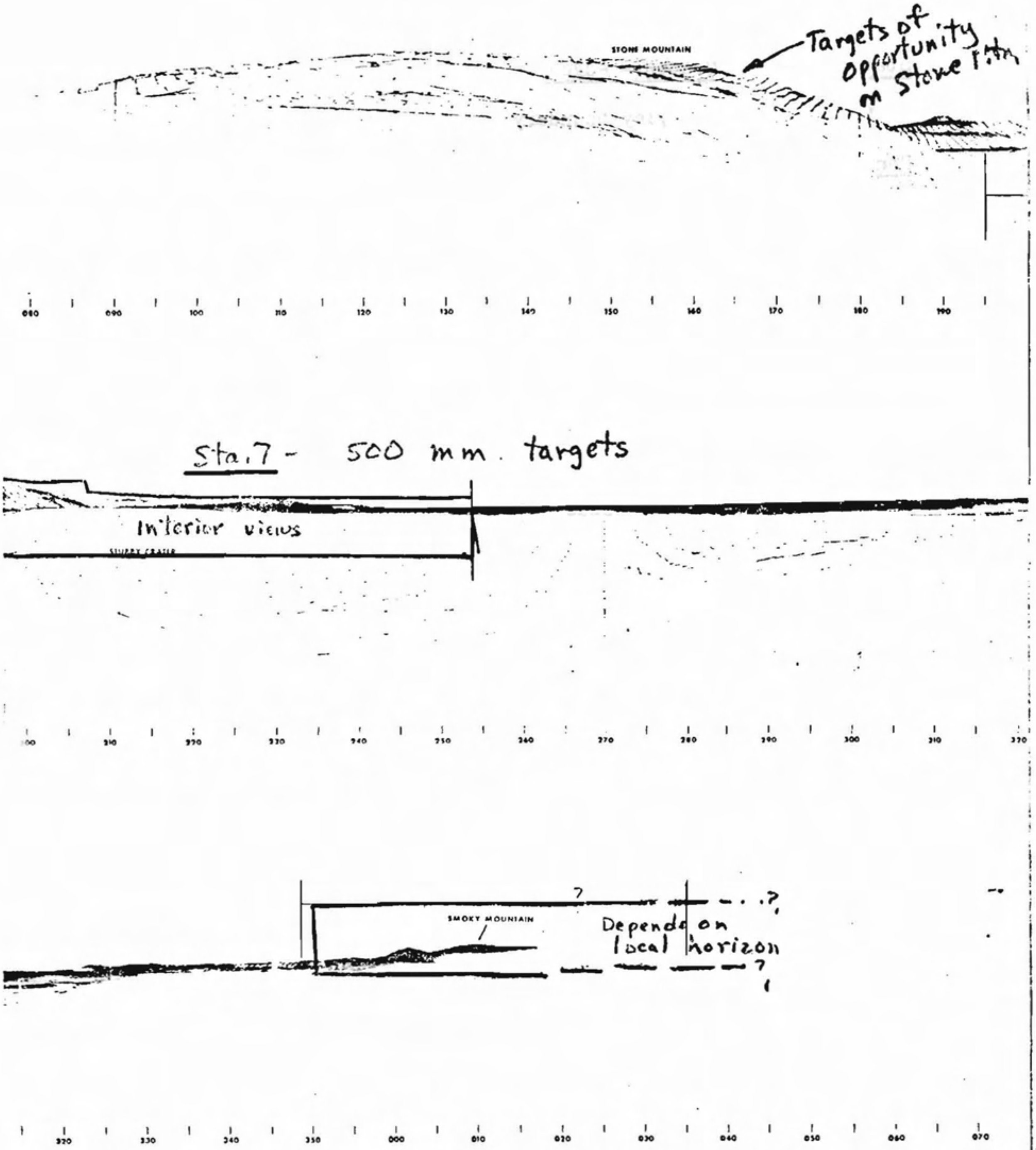
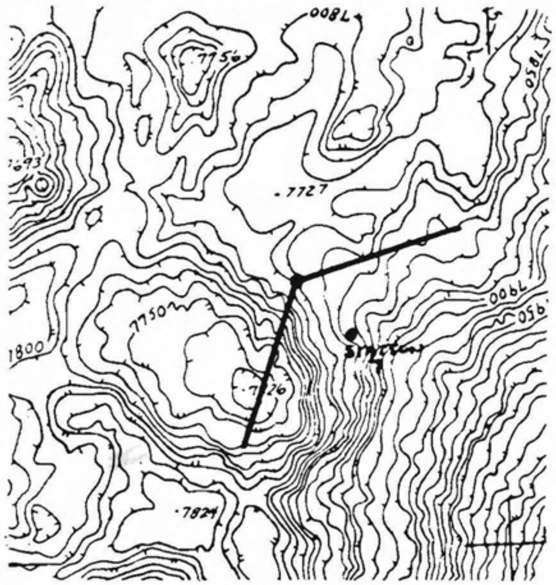
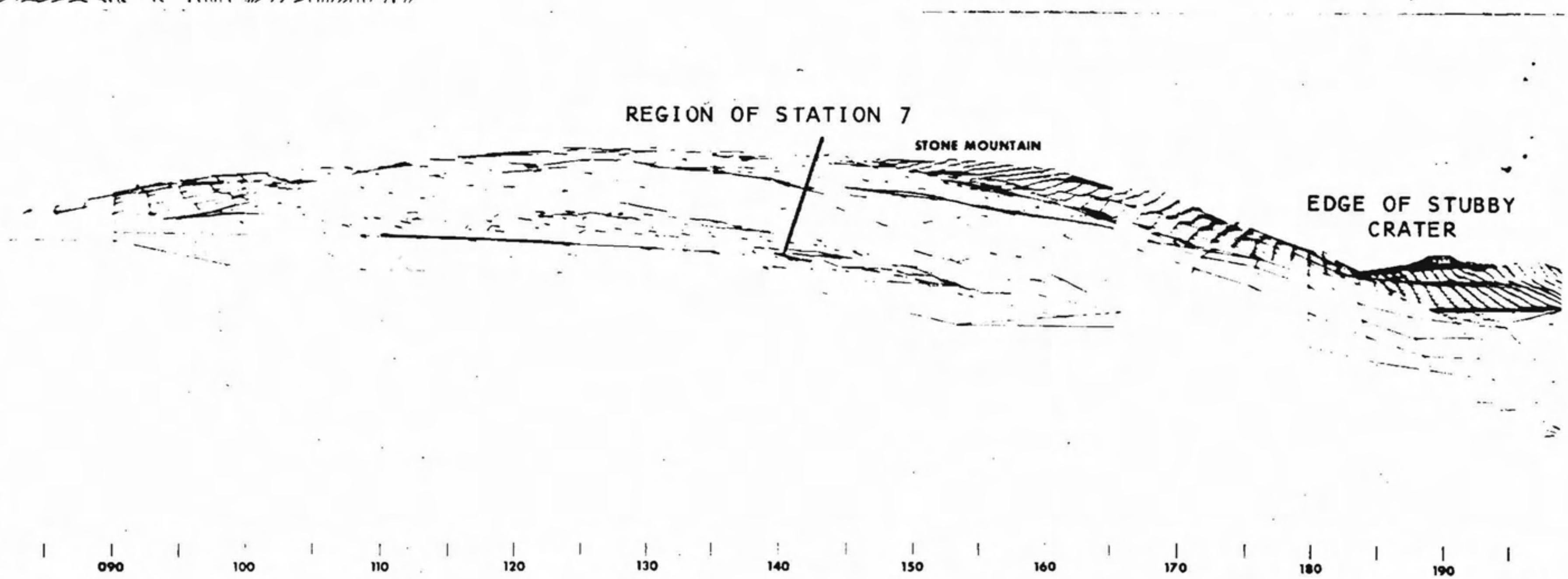


FIGURE 3 - VIEW FROM STUBBY CRATER (STATION [illegible])

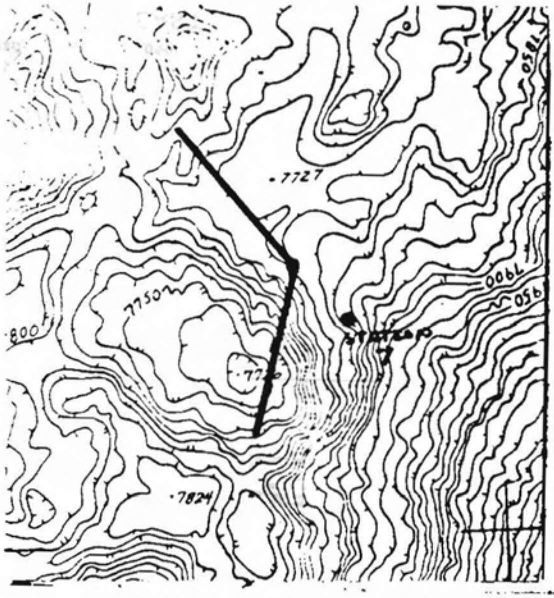
VIEW L(,ING SOU EAST FROM ST 'BY CRATER

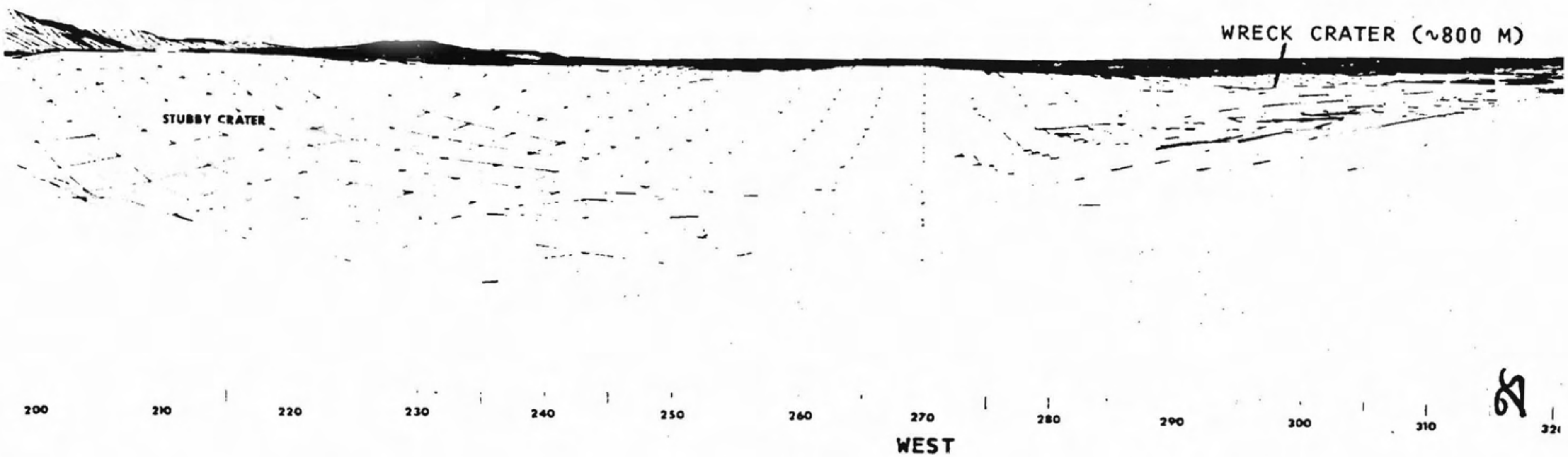


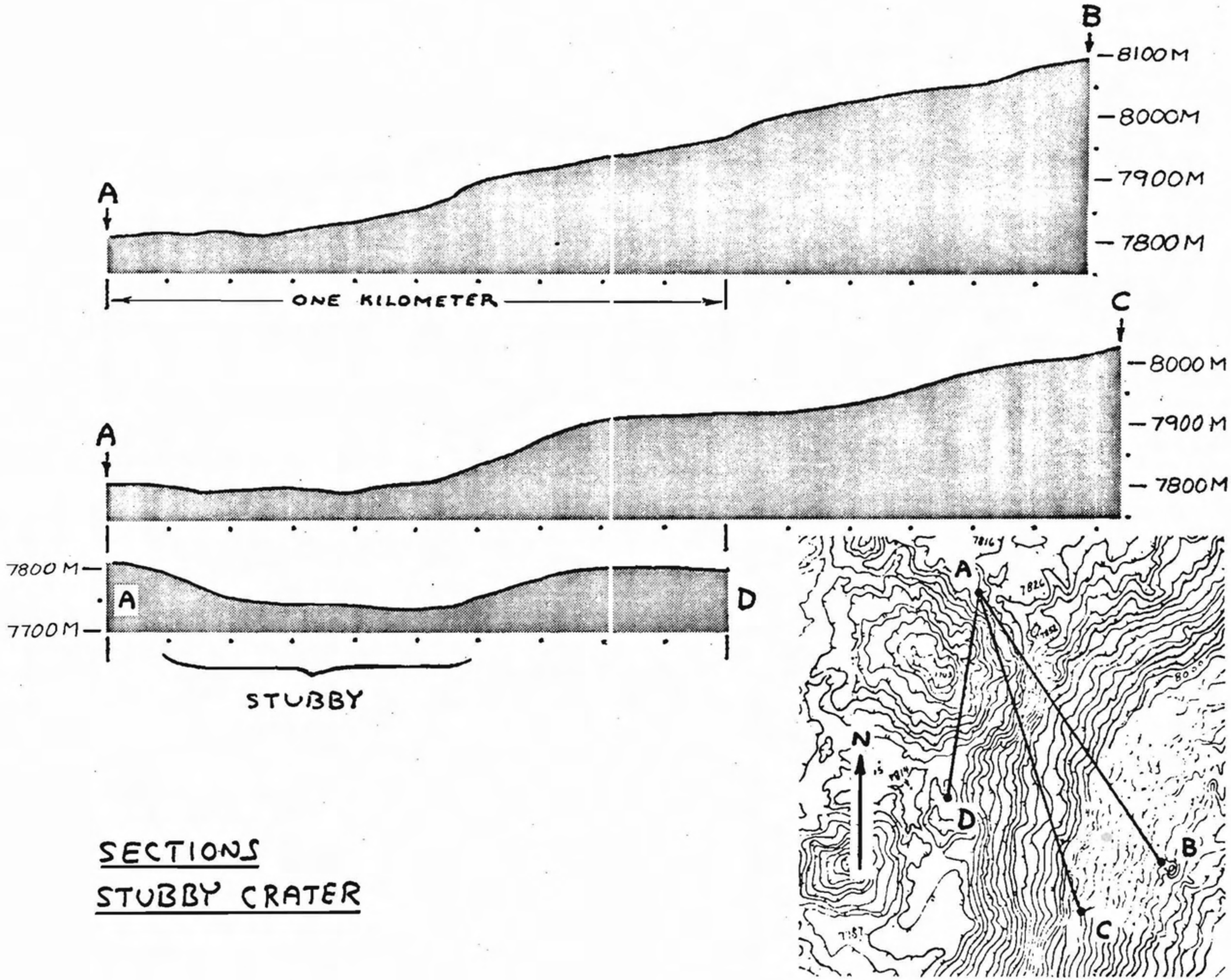


55

VIEW LC ING WEST FROM STUBBY C ATER







SECTIONS
STUBBY CRATER

Travel Station 7 - Station 8

- Increase in block density as travel west
- Cross low escarpment - Descartes/Cayley contact
- Ahead to north will be scarp facing you

TRAVERSE

STA. 7 TO STA. 8

STATION:

:ATION 8 - SOUTH RAY RAY (:60)

CDR	O/H	DESC.	RAKE/SOIL SAMPLE	DOUBLE CORE	SAMPLING (INCLUDING BOULDER OPERATIONS)*	O/H
	:03	:03	:08	:08	:36	:02
LMP	O/H PAN	DESC	RAKE/SOIL SAMPLE	DOUBLE CORE	SAMPLING (INCLUDING BOULDER OPERATIONS)	O/H

CUFF-CHECK LIST

TASKS

LOOK FOR:
•DES/CAY contact
•S Ray ejecta
STATION 8 BLOCK RAY/WRECK :60
S. RAY RAY

CDR	DAC OFF LMP
MODE SW-2	DISPLAYS
HGA	PAN
DUST	

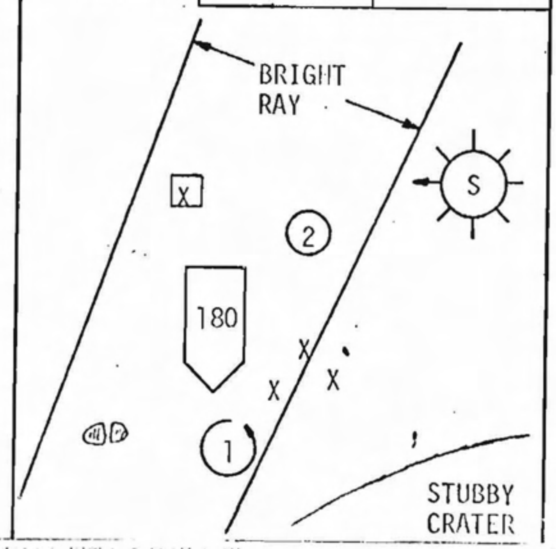
3: DESCRIPT
8: DOUBLE CORE
8: RAKE/SOIL
(away from boulders)
20: BOULDER (SEE BOULD)
16: SAMPLING
FRAME COUNT
MODE SW-1
POS TV HORIZ, CCW

CUFF-CHECK LIST

DRAWING

STATION 8

302/0.5 014/2.9



Station 8 - South Ray (ejecta)

- Stop in most prominent boulder train
- Face LRV at 180

Pan - Show boulder train, sampling area

Description:

- Ray appearance - size, distribution of boulders (limit because TV will later pan)
    - Layer of material deposited or discrete blocks, clods, etc.
- Stubby/Wreck interiors - benches, ray spatter, Stubby "slide/flow"
- Scarps visible to photo to ENE

Double Core:

- Avoid heaviest block concentrations
- Hope to penetrate ray material and obtain undisturbed Cayley below

Rake/Soil:

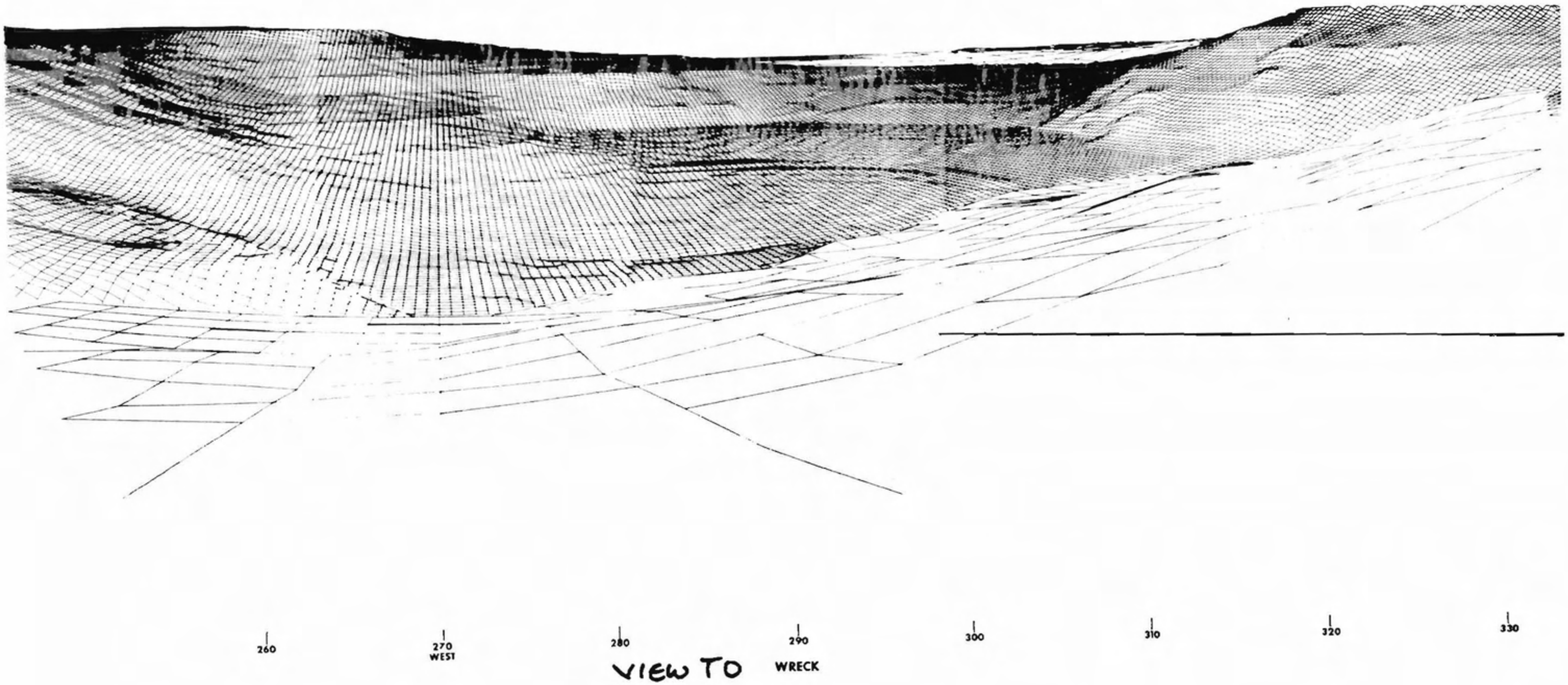
- Avoid heaviest block concentration so sample area will not be overly "salted" with pieces from nearby blocks and will thus be a wider representation of materials from South Ray crater

Sampling:

- Variety of rocks - get one each if possible
    - Gives units in crater and crater age + age of each rock unit
- Data on thickness of ray
    - Double core
    - Exploratory trench (?) (-optional)
- Observe size, angularity, secondaries
    - Might find rare sample from Baby Ray - get it
- Boulder observations

- Split boulder or roll-over boulder, best chance here
- This sample gives best dating of crater plus data on radiation penetration of rock

- Photographs of areas showing variety of rocks - give chance of of unit derived from
- Appearance of ray - photographs; gardening, secondaries (photos of secondaries (with gnomon) show bounce direction and their probable source direction


260
270
WEST
280
290
300
310
320
330
VIEW TO WRECK

<u>Travel Station 8 - Station 9</u>

- Traverse ray field
- Cross crease trending NE

STATION:

STATION 9 - CAYLEY PLAINS (:25)

CDR	O/H		SURFACE SAMPLER	CSVC	O/H
	:03		:12	:08	:02
LMP	O/H	PAN	SURFACE SAMPLER	CSVC	

CUFF-CHECK LIST

TASKS

LOOK FOR:
- NE scarp 015/2.6
- Pristine area

STATION 9
VACANT LOT :25

008/0.4 015/2.6
LRV=180°

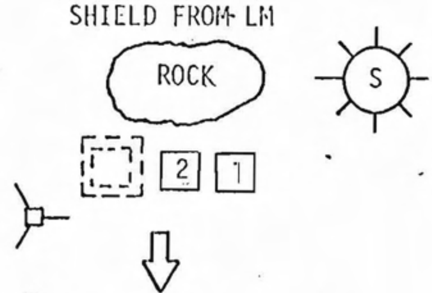
CDR	LMP
MODE SW-2	DISPLAYS
HGA	PAN
DUST	

12: SURFACE SAMPLES
8: CSVC
(SINGLE CORE)
FRAME COUNT
MODE SW-1
POS TV HORIZ, CCW

CUFF-CHECK LIST

DRAWING

SURFACE SAMPLES
SHIELD FROM LM



3 4 2 1

SKIM SCOOP VELVET BETA

AFTER 2 PLACE GNOMEN
XSUN STEREO AFTER, DNSUN, LOC
DO SKIM 3 , XSUN AFTER, WIDEN
AREA DO SCOOP 4 , XSUN AFTER

Station 9 - "Typical" Cayley surface = Vacant lot

To locate station:

- No recognizable ray patterns or material
- No LM descent or astronaut boot spray
- Want "Normal" Cayley albedo for extrapolation to other areas

Pan - show sampling area

Area will provide a sequential set of regolith samples.

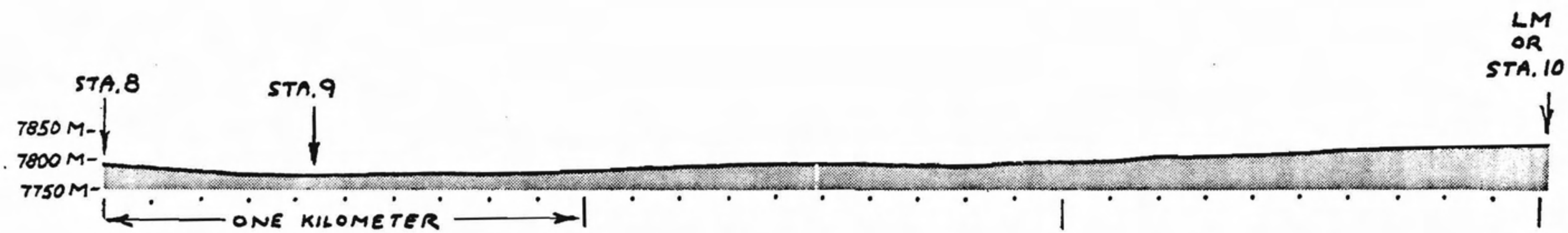
- Topmost surface layer
- Top (several?) surface layers
- Skim
- Deeper scoop

This comparison set should determine origin of optical layer of moon

- One studied by remote sensing
- Different as demonstrated by all lunar surface activities
- CSVC - to bring most virgin regolith sample back ever

Travel 9 - 10

- Blocks be rare or in elongate patches
- West rim of large old crater to right
- Pass between SP - 60 m and Sunset - 80 m Craters
  - Should have visible rims, blocky)?)
- WC - 38 m crater be blocky, fresh crater
  - LM should come into view



TRAVERSE

STA. 8 TO LM

STATION:

STATION 10 - LM/ALSEP AREA (:33)

CDR	O/H	DOUBLE CORE	TRENCH	SAMPLING	PAN	TRENCH SAMPLES	O/H
	:03	:08	:05	:08	:02	:05	:02
LMP	O/H	DOUBLE CORE	PENETROMETER READINGS			TRENCH SAMPLES	O/H

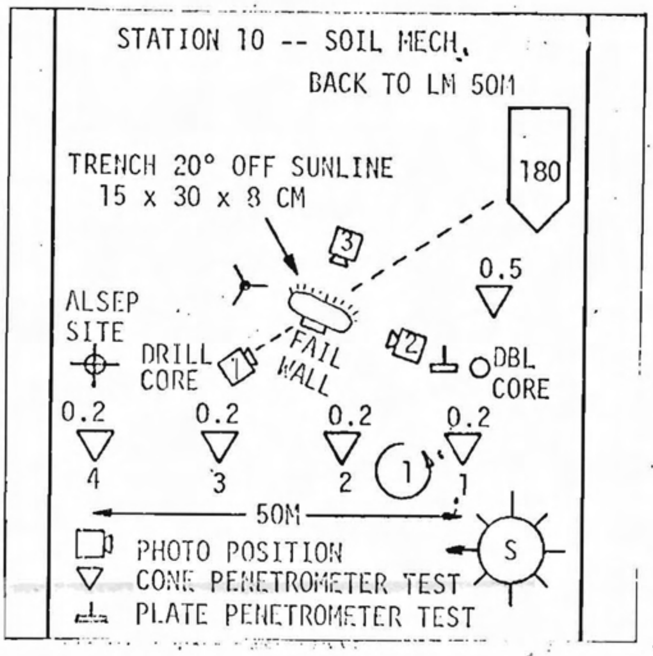
CUFF-CHECK LIST

TASKS

```
STATION 10
      HALFWAY BETW. ALSEP & LM :33

   CDR                 LMP
   MODE SW-3           DISPLAYS
   HGA
   DUST
 8:       DOUBLE CORE
 5:TRENCH              PENETROMETER
15:TRENCH SAMPLES      0.5 CONE 1st*
   (Incl. Photos       0.2 CONES
    1,2,3)             PLATES LAST
   PAN
          FRAME COUNT
   BACK TO LM FOR CLOSE

*If penetration < 12" switch to .2
 cone for 2,3,4

   MODE SW-1
   POS TV HORIZ., CCW
```

CUFF-CHECK LIST

DRAWING



Station 10 - LM/ALSEP area

Rationale -

- Regolith soil mechanics characteristics
- Regolith stratigraphy
    - Can units be traced laterally
        - Example, South and North Ray ejecta
          Theophilus?
    - Penetrometer tests for major unit correlation
    - Double core to compare with drill stem
    - Trench samples for shallow units

Double Core:

- Sink about 50 m from drill core site

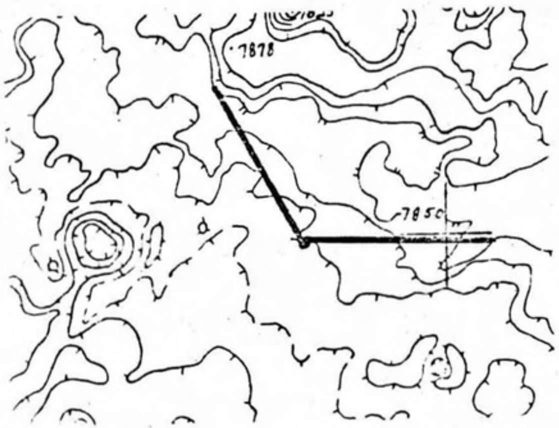
Soil Mechanics:

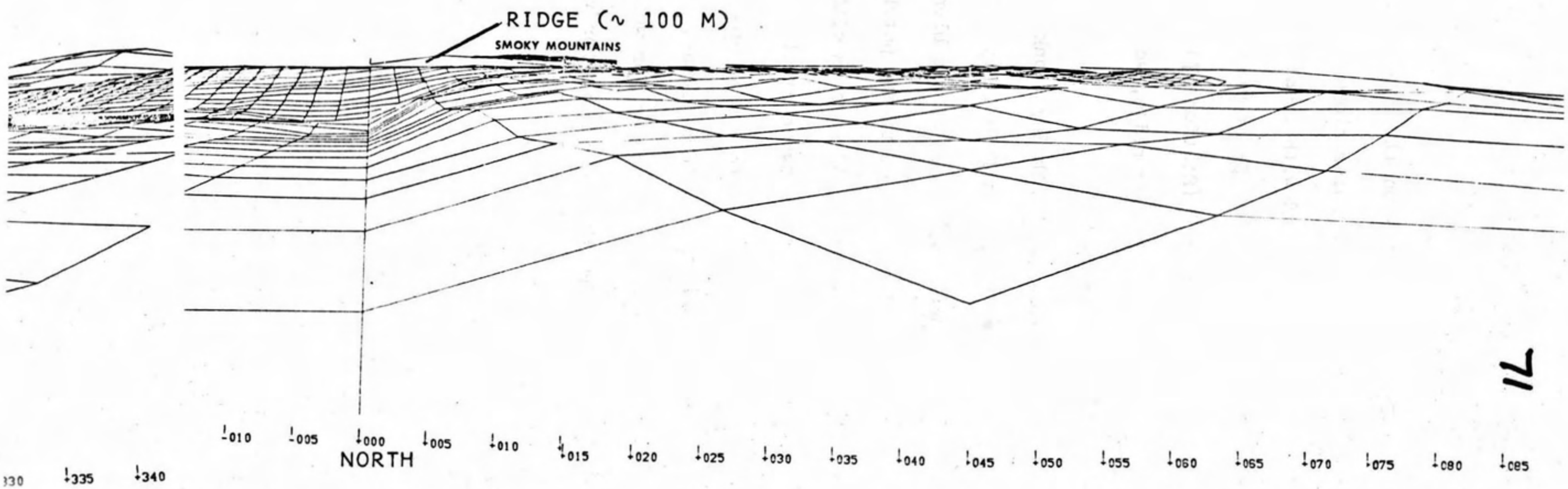
- Penetrometer line between double core and drill core site should identify major regolith units between them
- Trench and tests related to it - cones and plates will give values for 3 parameters that predict strengths between site and others where penetrometer readings have been taken. Penetrometer readings also provide quantitative values to extrapolate from using astronaut footprint and LRV track pictures

Pan:

- Must show area covered by penetrometer line. If cannot, take pan followed partial pans along penetrometer line.
- Pan also provides repeat photography of Stone Mountain for possible lineations at different sun angle

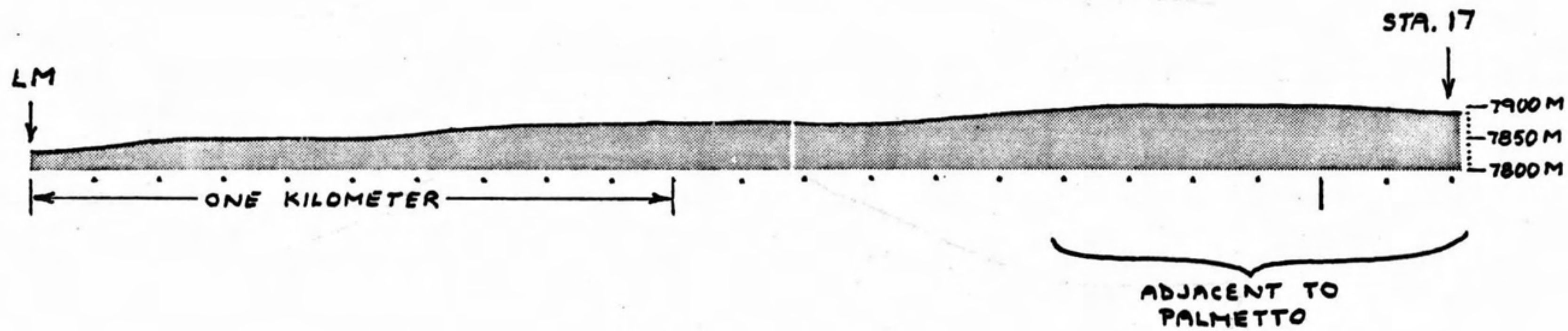
VIEW LOOKING NORTHEAST FROM LM LOCATION





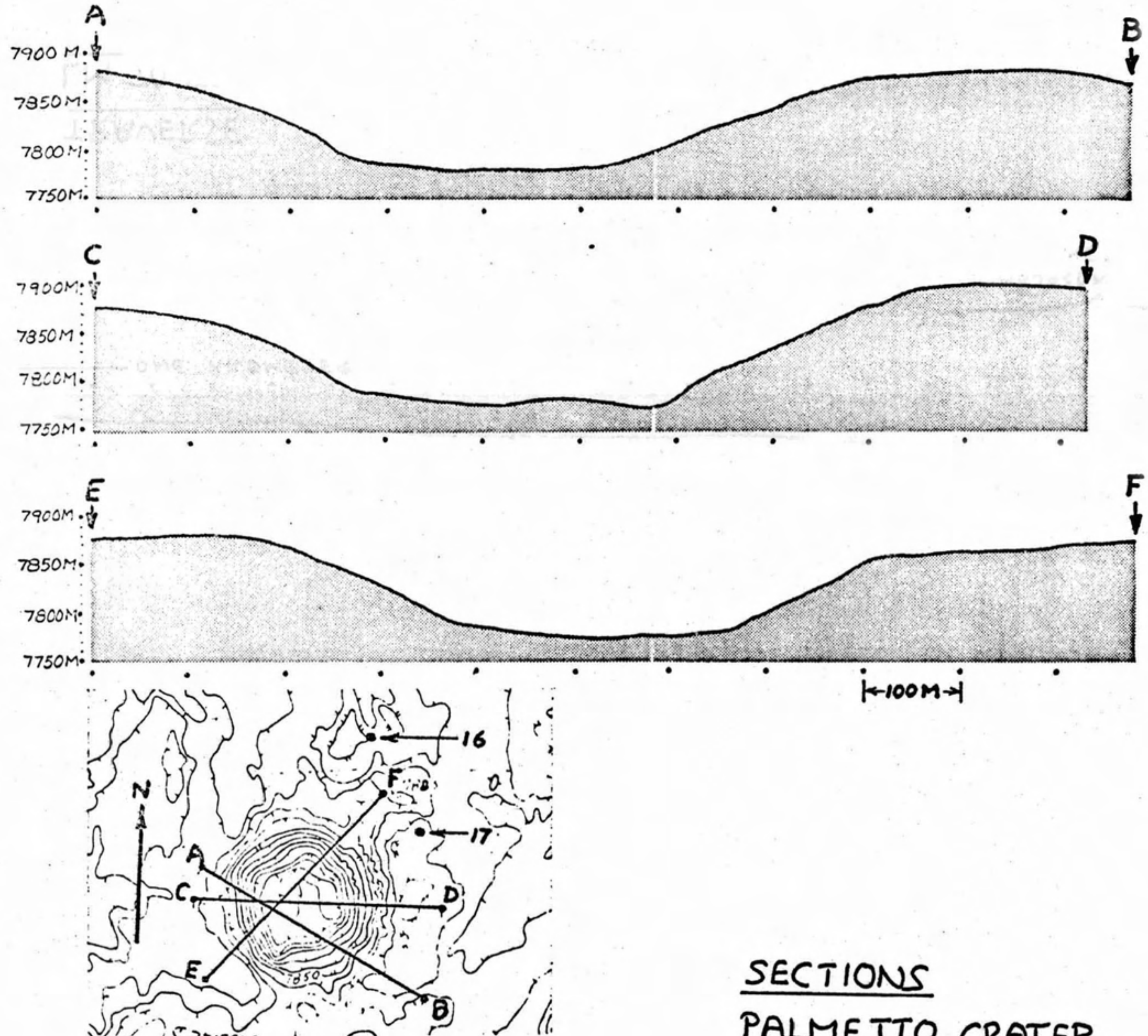
Travel/LM - Station 11

- Climb irregular slope
- Large mound with crestal crater
- Cross crease SE of Palmetto
- End crater (Station 17) sits on low mound
- Driving along ridge, west facing escarpment (flow fronts, faults, outcrop)
- Views of North Ray flank
    - Rays, trafficability
- Onto continuous ejecta blanket - probably blocky - Station 13
- Drive parallel to ray patches
    - Do rocks of rays on either side of route appear different or same? Sample between stations 12 and 13 if not found along rims.
- Giant landmark blocks should be in vicinity of station 12
- LRV photos-block fields, giant boulders, DAC also running
- Move station 11 as far west on rim as practicable
    - Better sun angles for viewing and photographing the crater interior



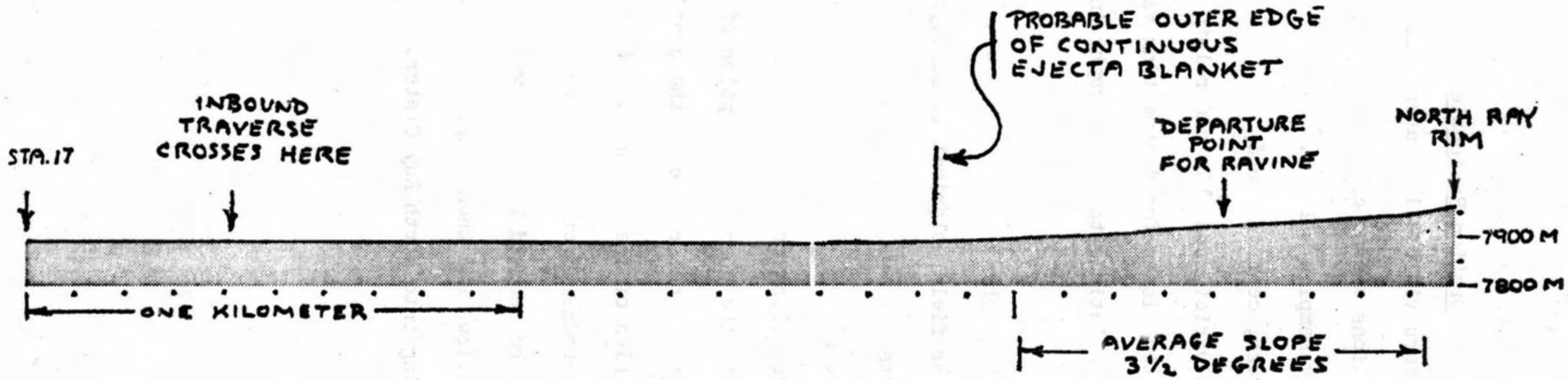
TRAVERSE

LM TO STATION 17



SECTIONS

PALMETTO CRATER

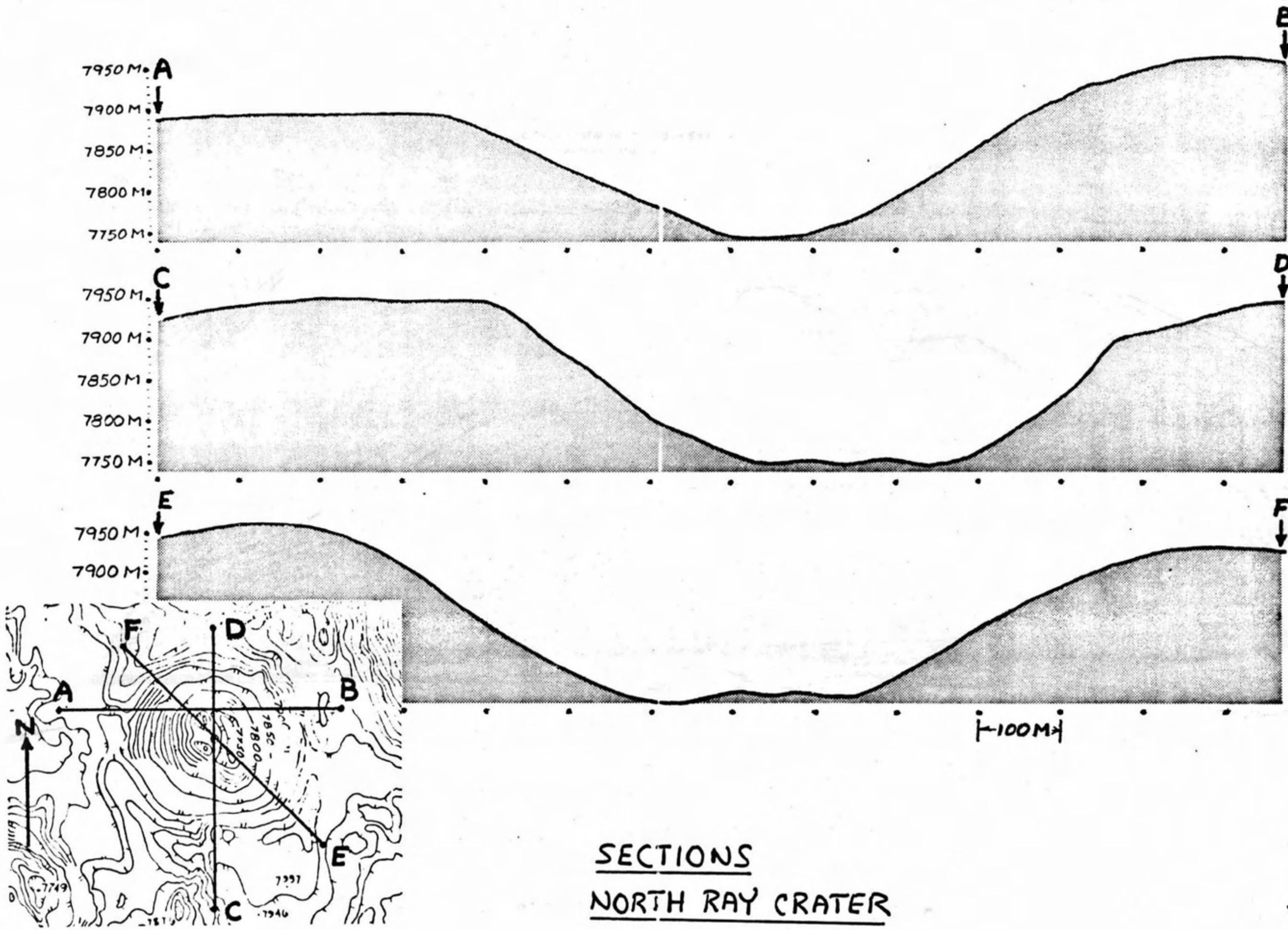


TRAVERSE

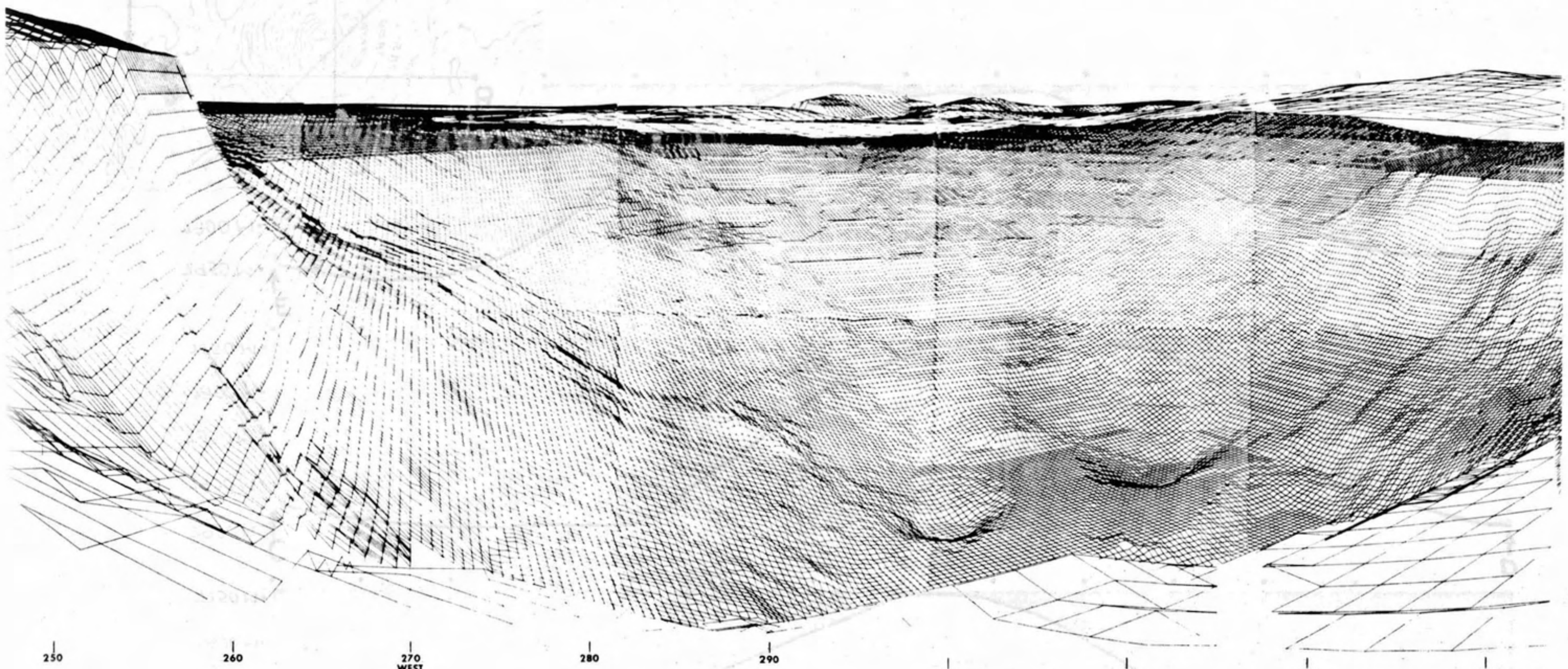
STA. 17 TO NORTH RAY

North Ray Crater Exploration Rationale

- At least 7 layers visible in crater wall
- Lateral variations across crater
- Deepest Cayley samples - 160 m.
- Relatively fresh, central mound
- Sample widest variety possible and relate to any observed stratigraphy
- Photographic techniques for documenting variety, layering, textural features, and relations to stratigraphy include
  - Panoramas
  - 500 mm photography
  - Near and far field polarimetric surveys
  - Close-up stereo
  - Flight-line stereo
- Sample traverse along crater rim whould show up every rock unit within the crater with the possible exception of the top unit. Therefore, station 13, at the outer edge of the continuous ejecta blanket, is to guarantee samples of the top unit. (Rim sampling of Meteor Crater, Arizona and Schooner Crater, NTS, actually does the above.)
- If rim cannot be reached by LRV or walking, then walk toward rim as far as time allows and then sample radially back to LRV
- Park LRV facing into North Ray Crater.

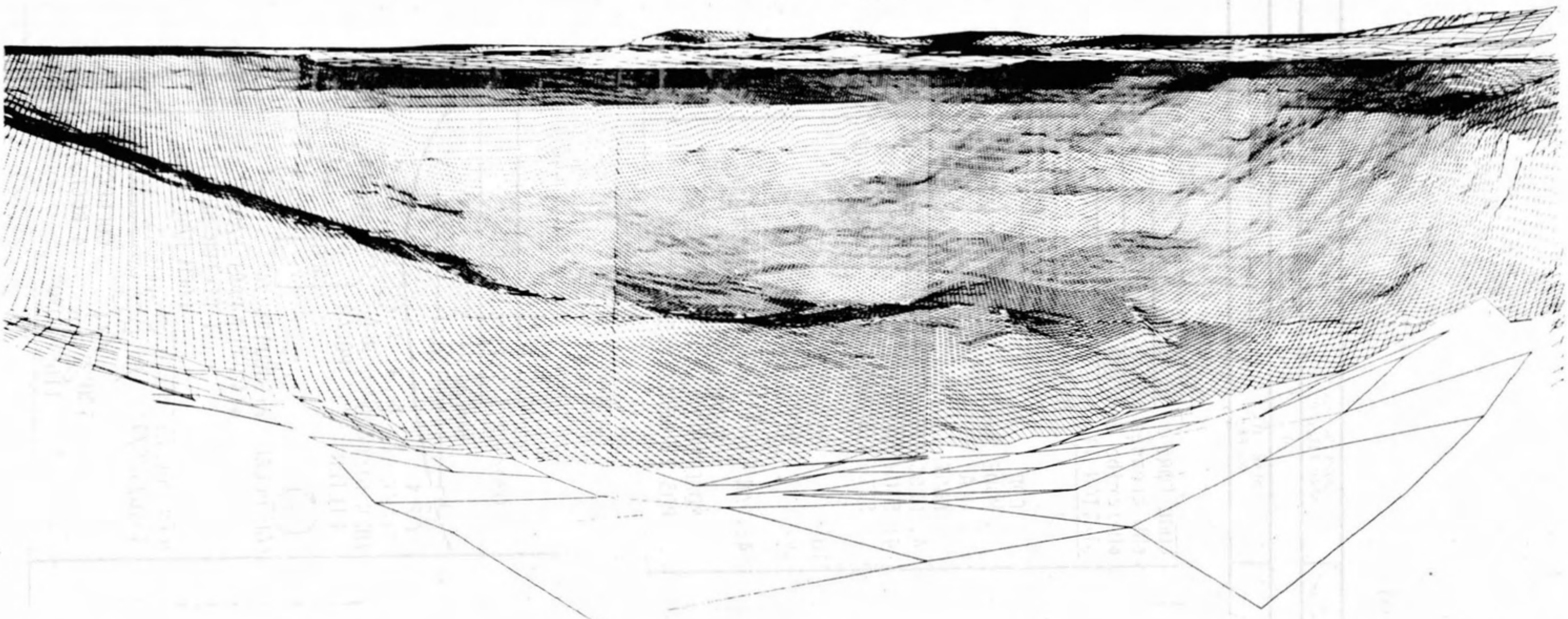


SECTIONS
NORTH RAY CRATER



VIEWING AZIMUTH

FIGURE 1 - VIEW INTO NORTH RAY



270
WEST
280
290
KIVA
320
330
340
350

STATION:

STATION 11 - NORTH RAY RIM (:53)

R	O/H	DESCRIP-TION	SET UP FOR NEAR FIELD POL.	SAMPLING FOR NEAR FIELD POL.	SAMPLING	PAN	O/H
	:03	:04	:04	:10	:26	:04	:02
P	O/H PAN	500mm	FAR FIELD POLAR NO. 1	NEAR FIELD POLAR.	SAMPLING	FAR FIELD POL. NO. 2	O/H

CUFF-CHECK LIST

TASKS

LOOK FOR:
- NW creases 190/1.3
- Describe end 188/2.1

STATION 11

N. RAY RIM :53

DAC OFF

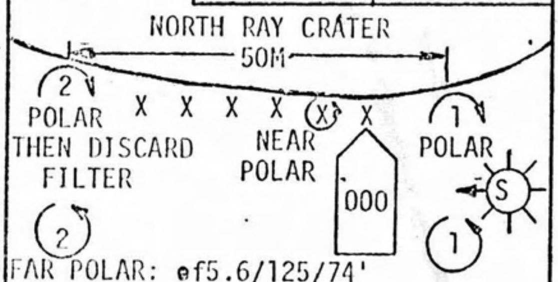
CDR	LMP
MODE SW-2	DISPLAYS
HGA	PAN
DUST	
4: DESCRIPT	500 • Stone-20
4: STOW 500-PICK	• Kiva-15
SITE FOR NEAR	• N.Ray-60
	FAR POLAR$_1$
10: NEAR POLAR	
26: SAMPLING	
4: PAN	FAR POLAR$_2$
FRAME COUNT	
MODE SW-1	
POS TV HORIZ. CCW	

CUFF-CHECK LIST

DRAWING

STATION 11

030/5.2 179/4.6



FAR POLAR: • f5.6/125/74'
• 1&2 - 3 PART PANS
1 FILTER SETTING
EACH PAN

NEAR POLAR:
f5.6/125/7'

Station 11 - Rim of North Ray Crater (Tasks)

Pan 1 - Black and White - On crater rim or outside of crater so that a maximum of the surrounding terrain is visible.

- Permit triangulation of station location
- Best view across ejecta blanket

Description -

- Interior of North Ray Crater
    - Number, approximate thickness, and distinguishing characteristics of each layer
    - Lateral continuity
    - Mound - block field
- Summary of block size and variety on rim
- Assessment of desirability and feasibility of reaching station 12

500 mm photography -

- Stone Mnt. - one leg of stereo pair - 20 frames
- KIVA - might not be visible because of blocks and/or intervening ridges - 15 frames
- North Ray interior - 60 frames
    - Horizontal pan of best outcrop band
    - Vertical pan of most complete outcrop sequence
    - SW quandrant looks like best stratigraphy
    - At far wall, single frame covers 80-90 m on a side. SW wall each frame covers @ 50 m - need @ 7 frames for vertical pan to guarantee overlap
    - Any target of opportunity
    - Sets up stereo base for vertical and horizontal pan at station 12
- Targets of opportunity on slope of Smoky Mountain (See computer pans for possible targets)

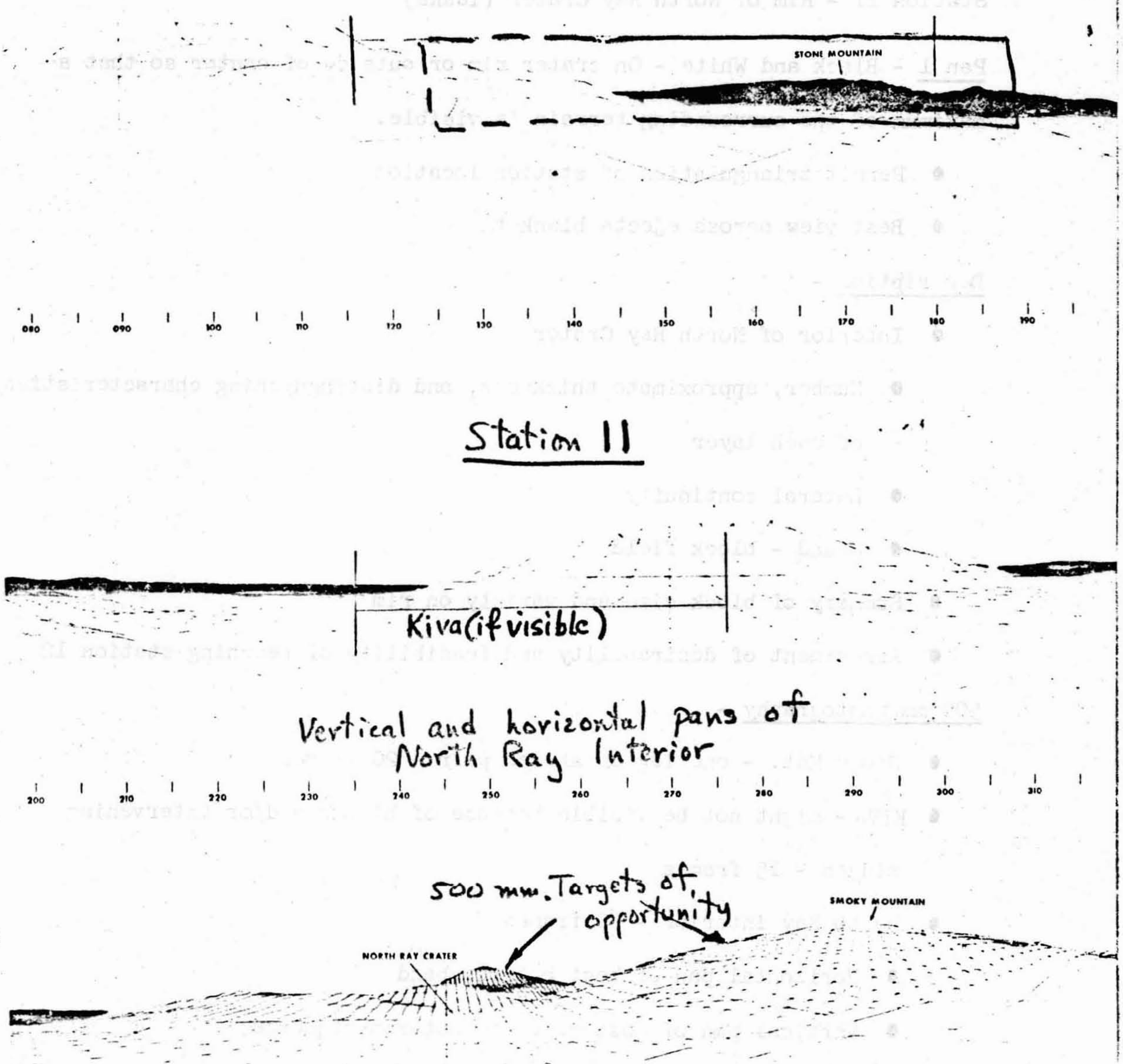


FIGURE 4 - VIEW FROM REGION OF NORTH RAY CRATER (STATION 11)

Far Field Polarimetry

- Partial pan of crater interior at each filter setting
- Gives all possible phase angle combinations for all regolith coated surfaces
- For blocky areas, measurements on all blocks in a narrow angle band will give average polarization
- Second far field polarimetric survey will give (slightly) different viewing angle to improve statistics for blocky/outcrop areas (end of station)

Near Field Polarimetry -

- Sample area with variety of small (returnable) fragments
- Lunar and terrestrial study of these samples will set up parameters to extrapolate to other blocks still on lunar surface in both near and far field polarimetric photography

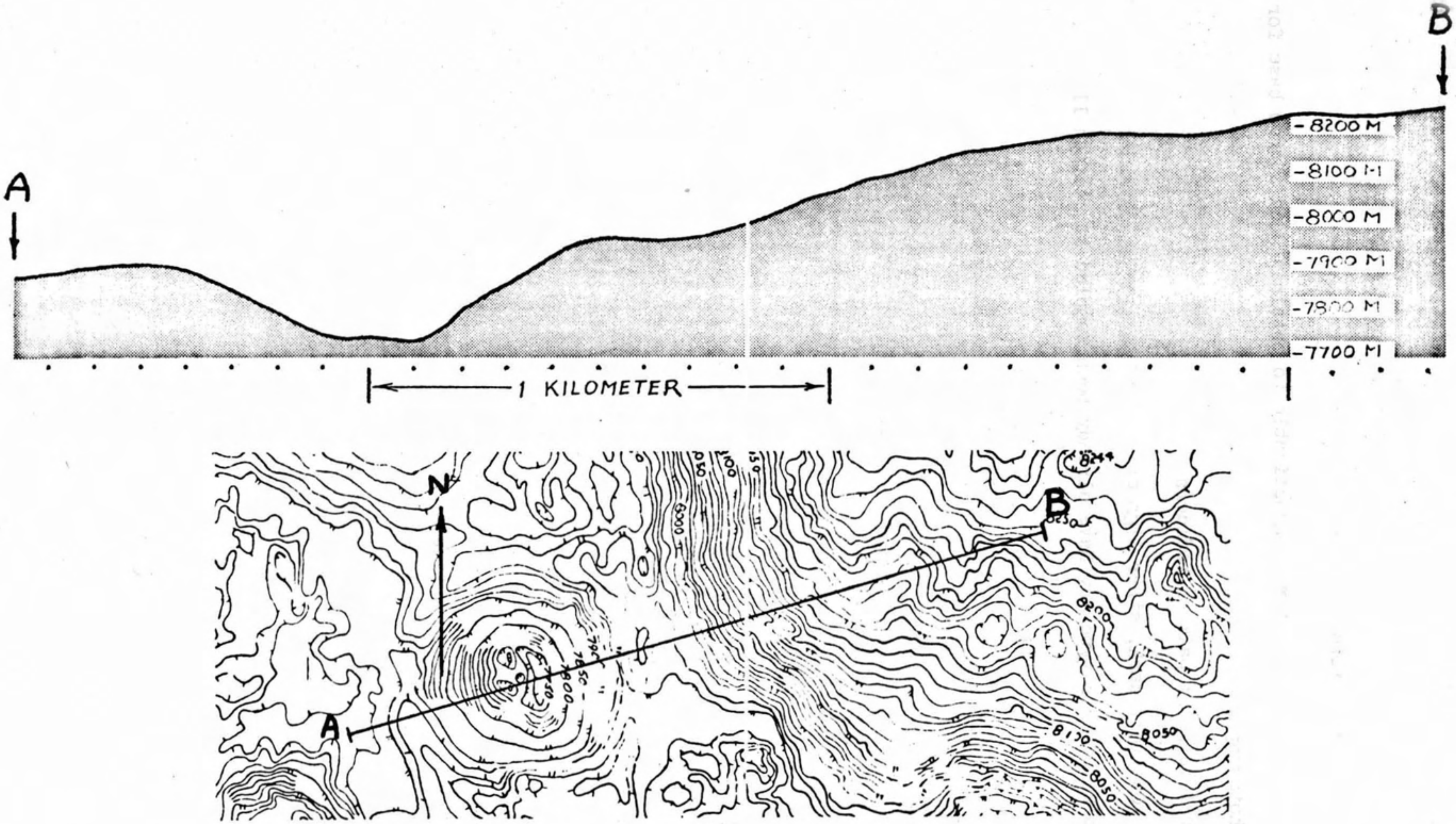
Sampling -

- Sample westward from LRV to maximize length of rim traversed, i.e., maximize variety of rock types encountered
- Anticipate a higher than normal film usage - Give us frequent frame counts - can warn when might be needing to change magazines
- Chip from large block or pick up hand sample of identical lithology
- Large blocks are easiest to relate to crater stratigraphy

- If all rocks are crystalline: (igneous)
  - One of each lithology or textural difference
  - Sample layers, inclusions segregations, and dikes within large blocks
  - If all big blocks look alike, do only one giant boulder procedure
- If all rocks are breccias (impact or volcanic):
  - One of each large clast type in boulders
  - Matrix and clast in one sample if possible
  - Samples with several (many) clasts
  - If only small clasts sizes, collect variety of coarser sizes (easier to analyze)
- If rocks are crystalline and breccia
  - Intersperse sampling tasks in proportion to rock types

Pan 2 - Color - Take at end of sampling traverse - Try to include interior of North Ray Crater

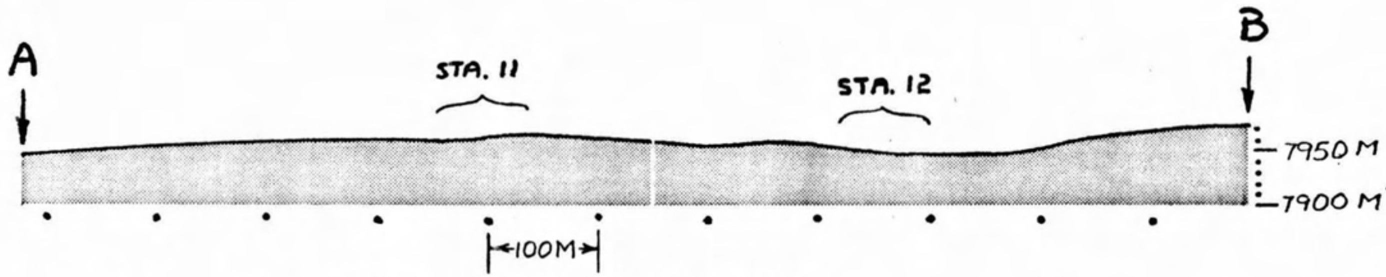
Far Field Polarimetry 2 - Highly desirable for additional data on outcrop bands

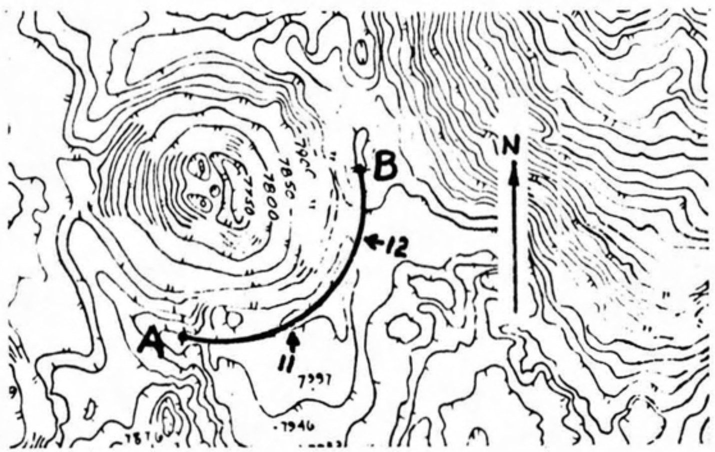


SECTION
NORTH RAY THROUGH
SMOKY MTN.

Travel/Station 11-12

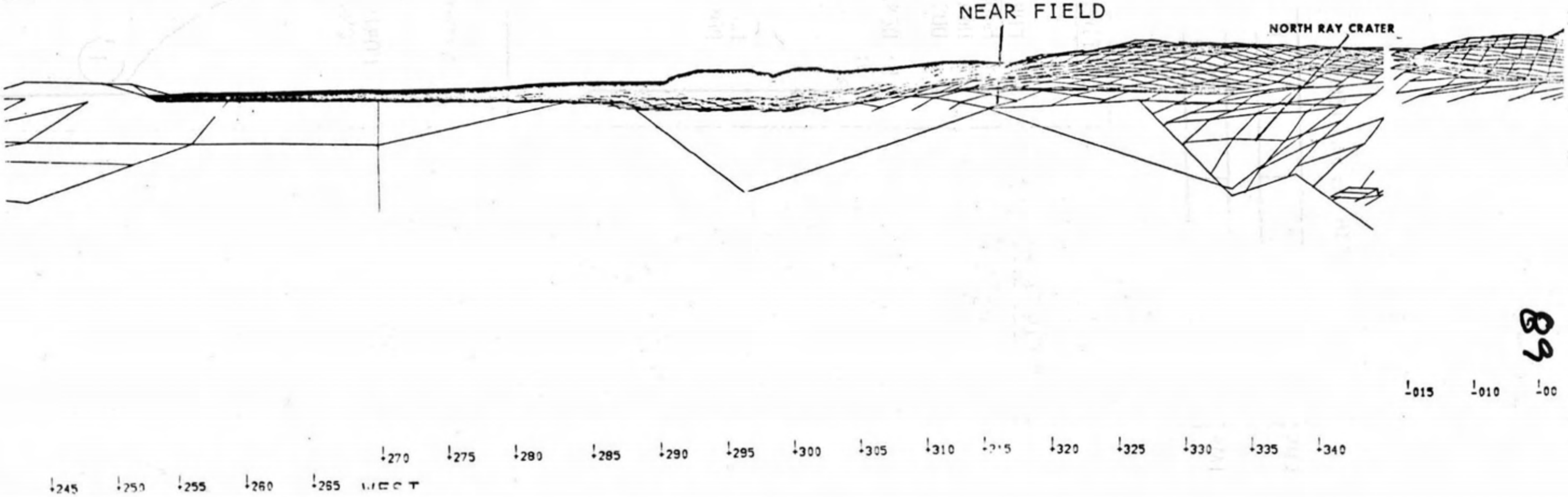
- Move along rim as far as practicable to obtain a good stereo base for photography
- Goal is giant pair of boulders
  - One very dark, other lighter
- Rocks of this type may have already been sampled at station 11





PROFILE
RIM OF NORTH RAY
IN SE. QUADRANT

VIEW LOOKING NORTHWEST FROM AREA
OF NORTH RAY CRATER



STATION:

STATION 12 - NORTH RAY RIM (:56)

CDR	O/H		DESCRIPTION	RAKE/SOIL SAMPLE	SAMPLING *	O/H
	:03		:05	:08	:38	:02
LMP	O/H	PAN	500mm PHOTOS	RAKE/SOIL SAMPLE	SAMPLING	O/H

CUFF-CHECK LIST

TASKS

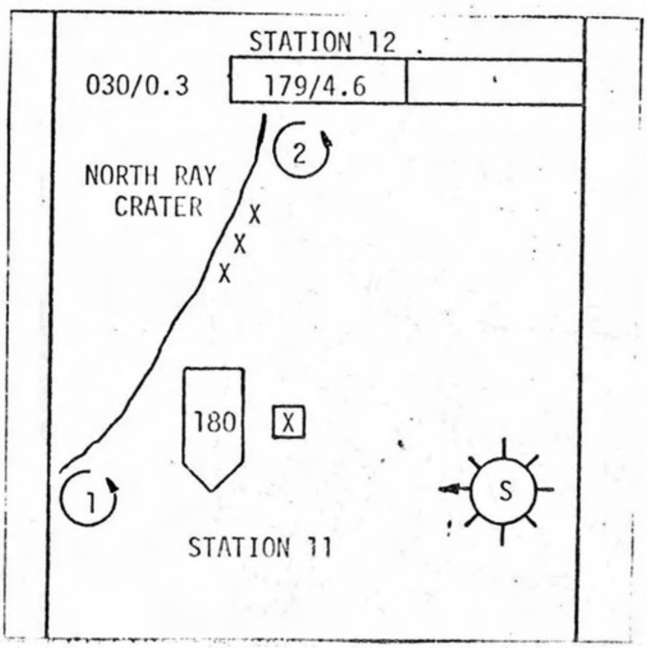
STATION 12
N. RAY RIM :56

CDR	LMP
MODE SW-2	DISPLAYS
HGA	PAN 1
DUST	500 W Wall of N Ray-30

5: DESCRIPT
8: RAKE/SOIL
38: SAMPLING
SAMPLE BOULDERS (SEE BOULD)
PAN 2
FRAME COUNT
MODE SW-1
POS TV HORIZ, CCW

CUFF-CHECK LIST

DRAWING



Station 12 - Rim of North Ray Crater

- Eastern end of sampling strip on rim
- At edge of giant boulder field that extends down east side of ejecta blanket

Pan 1 - Black and White - From rim of North Ray so that crater interior is visible. Gives 60 mm stereo coverage when combined with polarimetric pans.

500 mm - Horizontal and vertical pan of best layers photographed from station 11 - for stereo coverage

Targets of opportunity:

- Smoky Mountain flanks
- Giant boulders on ejecta blanket
- Stone Mountain if blocked from station 11 (See computer generated pans)

Description -

- Continue with interior of North Ray if are new or better views
- Boulders - layering, how many rock types
- Best view of N-S fault (?) through center of crater

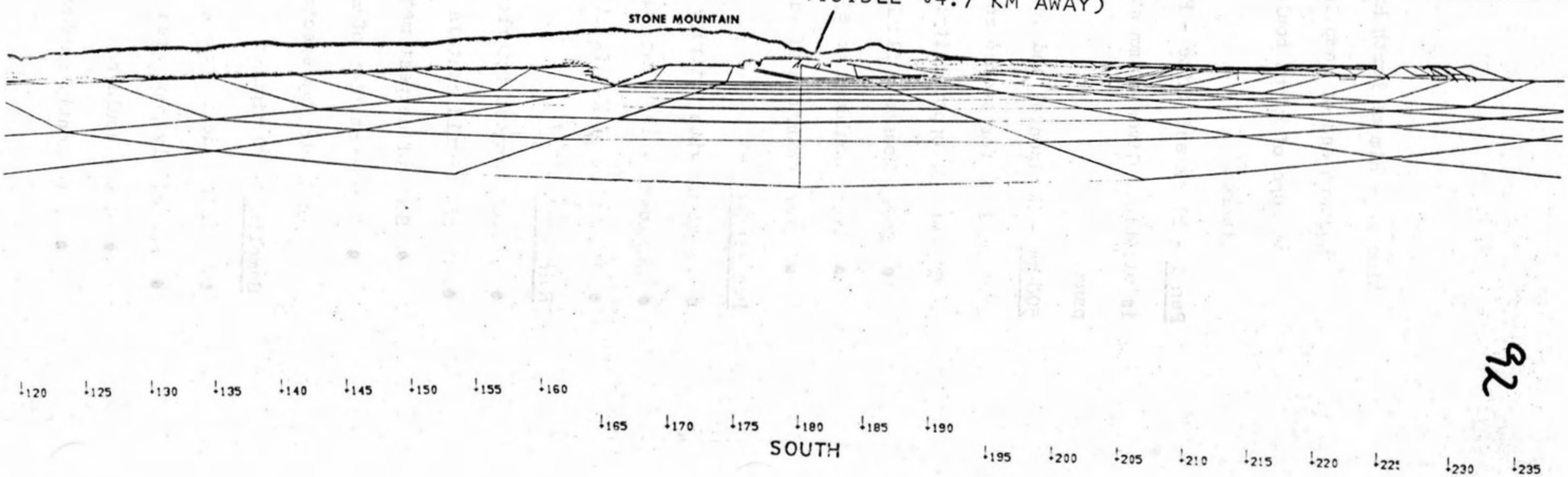
Rake/soil -

- Select largest interboulder area
- Sample should contain
  - Some of deepest material from North Ray
  - Representation of material thrown in - both distant exotics and other parts of North Ray ejecta

Sampling - 30 minutes

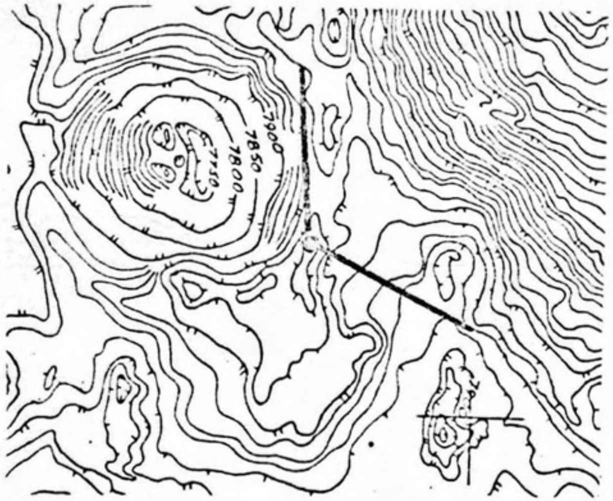
- Obtain widest variety possible
- Especially good area for
  - Giant boulders
  - Permanently shadowed soil
  - E-W split soil sample

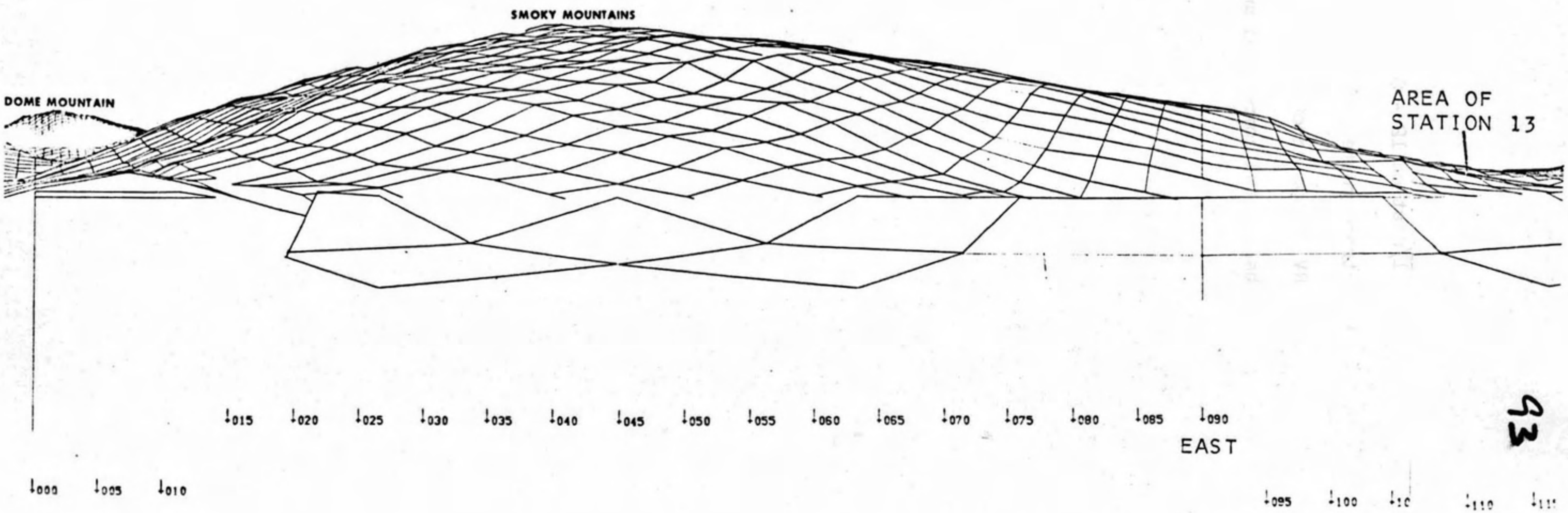
VIEW LOOKING SOUTH FROM AREA
OF NORTH RAY CRATER



92

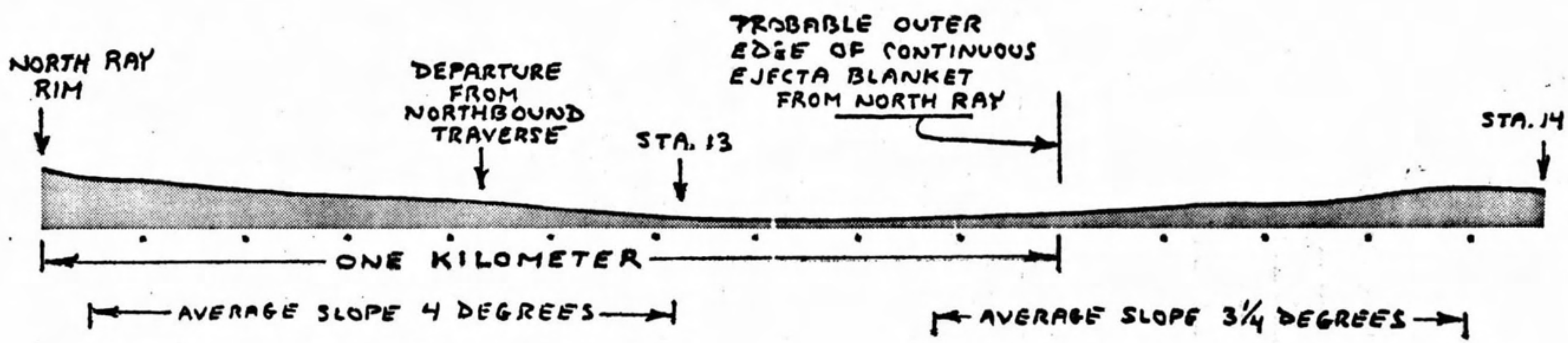
VIEW LOOKING NORTHEAST FROM AREA OF NORTH RAY CRATER





Travel/Station 12 - Station 13

- Retrace route to edge of continuous ejecta blanket
- LRV photos enroute
- Observe and comment on any additional boulder types not seen before



TRAVERSE

STA. 12 TO STA. 14

STATION:

STATION 13 - NORTH RAY EJECTA BLANKET (:10)

CDR	O/H	ROCK/SOIL SAMPLE		O/H
	:01	:02	:05	:02
LMP	O/H	PAN	ROCK/SOIL SAMPLE	O/H

CUFF-CHECK LIST

TASKS

STATION 13
NORTH RAY EJECTA BLANKET :10

130/.7 | 186/4.3

LRV=180°

NO TV OR DUST

CDR — LMP PAN

8: ROCK
SOIL (1 KG)
FRAME COUNT

CUFF-CHECK LIST

DRAWING

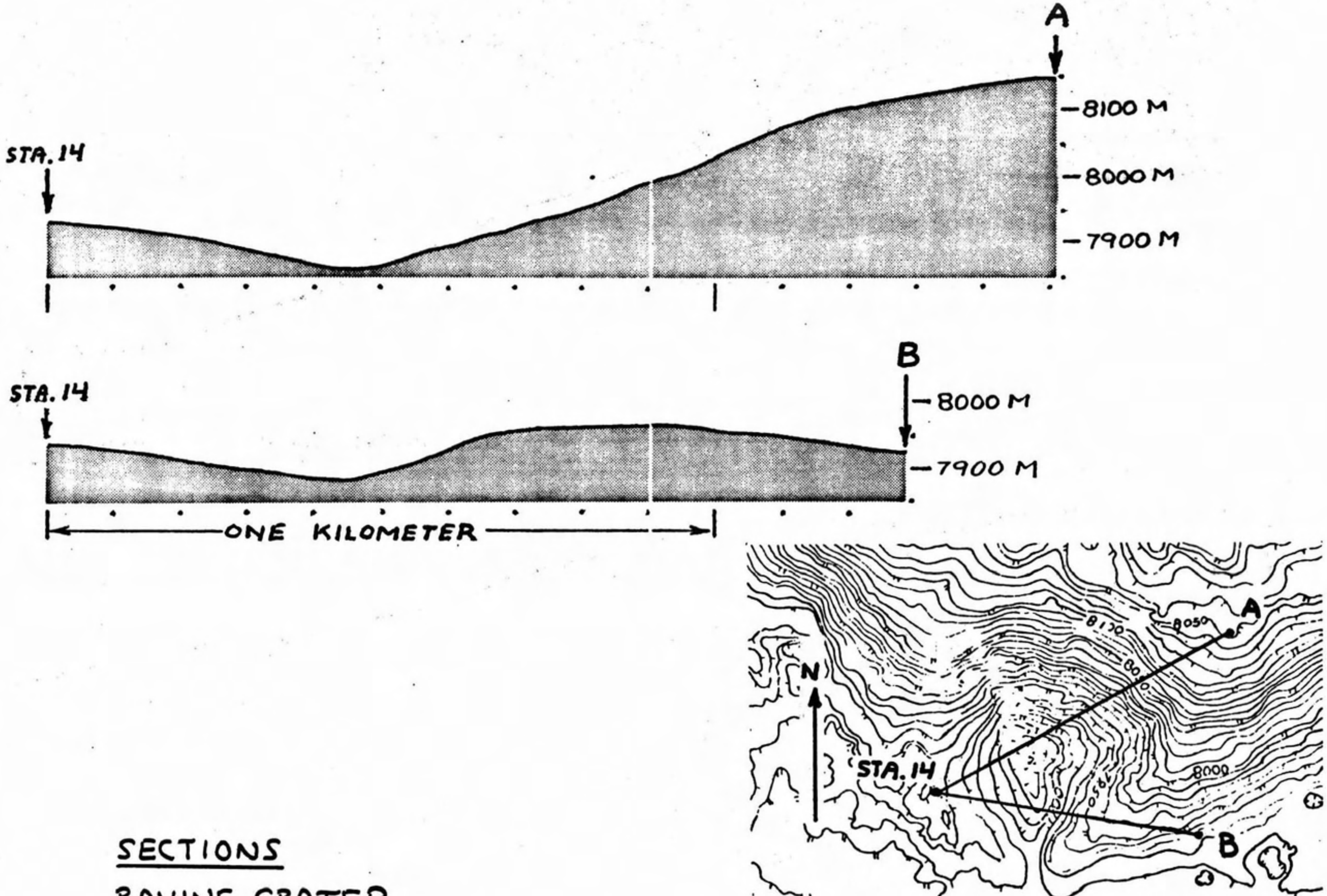
Station 13 - Edge of North Ray Crater Continuous Ejecta Blanket

- Short sample stop to guarantee samples from the upper unit at North Ray
- Will permit a better assessment of stratigraphic sequence within North Ray crater
- Stop should be on blocky side (North Ray side) of edge of ejecta blanket
- The edge should be a low escarpment, may also be lighter albedo
- If no other criteria available for identification stop 1 km from crater rim
- Collect as many rock types as time permits plus least 1 kg of soil
- Pan - very important. Will be only good view of the ejecta blanket. Partial views will be gotten by LRV photos plus pans at rim

Travel/Station 13-14

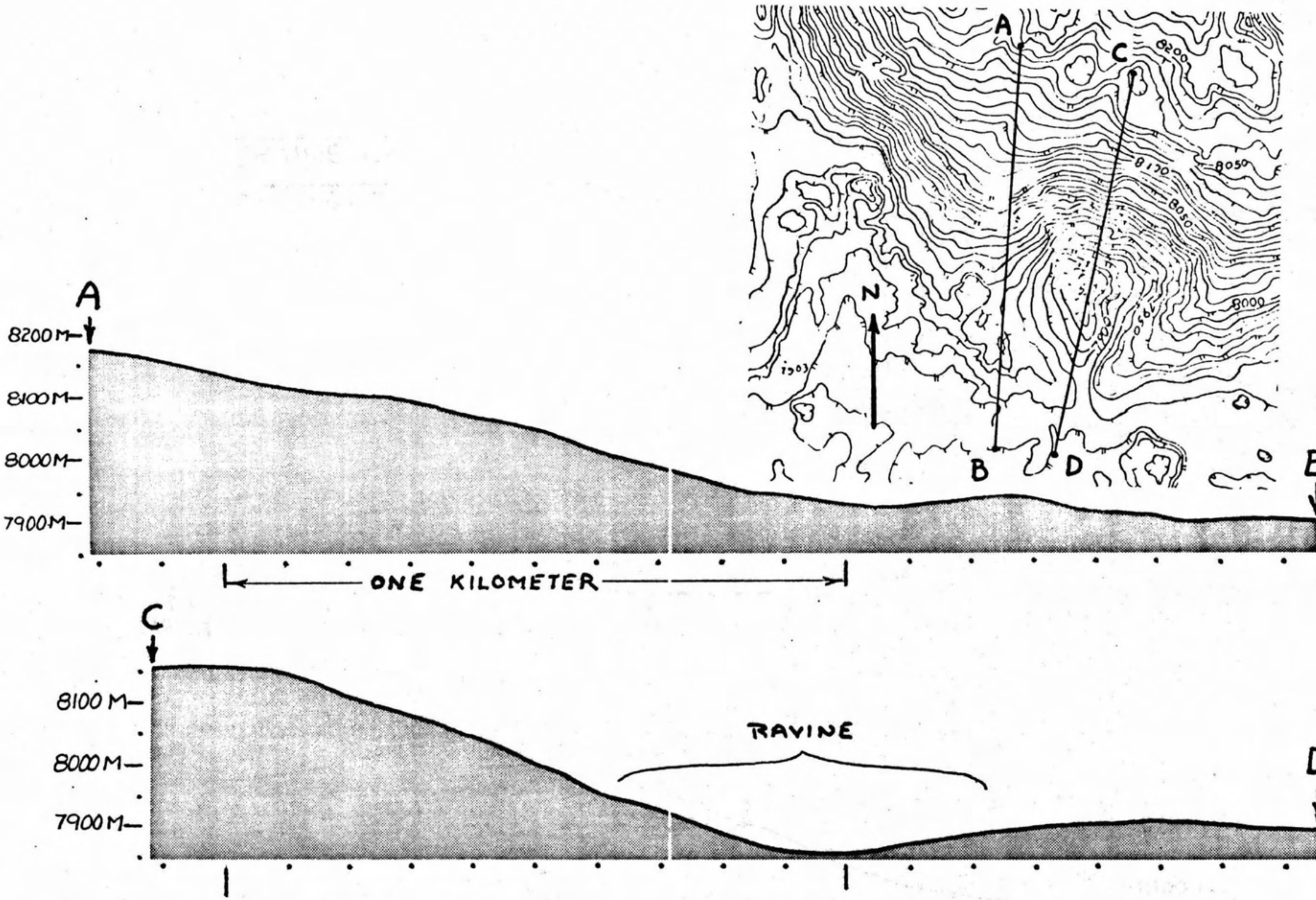
- Smoky Mountain ahead
  - Scarps = faults ?
  - Subhorizontal banding (filigree) = lava flows or slides?
  - Any bedrock exposed?
  - Should have spatter of North Ray secondaries as well as probable discontinuous veneer of North Ray ejecta
- Descartes/Cayley contact - base of slope
  - Any visible differences?
    - Regolith albedo, strength
- Climb slope to ridge overlooking Ravine Crater and Smoky Mountain
- Broad depression near crest to north of Cat Crater

(See topographic profiles)



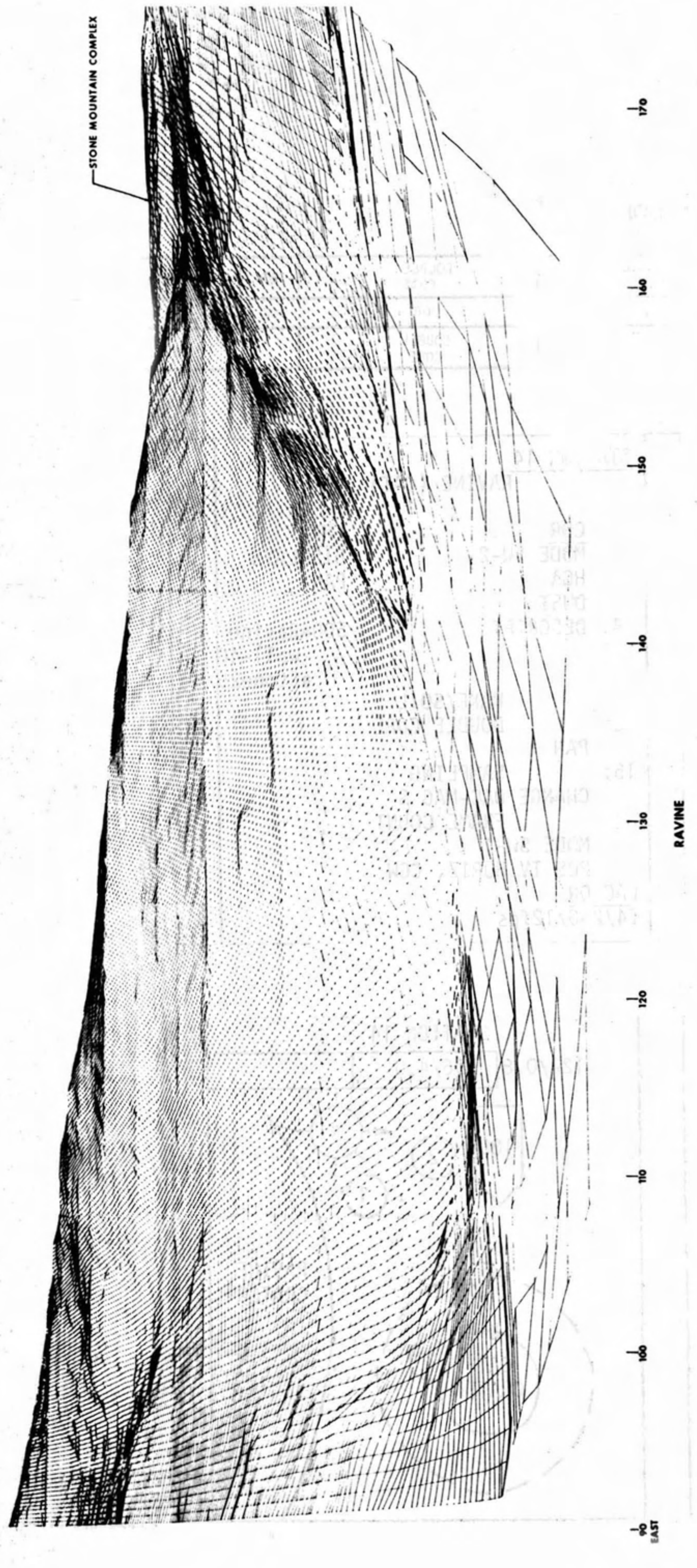
SECTIONS

RAVINE CRATER



SECTIONS

RAVINE CRATER


STONE MOUNTAIN COMPLEX
170
160
150
140
130
120
110
100
90 EAST
RAVINE

STATION:

S' 'ON 14 - SMOKY MOUNTAIN (:40)

)R	O/H		DESCRIP-TION	RAKE/SOIL SAMPLE	DOUBLE CORE	PAN	SAMPLING	O/H
	:03		:04	:08	:08	:02	:13	:02
ΛP	O/H	PAN	500mm PHOTOS	RAKE/SOIL SAMPLE	DOUBLE CORE	SAMPLING		O/H

CUFF-CHECK LIST

TASKS

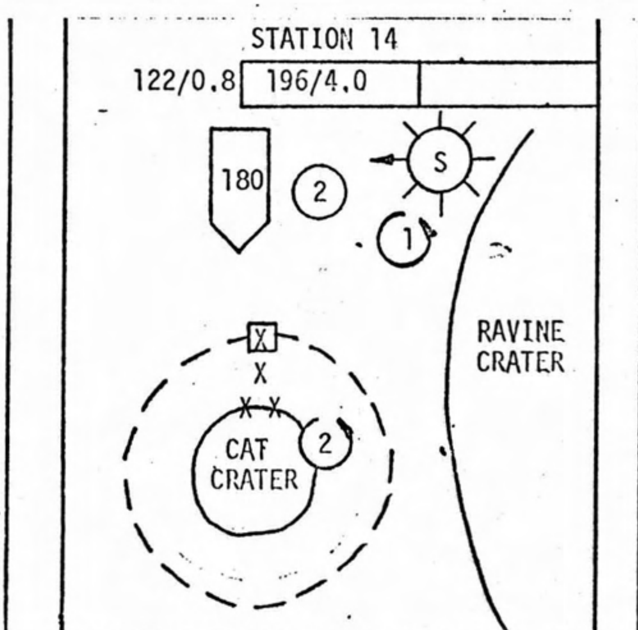
STATION 14
RAVINE (CAT) :40

CDR	LMP
MODE SW-2	DISPLAYS
HGA	PAN
DUST	
4: DESCRIPT	500•Ravine wall-40 •Stone25
8: RAKE/SOIL	
8: DOUBLE CORE	
PAN	
15: SAMPLING	
CHANGE DAC-MAG S FRAME COUNT	
MODE SW-1	
POS TV HORIZ, CCW	

DAC ON
f4/250/12fps

CUFF-CHECK LIST

DRAWING



Station 14 - Cat Crater 50 m diameter

Rationale:

- Flank of Smoky Mountains overlooking Ravine Crater
- Descartes materials for comparison with Stone Mountain
- Complicated area:
  - Near Cayley/Descartes contact
  - North Ray ejecta present
  - Ravine Crater ejecta?
- Cat Crater should have blocky rim and floor. If so has penetrated local bedrock (Descartes)
- Ravine Crater, very irregular shape, sharp bottomed ravine exiting south
  - May be endogenetic with little or no ejecta
  - Possible interpretation - secondary impacts from Theophilus (in line with Big Sag)
  - Either of above cases means Cat Crater ejecta should be dominately Descartes materials

Tasks:

- Park LRV on rim of Ravine facing 180° at Cat Crater about 1 crater diameter from Cat

Pan 1 - Black and White - rim of Ravine Crater and with Cat Crater in view to south

Description -

- Smoky Mountain
  - Banding = lava flows?, slumps?
  - Lineation
  - Outcrop
- Ravine Crater
  - Layering visible on near side on photos - might be on far wall = lave flow fronts? slumps?

500 mm -

- Ravine interior - 40 frames
  - West wall
  - Far wall
  - Ravine itself
- Stone Mountain - 25 frames/second leg of stereo set
- Targets of opportunity up Smoky Mountain

Rake/soil -

- Beyond ejecta blanket of Cat Crater
- If there is a great variety of rock types on Cat Crater, then it is likely that it did not penetrate to bedrock. Rake on crater rim in this case

Double Core -

- Take it away from the ejecta blanket of Cat Crater
- General vicinity of rake sample

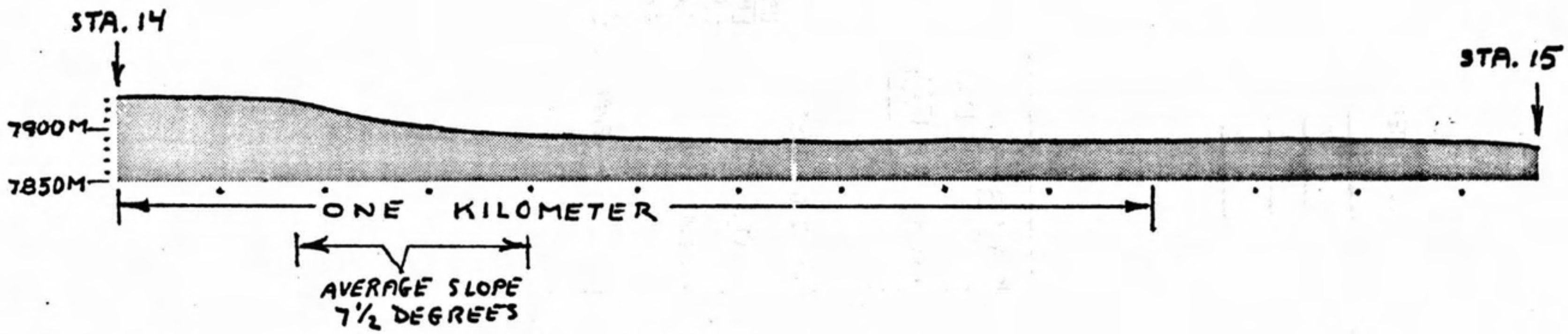
Pan 2 - Color - Rim of Cat Crater so that interior of both craters can be studied

Sampling - 15 minutes

- Rim of Cat Crater first, then radially out for 1/2 D sample
- Variety of rock types plus large bag of soil
- The combination of the sample types (rake/soil, core, documented samples) should give the necessary material to unravel the superportion relationships and (hopefully) origin of the major features

Travel/Station 14-15

- Down Smoky Mountain to base
- Southward across terrain that should have decreasing amounts of North Ray ejecta
- Ray material from South Ray crater might be faintly visible in bands
- North-trending escarpments to east of traverse.Giant block field beyond them



TRAVERSE

STA. 14 TO STA. 15

STATION:

STATION 15 - DOG LEG CRATER (:10)

CDR	O/H	LPM MEAS.		O/H
	:01	:02	:05	:02
LMP	O/H	PAN	ROCK/SOIL SAMPLE	O/H

CUFF-CHECK LIST

TASKS

STATION 15
DOG LEG CRATER :10

183/1.3 | 201/3.0 |

LRV=180°
(20 M from rim)

NO TV OR DUST

DAC OFF

CDR — 8: LPM

LMP — PAN, ROCK, SOIL (1 KG)

FRAME COUNT

CUFF-CHECK LIST

DRAWING

Station 15 - Dogleg 50 m diameter

- Several craters of either side of Dogleg appear to be suitable alternate candidates for station 15
- Travel appropriate distance and pick best 40-50 m diameter, blocky-rimmed crater for this stop
- Park facing 180° about 20 m from crater rim

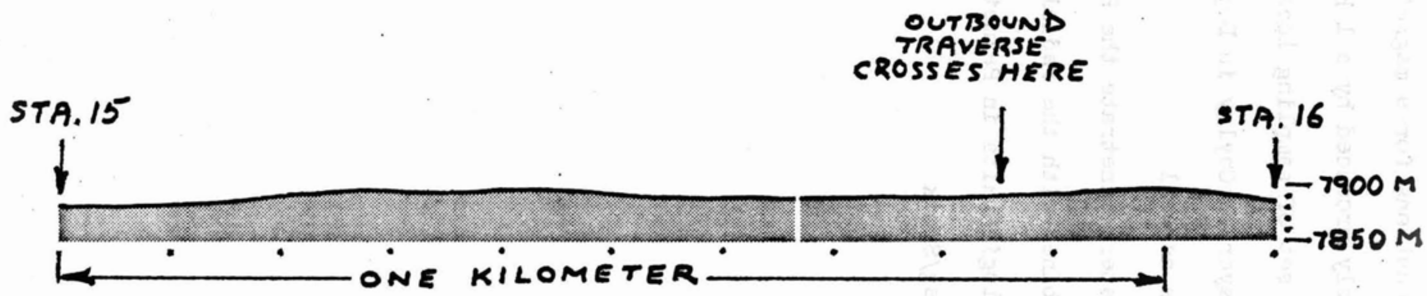
Pan - Black and White - From crater rim adjacent to sampling site - will also show setting of LPM measurement

Sample - On crater rim. Specifically, after top layer of Cayley plus 1 kg soil sample

LPM Measurement - Taken as far away from crater rim as cable and parking location permits

Travel/Station 15-16

- Escarpments facing west and creases trending north lie across traverse route although are mainly to north
- Cross outbound tracks
- Dot Crater should have blocky prominent ejecta blanket and be on low ridge



TRAVERSE

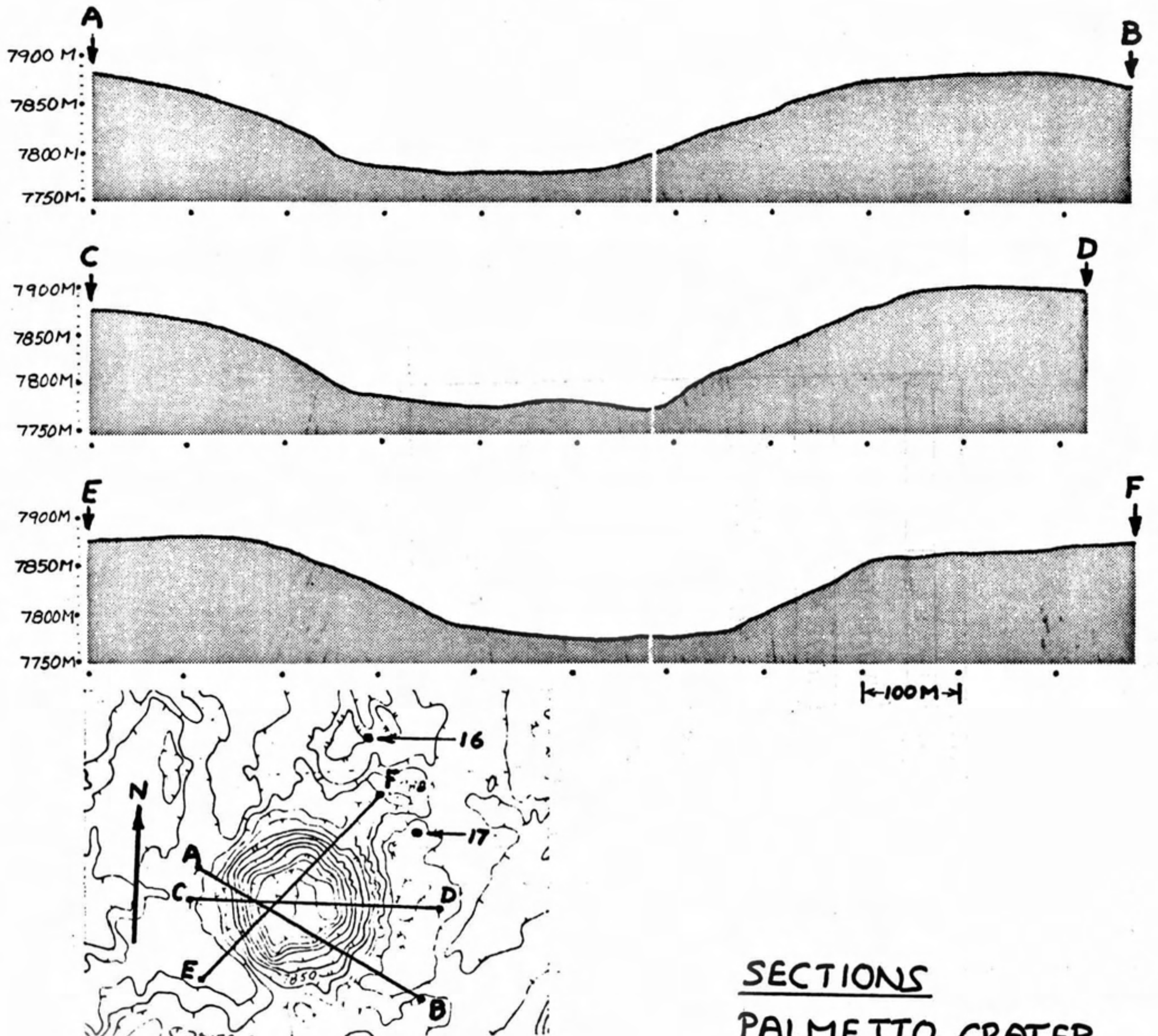
STA. 15 TO STA. 16

Palmetto Crater Exploration Scheme

- Stations 15, 16, and 17 are 1 D, 1/4 D, on rim of Palmetto Crater
- Constitute prime locations for a magnetic survey of Palmetto to determine the anomaly produced by a 1 km crater
- Constitute a prime set of sampling locations to

1. Identify top layer of Cayley in Dogleg (station 15) and probably at Dot and End Craters as well

2. Dot and End Craters penetrate the Palmetto ejecta blanket. The rim sample of Dot combined with the radial sample of End should permit analysis of the lithologic units in Palmetto and possible correlations into North Ray and Flag/Spook



SECTIONS
PALMETTO CRATER

STATION:

STATION 16 - DOT CRATER (:10)

CDR	O/H	LPM MEAS.		O/H
	:01	:02	:05	:02
LMP	O/H	PAN	ROCK/SOIL SAMPLE	O/H

CUFF-CHECK LIST

TASKS

LOOK FOR:
●N scarp | 196/2.8 |
STATION 16
DOT CRATER :10

251/1.0 | 182/2.4 |

LRV=180°
(20 M from rim)

NO TV OR DUST

CDR	LMP PAN
8: LPM	ROCK SOIL (1 KG)

FRAME COUNT

CUFF-CHECK LIST

DRAWING

Station 16/Dot Crater 50 m diameter

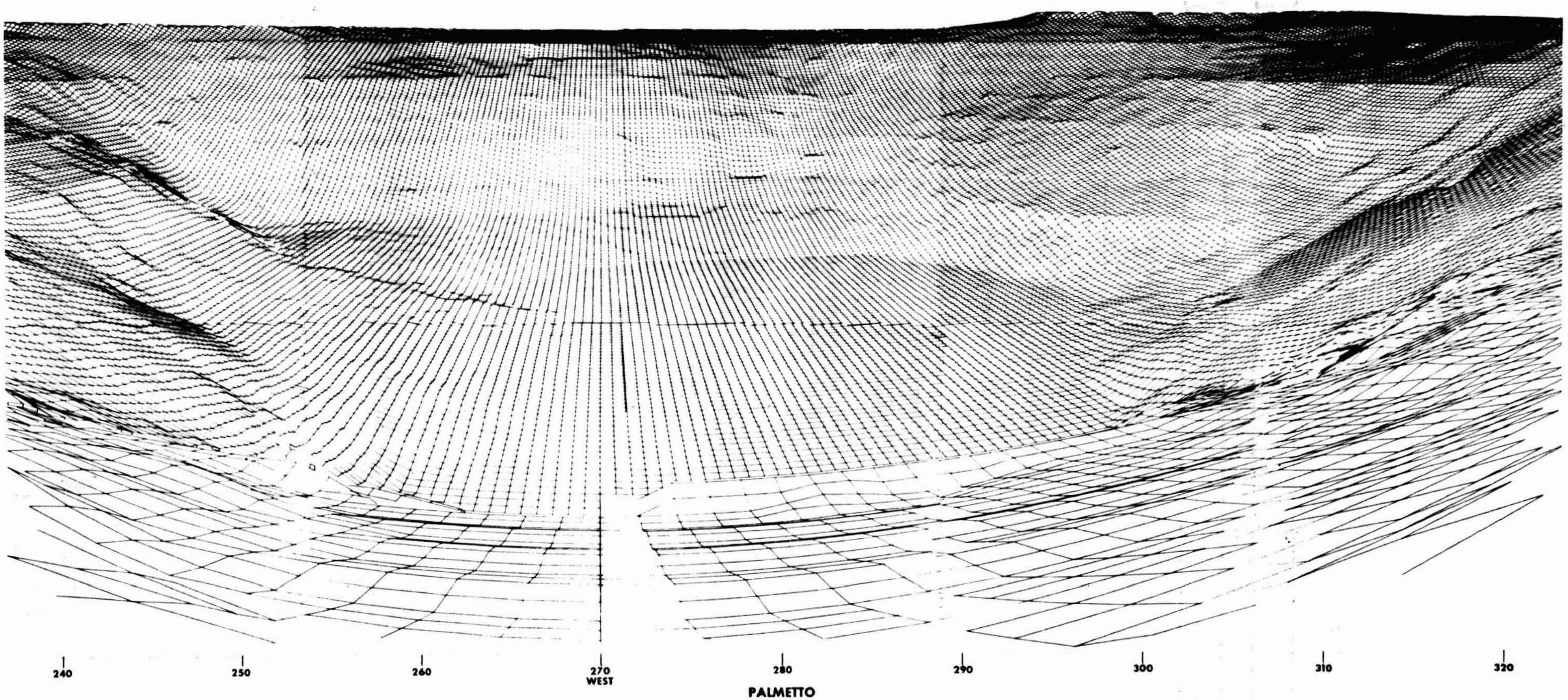
- Procedures same as for Dogleg - Station 15
- Park LRV about 20 m from crater
- Pan - Crater rim next to sample area
- Samples - Collect as wide a variety of rock types as time permits
  - Station is 1/4 D out on ejecta blanket and thus should contain samples from about top 50-60% of Palmetto sequence
  - Collect 1 kg soil
- LPM - Take reading as far from crater rim as cable permits

Press on

Travel/Station 16-Station 17

- Pass along northeast rim of large (250 m) degraded crater on rim of Palmetto crater
- End Crater is on summit of low mound near rim of Palmetto Crater

VIEW ON PALMETTO RIM



STATION:

STATION 17 - PALMETTO CRATER (:38)

CDR	O/H	DESC	RAKE/SOIL SAMPLE	LPM MEAS. (2)	SAMPLING*		O/H
	:03	:03	:08	:10	:12		:02
LMP	O/H PAN	DESC	RAKE/SOIL SAMPLE	SAMPLING			O/H

CUFF-CHECK LIST

TASKS

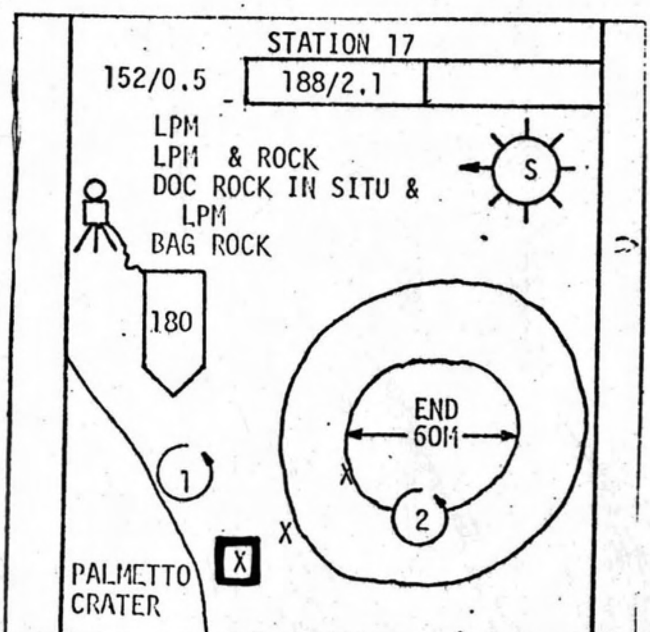
STATION 17
PALMETTO CRATER :38

CDR	LMP
MODE SW-2	DISPLAYS
HGA	PAN 1
DUST	

3: DESCRIPT
8: RAKE/SOIL
10: LPM / LPM/ROCK — SAMPLING (igneous rock for LPM)
12: PAN 2
RADIAL SAMPLING
ROCK
SOIL (1 KG)
FRAME COUNT
MODE SW-1
POS TV HORIZ, CCW
LOOK FOR: NW creases | 190/1.3

CUFF-CHECK LIST

DRAWING



Station 17 - End Crater 60 m diameter

- End Crater has two possible interpretations

  1. Fresh impact crater and thus penetrates Palmetto Crater ejecta
  2. Central vent of low volcanic mound (less likely - but if so would probably constitute youngest volcanism in the landing area)

Either of the above cases make End Crater very important.

- Park LRV on rim of Palmetto for views into Palmetto, unless walking distance to rim of End Crater is too great

Pan 1 - Black and White - Rim of Palmetto Crater

View of mound in bottom if possible

Description -

- Palmetto very degraded. Thus anticipate only regolith slump features on walls
- End Crater - blockiness and appearance - Observations pertinent to origin probably best done on drive up, and from crater rim

Rake/soil - Take near LRV parking area (on Palmetto rim?)

One man sampling - in vicinity of LPM measurement so that one of these rocks can be used for the magnetic rock study on the LPM.

LPM Measurements

- Station measurement as for Station 15/16
- Put igneous documented rock on LPM
    - Stereo pair of rock on LPM
    - LPM reading with rock on meter
    - Bag sample

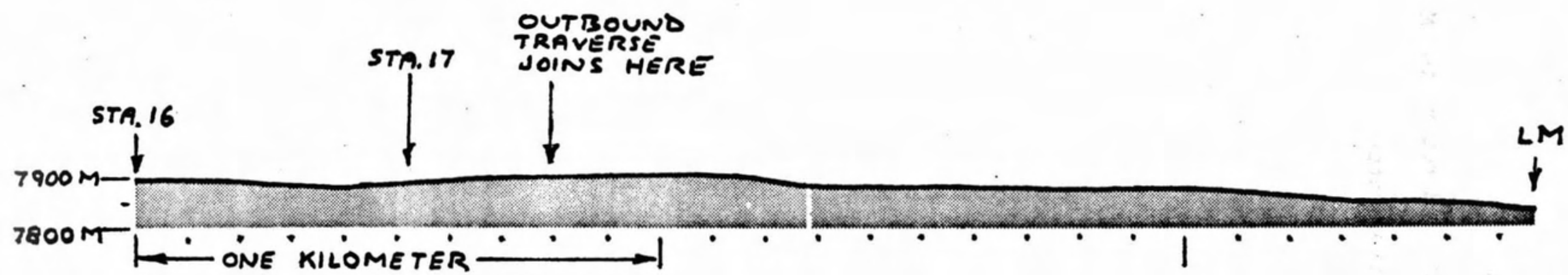
Pan 2 - Rim of End Crater

Sampling - Radial sample of End Crater rocks plus 1 kg soil

1. On rim
2. 1/2 D out

Rake sample constitutes 1 D sample

Hurry on



TRAVERSE

STA. 16 TO LM

Travel/Station 17 - LM

- Rejoin outbound route and return to LM
- P^ss flank of Palmetto Crater
- Cross crease
- Large mound to west
- LM in view

Home free

The enclosed maps will be on board the spacecraft. The crew will carry, during an individual EVA, only those sheets which are pertinent to that particular traverse.

The maps are mounted on a clipboard on the Rover.

EXPLANATION FOR GEOLOGIC MAPS (1:12,500 and 1:25,000 SCALES) APOLLO 16 (DESCARTES) LANDING SITE AREA

STRATIGRAPHY

Ici

CAYLEY FORMATION

Stratified materials, with layers about 10-40 m thick. Underlying rolling, irregular surface; interpreted to be mafic to intermediate volcanics.

Idd	Idd_1	
	Idd_2	

MATERIALS OF THE DESCARTES MOUNTAINS

Stratified, with layers about 10-40 m thick; forms domes. Divided on Stone Mountain into a light medium-gray lower unit (Idd_1) and a dark medium-gray upper unit (Idd_2). Interpreted to be intermediate volcanics with lower part gradational into Ici.

IMBRIAN

GEOLOGIC AND TOPOGRAPHIC SYMBOLS (WHITE)

GEOLOGIC CONTACT

Dashed where approximately located

Convex Concave

ESCARPMENT CREASE

TRAVERSE SYMBOLS (BLACK)

NOMINAL LM SITE

LINE OF TRAVERSE

12• •A

LRV WALKING

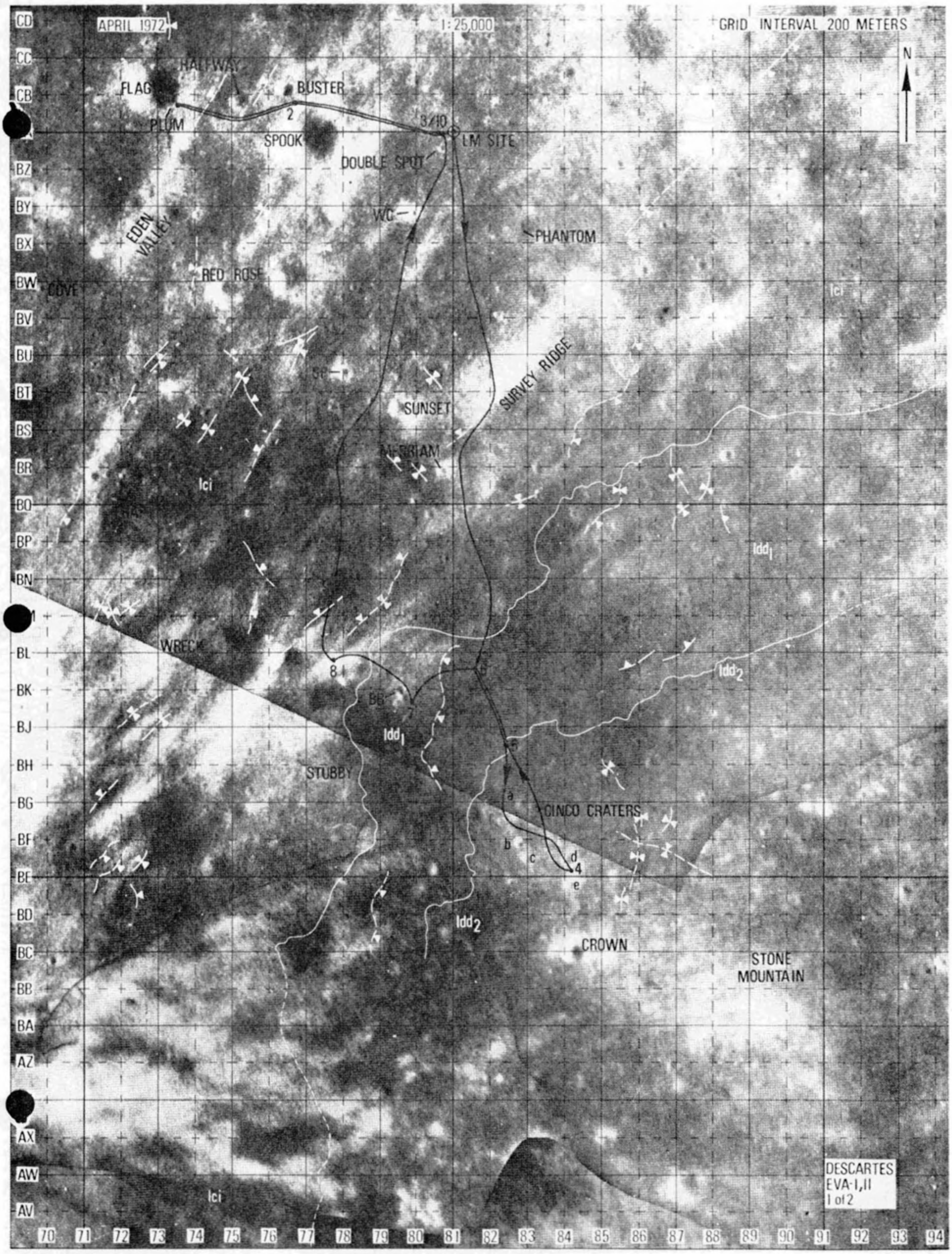
STATIONS

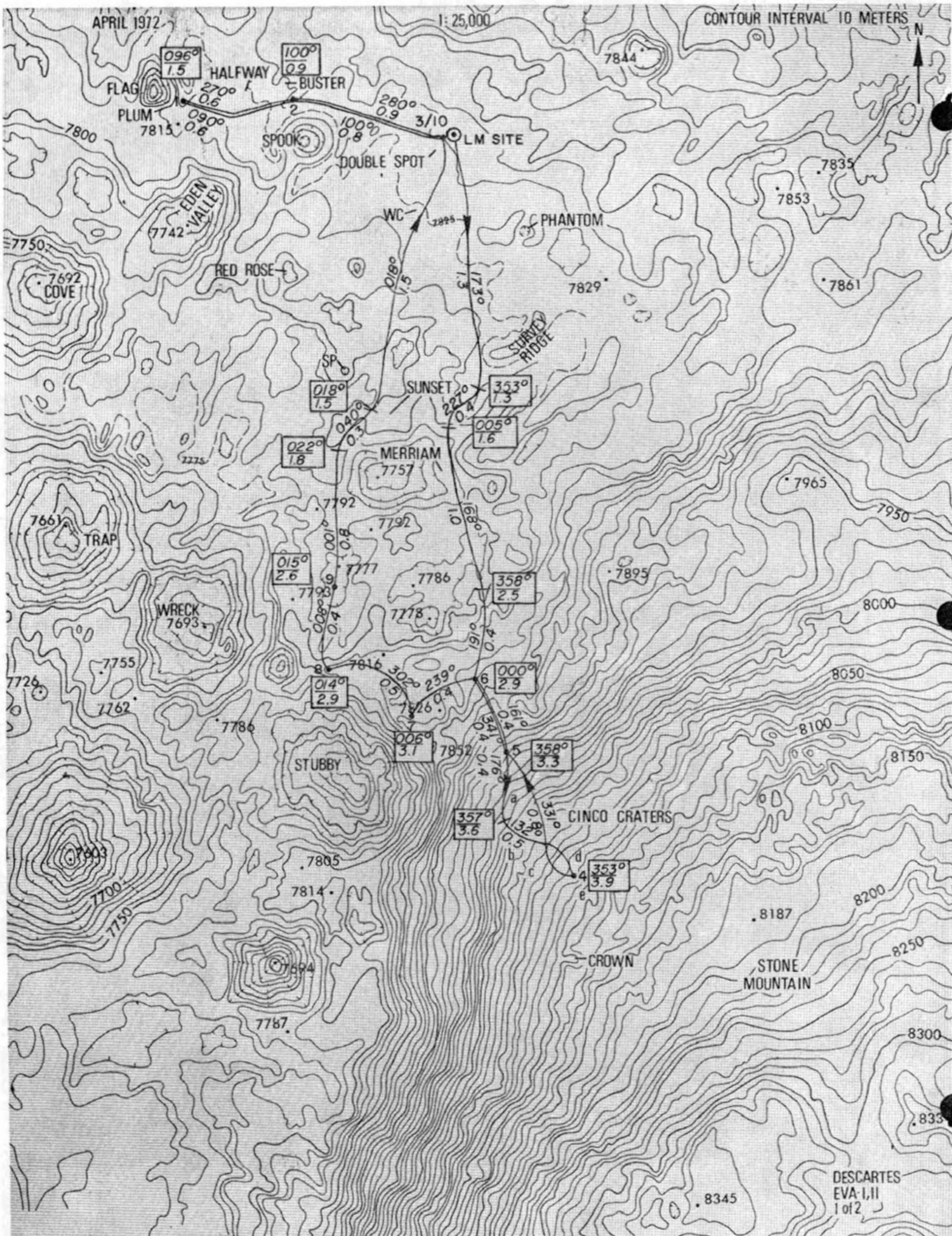
16• 251° / 1.0 •15

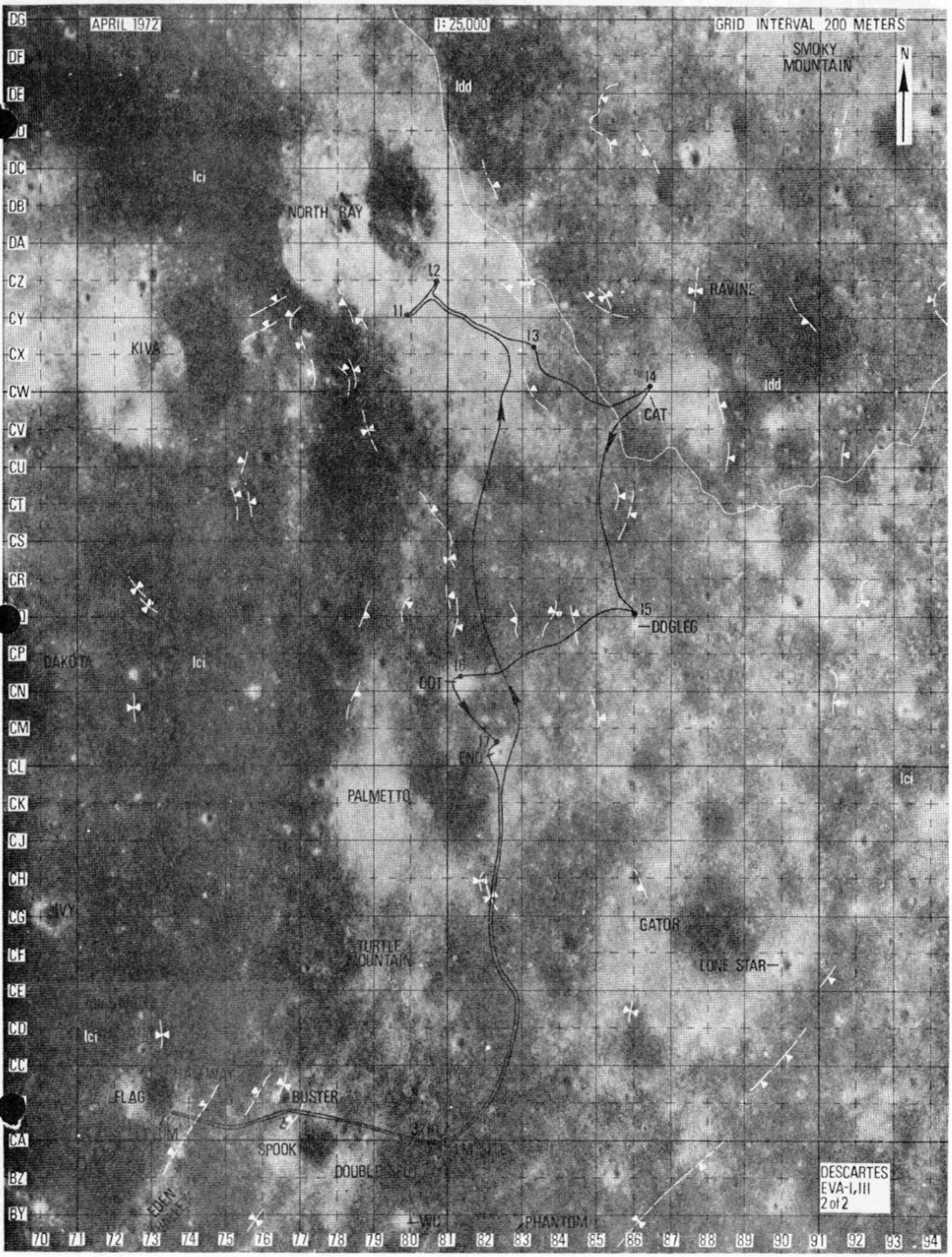
AZIMUTH (251°) AND APPROXIMATE DISTANCE (1.0) BETWEEN STATIONS: AVERAGE AZIMUTHS GIVEN ON CURVING TRAVERSE SEGMENTS.

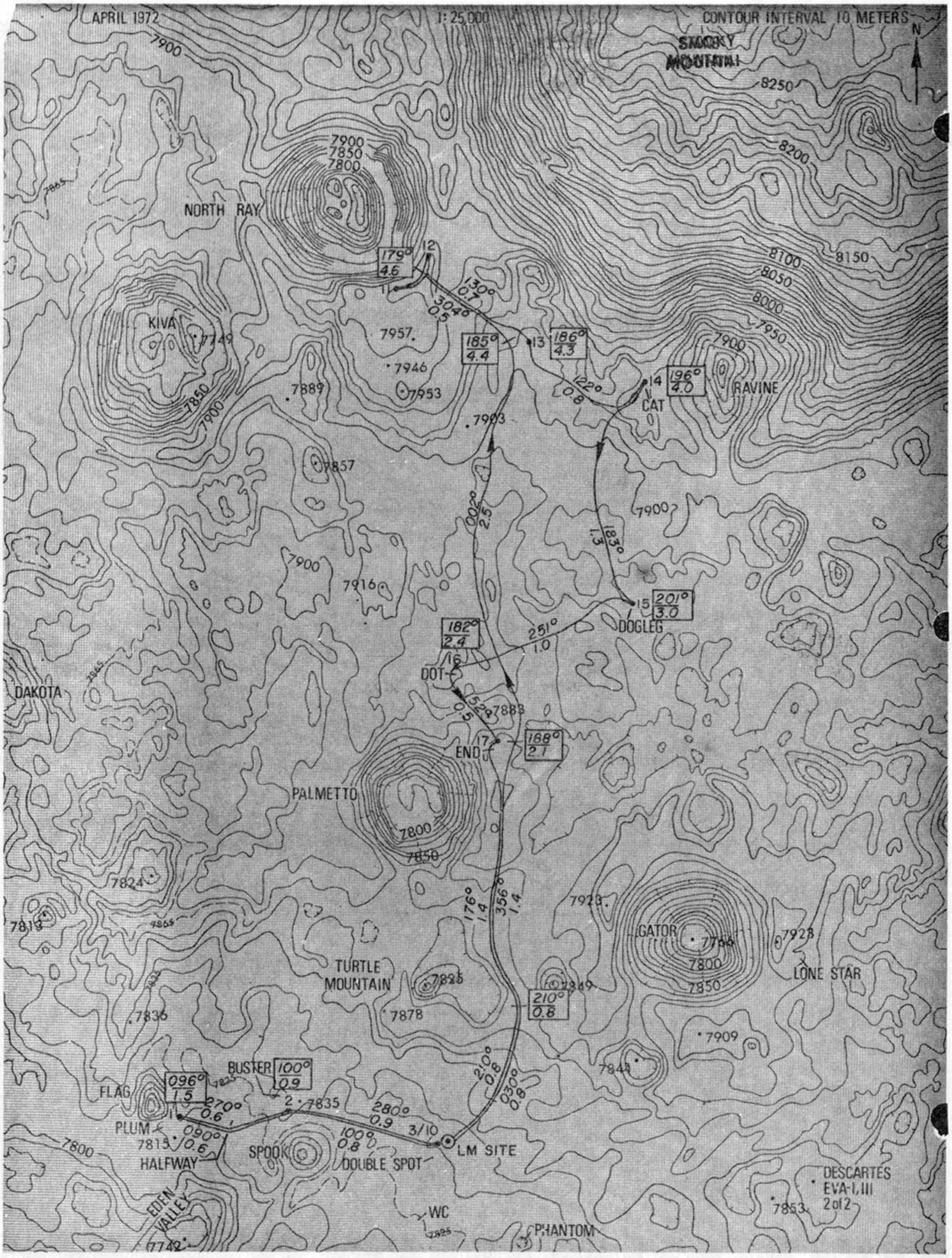
— $\boxed{179° / 4.6}$ •12

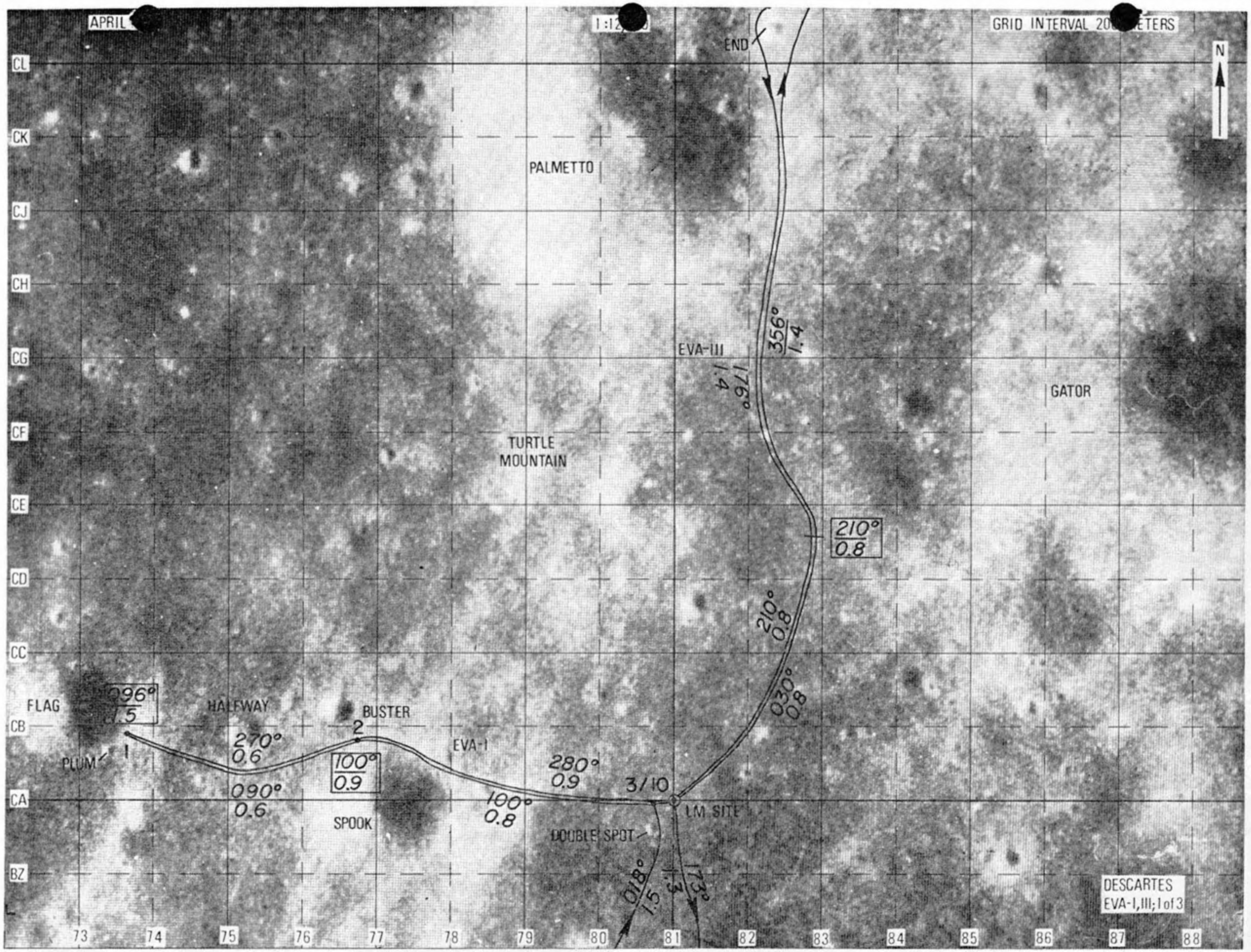
BEARING (179°) AND RANGE (4.6) OF SHORTEST DISTANCE TO LM FROM STATION OR FROM MAJOR CHANGE IN TRAVERSE DIRECTION.

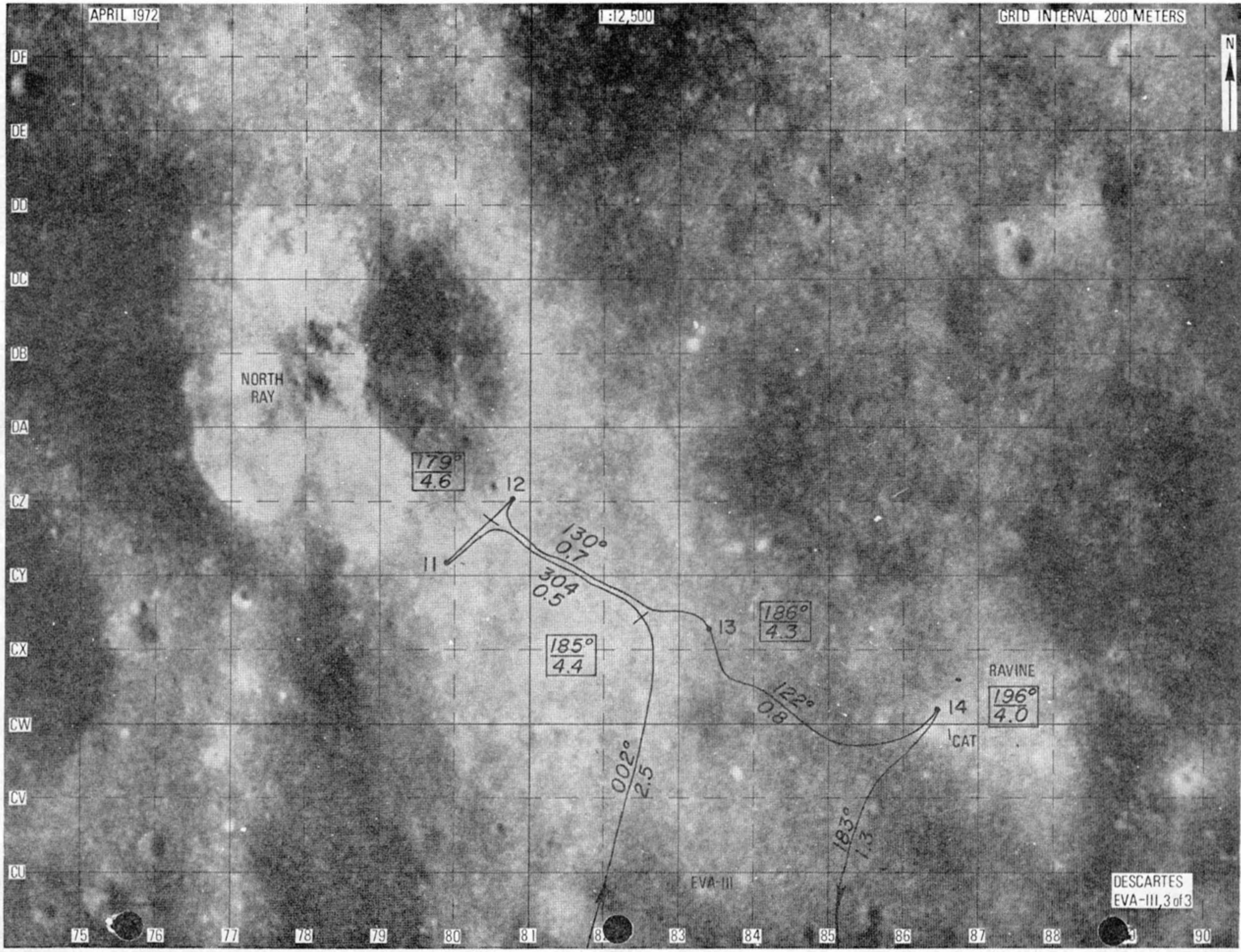

APRIL 1972
1:25,000
GRID INTERVAL 200 METERS
N
FLAG
HALFWAY
BUSTER
PLUM
SPOOK
LM SITE
DOUBLE SPOT
WC
PHANTOM
EDEN VALLEY
RED ROSE
COVE
SURVEY RIDGE
SUNSET
MERRIAM
Ici
Idd1
Idd2
WRECK
BB
STUBBY
CINCO CRATERS
CROWN
STONE MOUNTAIN
DESCARTES
EVA-I,II
1 of 2

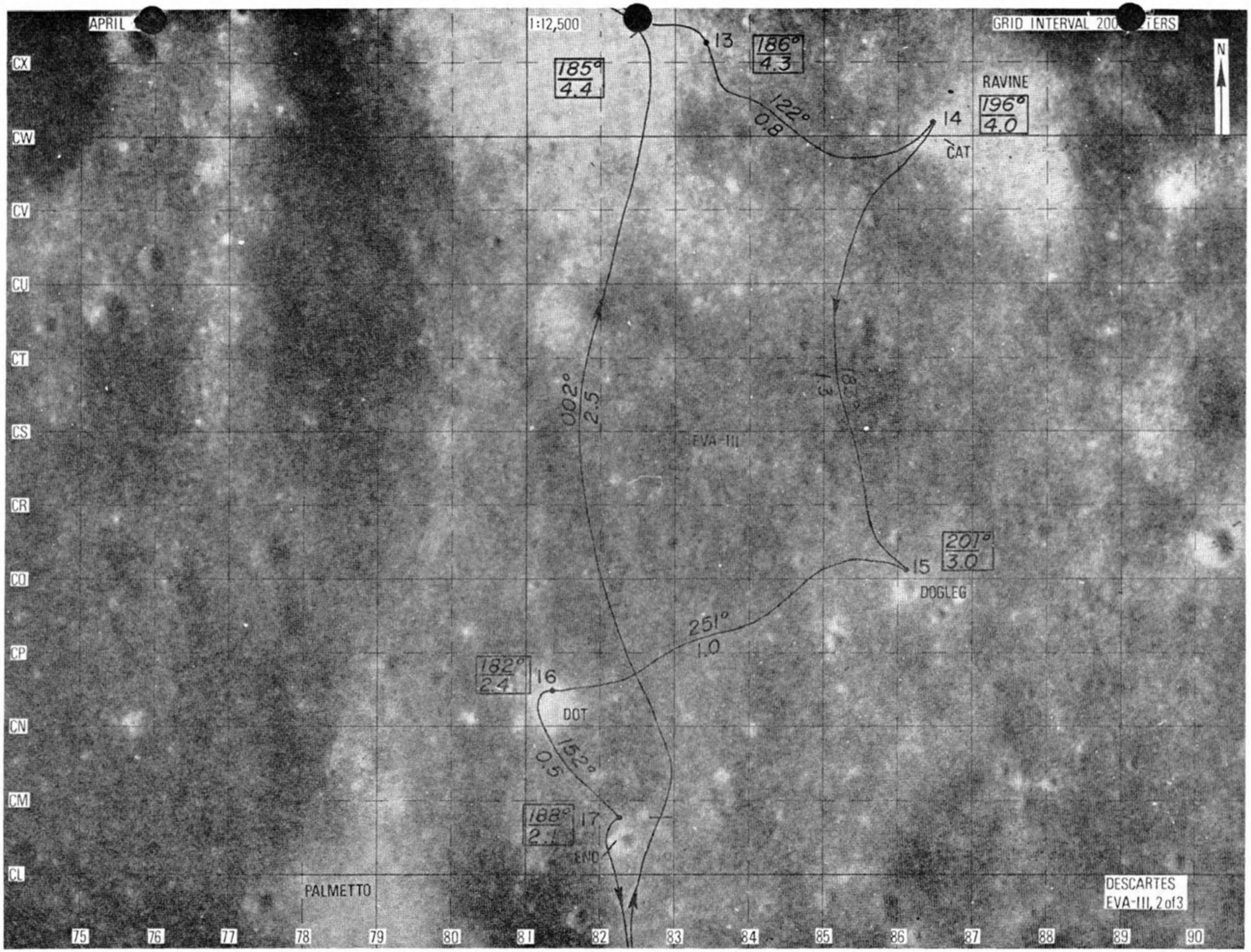

APRIL 1972
1: 25,000
CONTOUR INTERVAL 10 METERS
N
FLAG
PLUM
HALFWAY
BUSTER
SPOOK
DOUBLE SPOT
LM SITE
EDEN VALLEY
COVE
RED ROSE
PHANTOM
WC
SP
SUNSET
SURVEY RIDGE
MERRIAM
TRAP
WRECK
STUBBY
CINCO CRATERS
CROWN
STONE MOUNTAIN
096° 1.5
100° 0.9
018° 1.5
022° 1.8
015° 2.6
014° 2.9
006° 3.1
353° 1.3
005° 1.6
358° 2.5
000° 2.9
358° 3.3
357° 3.6
353° 3.9
DESCARTES
EVA-I,II
1 of 2


APRIL 1972
1:25,000
GRID INTERVAL 200 METERS
SMOKY MOUNTAIN
N
Idd
Ici
NORTH RAY
12
11
13
RAVINE
KIVA
14
CAT
Idd
15
DOGLEG
DAKOTA
Ici
16
DOT
17
END
PALMETTO
Ici
GATOR
TURTLE MOUNTAIN
LONE STAR
Ici
FLAG
BUSTER
SPOOK
PHANTOM
WC
DESCARTES
EVA-I, III
2 of 2


APRIL 1972
1:25,000
CONTOUR INTERVAL 10 METERS
N
SMOKY MOUNTAIN
NORTH RAY
KIVA
DAKOTA
PALMETTO
TURTLE MOUNTAIN
GATOR
LONE STAR
RAVINE
CAT
DOGLEG
DOT
END
FLAG
BUSTER
PLUM
HALFWAY
SPOOK
DOUBLE SPOT
LM SITE
EDEN VALLEY
WC
PHANTOM
DESCARTES
EVA-I, III
2 of 2


APRIL
1:12
GRID INTERVAL 200 METERS
N
END
PALMETTO
EVA-III
176°
1.4
356°
1.4
GATOR
TURTLE
MOUNTAIN
210°
0.8
210°
0.8
030°
0.8
FLAG
096°
1.5
HALFWAY
BUSTER
2
270°
0.6
EVA-I
280°
0.9
3/10
PLUM
1
100°
0.9
090°
0.6
SPOOK
100°
0.8
LM SITE
DOUBLE SPOT
018°
1.5
1.3
173°
DESCARTES
EVA-I,III; 1 of 3
CL
CK
CJ
CH
CG
CF
CE
CD
CC
CB
CA
BZ
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88


APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
N
NORTH RAY
179°
4.6
12
11
130°
0.7
304
0.5
13
186°
4.3
185°
4.4
RAVINE
122°
0.8
14
196°
4.0
CAT
002°
2.5
183°
1.3
EVA-III
DESCARTES
EVA-III, 3 of 3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CAT
DOGLEG
DOT
END
PALMETTO
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EVA-III, 2 of 3
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14
15
16
17
185° 4.4
186° 4.3
196° 4.0
201° 3.0
182° 2.4
188° 2.1
122° 0.8
1.3
002° 2.5
251° 1.0
152° 0.5
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CW
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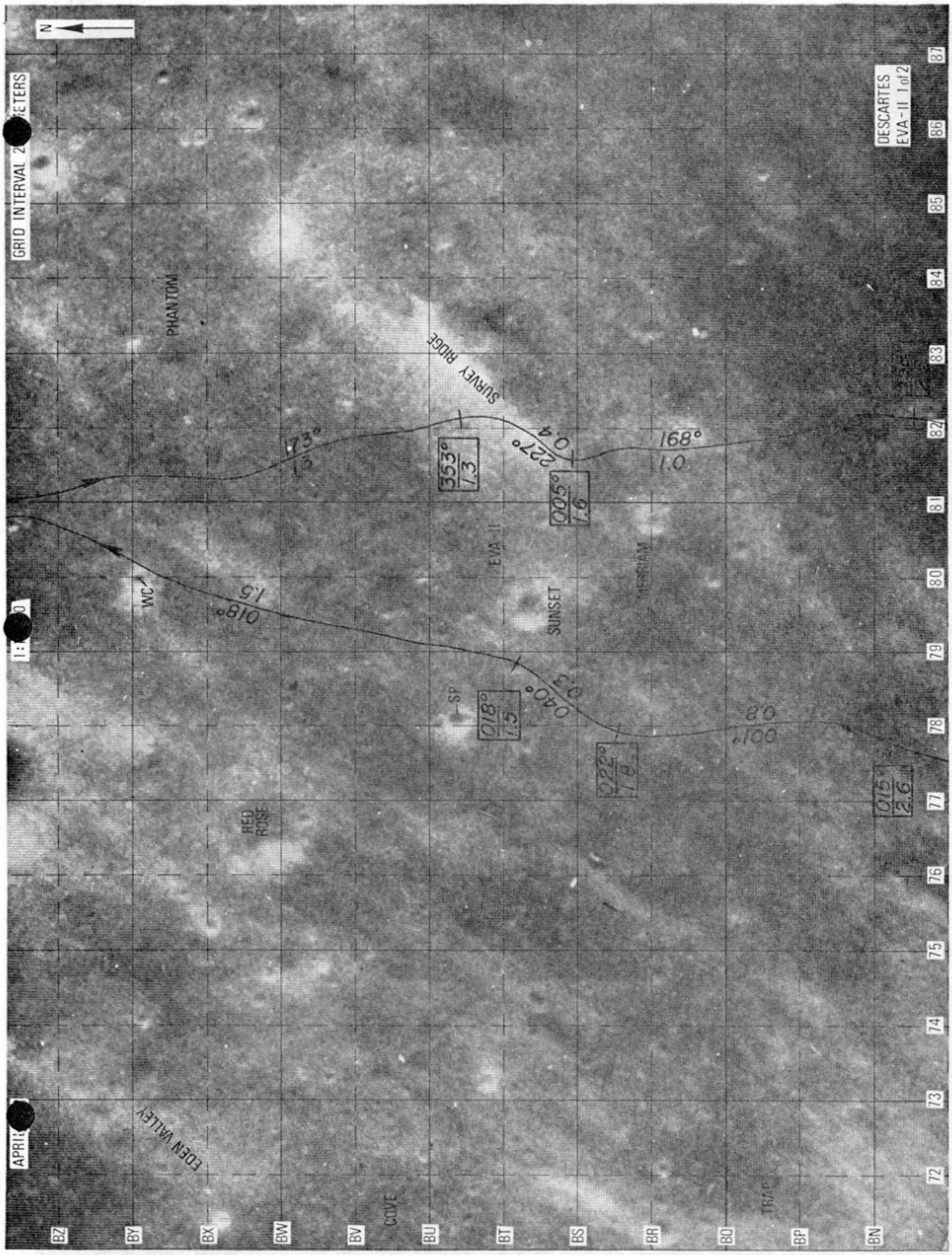
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DESCARTES
EVA-II 1 of 2
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SURVEY RIDGE
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353°
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EVA-II
SUNSET
WC
018°
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RED ROSE
EDEN VALLEY
COVE
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BV
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BS
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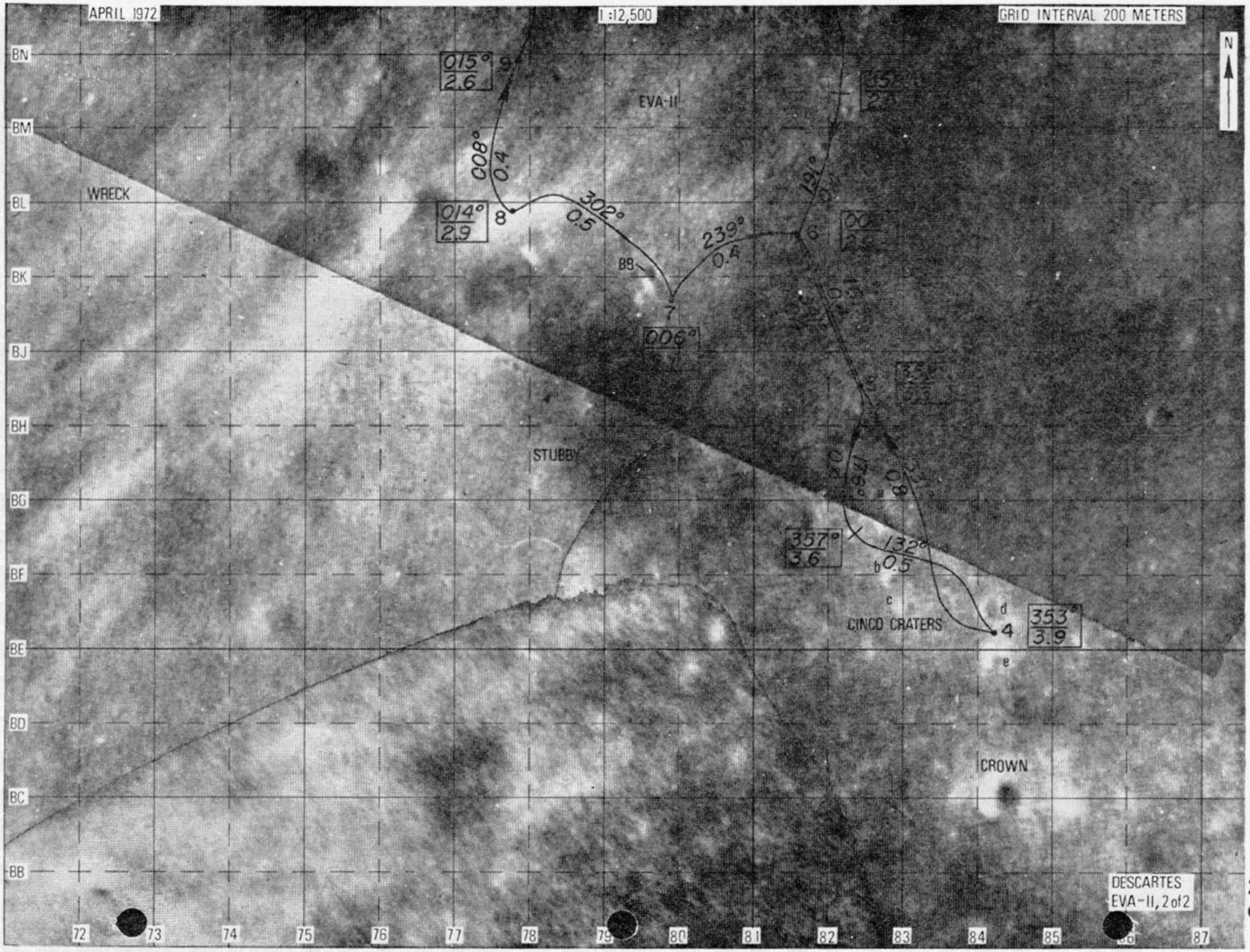
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STUBBY
CINCO CRATERS
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9
008° 0.4
014° 2.9
8
302° 0.5
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239° 0.4
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132° 0.5
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a
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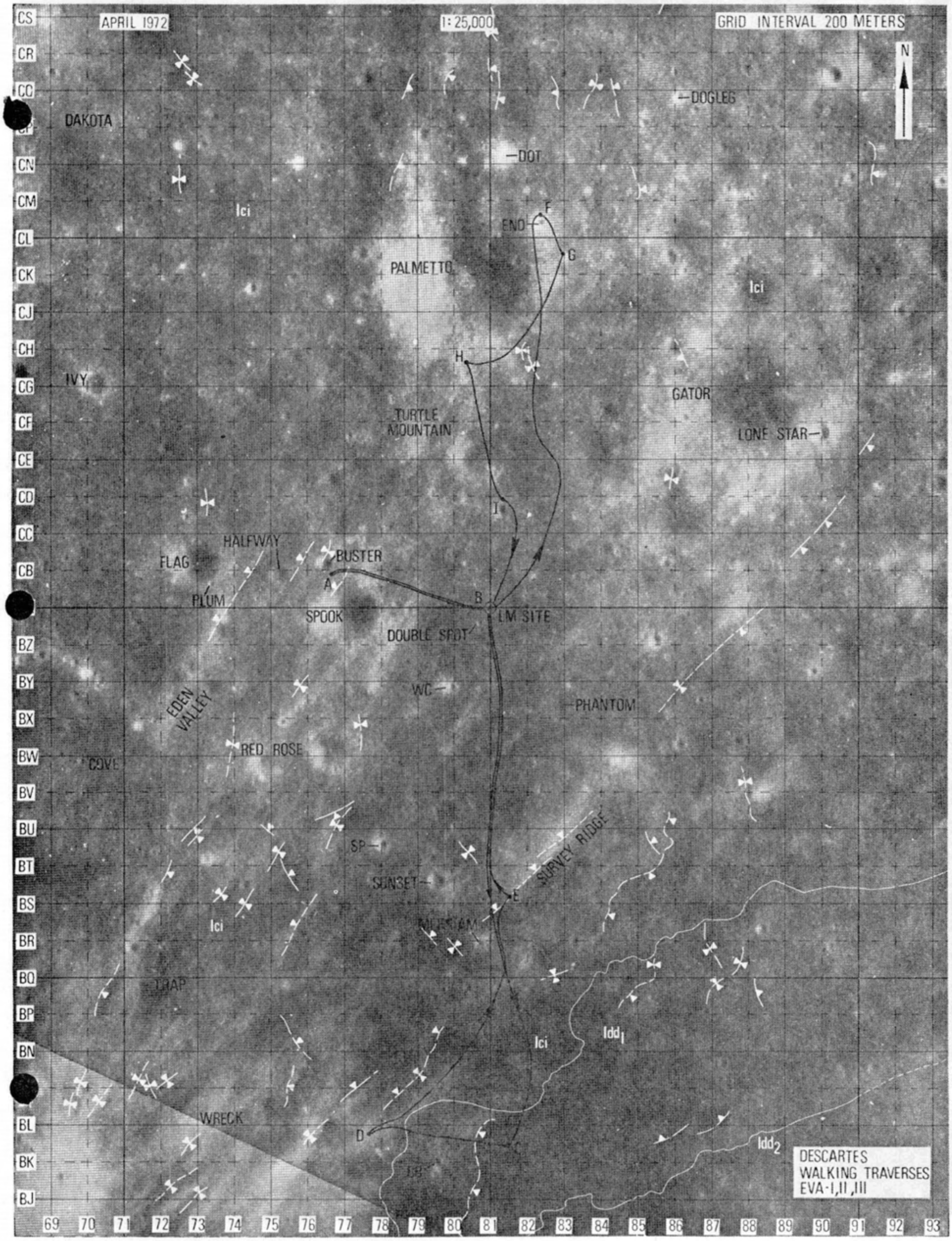
DESCARTES
EVA-II, 2 of 2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TURTLE MOUNTAIN
LONE STAR
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HALFWAY
BUSTER
FLAG
A
PLUM
B
SPOOK
LM SITE
DOUBLE SPOT
WC
EDEN VALLEY
PHANTOM
RED ROSE
COVE
SP
SURVEY RIDGE
SUNSET
E
TRAP
Idd1
WRECK
D
Idd2
DESCARTES
WALKING TRAVERSES
EVA-I,II,III
CS
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CM
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APRIL 1972
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DOGLEG
DAKOTA
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LM SITE
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PHANTOM
RED ROSE
EDEN VALLEY
COVE
SP
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MERRIAM
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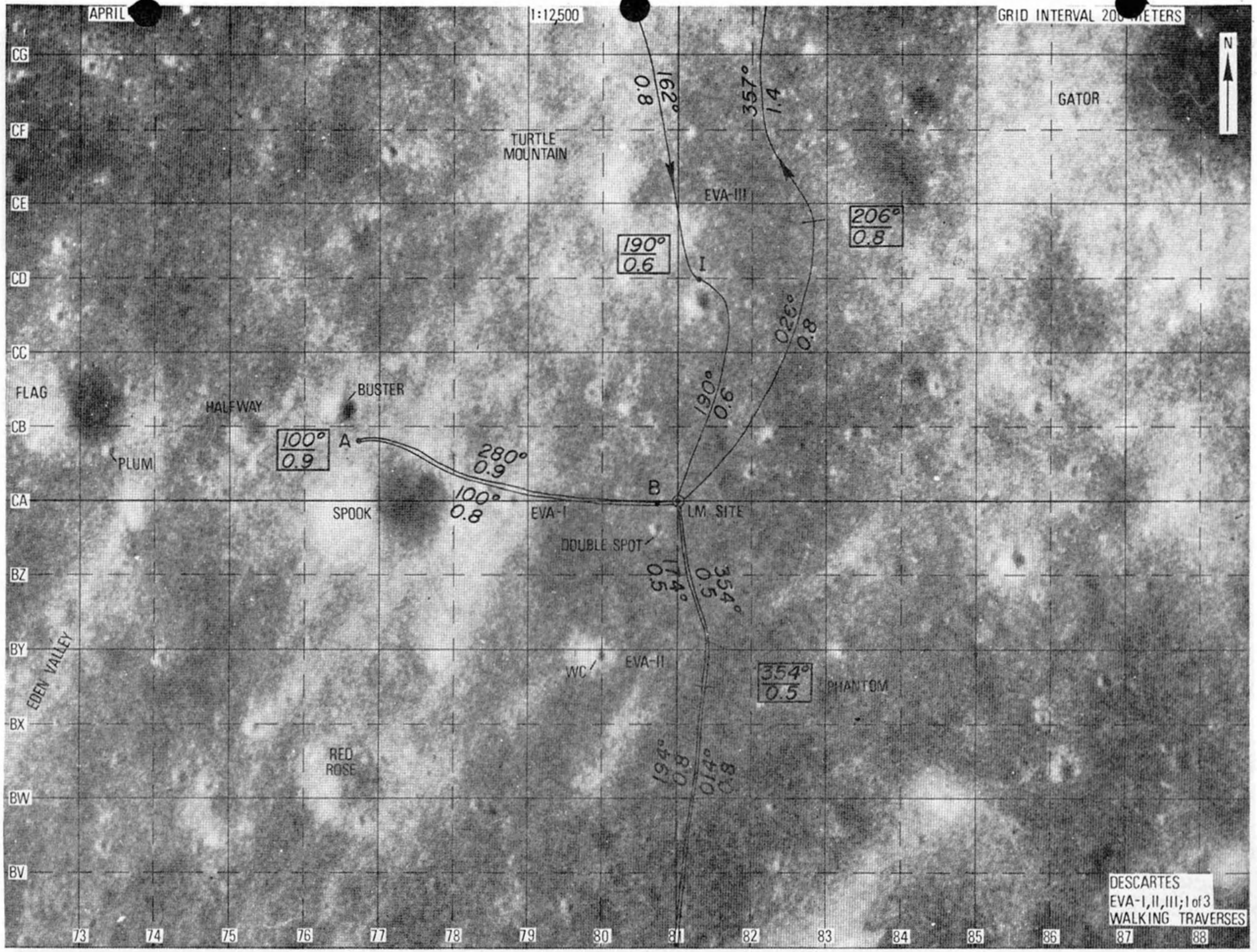
BB
STUBBY
DESCARTES
WALKING TRAVERSES
EVA-I, II, III



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190° 0.6
I
026° 0.8
190° 0.6
FLAG
HALFWAY
BUSTER
PLUM
100° 0.9
A
280° 0.9
100° 0.8
SPOOK
EVA-I
B
LM SITE
DOUBLE SPOT
174° 0.5
354° 0.5
EDEN VALLEY
WC
EVA-II
354° 0.5
PHANTOM
RED ROSE
194° 0.8
014° 0.8
DESCARTES
EVA-I, II, III; 1 of 3
WALKING TRAVERSES
CG
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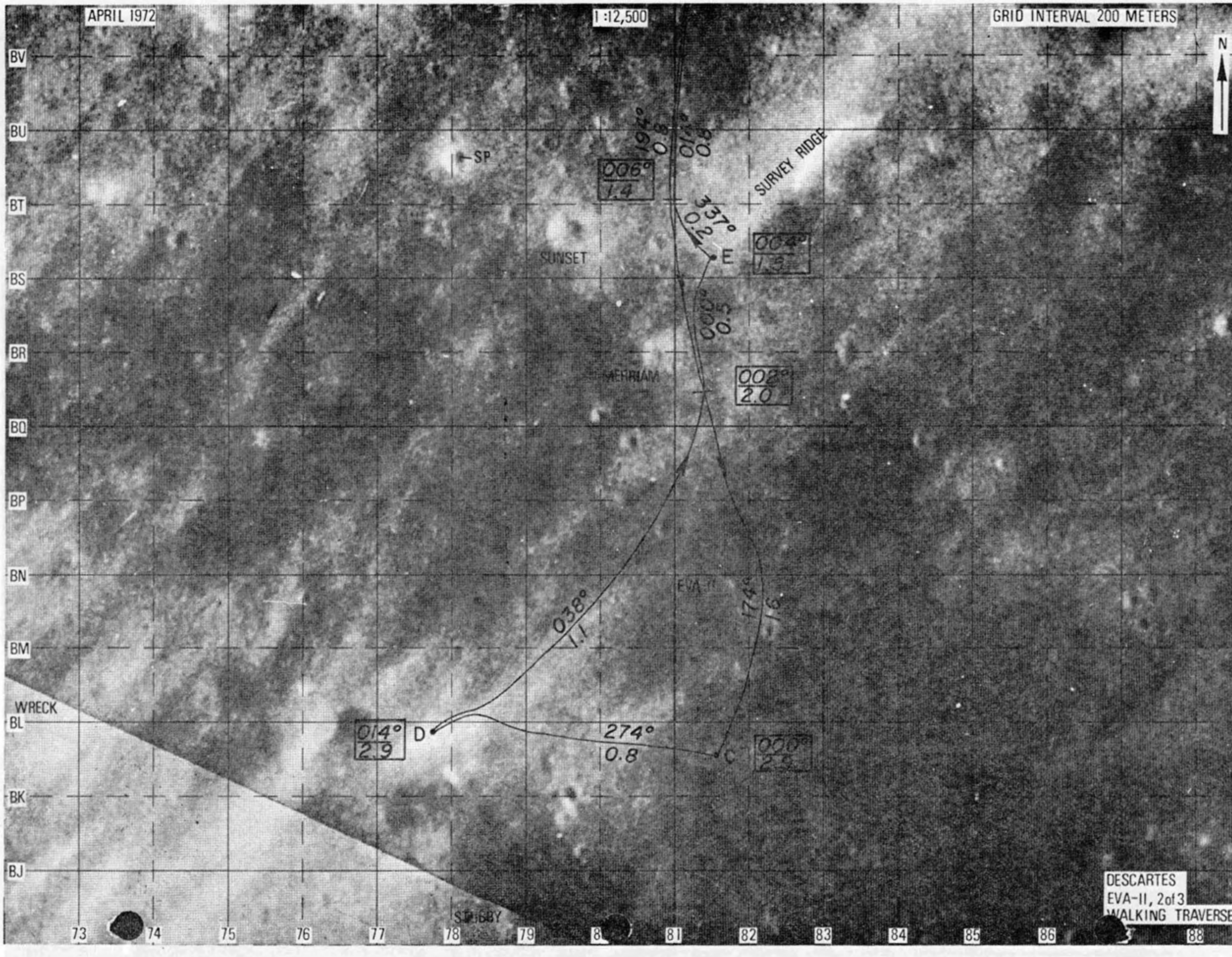

APRIL 1972
1:12,500
GRID INTERVAL 200 METERS
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SURVEY RIDGE
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MERRIAM
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WRECK
EVA II
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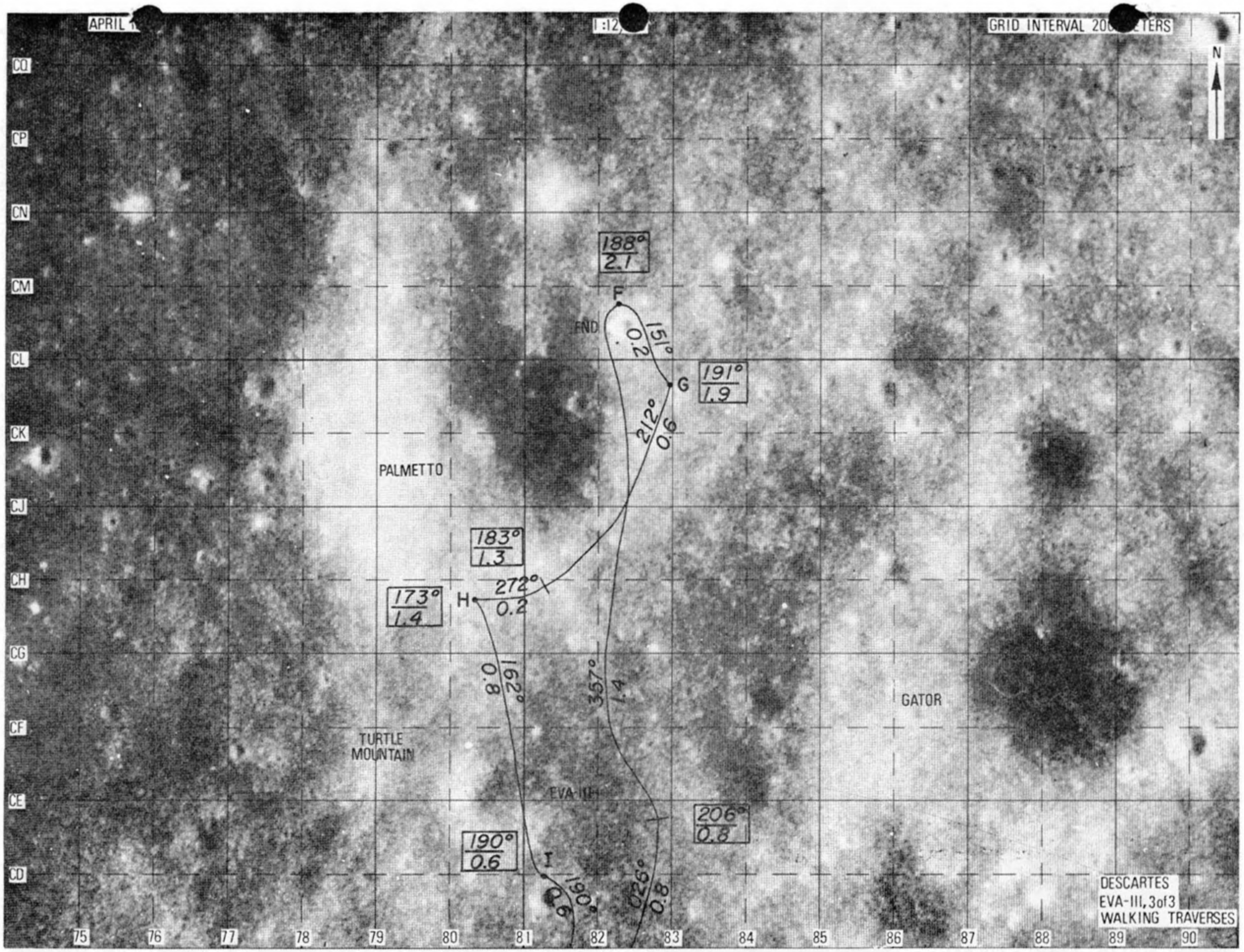
DESCARTES
EVA-II, 2 of 3
WALKING TRAVERSE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212° 0.6
PALMETTO
183° 1.3
272° 0.2
173° 1.4
H
162° 0.8
357° 1.4
GATOR
TURTLE MOUNTAIN
EVA-III
206° 0.8
190° 0.6
I
190° 0.6
026° 0.8
DESCARTES
EVA-III, 3 of 3
WALKING TRAVERSES

ROAD LOG - DESCARTES LANDING SITE

EVA I

0.0 KM/~~LV~~ Leave ALSEP area - Azimuth 280°

Drive over undulating terrain with degraded craters up to about 50 m across. ~~Views of Smoky Mountain to north and of Stone Mountain to south~~.

0.8 Area of Station 2, North Rim of Spook (degraded crater)

Convex escarpment about 15 m high facing southeast, which may require slight detour to north. Boulders 10-15 m appear to northwest in direction of Buster and possibly athwart path. Look for layering of colluvial features in Spook.

0.9 Leave area of Station 2 - Azimuth ~270° 1/

Small (~30 m), sharp craters about 100 m to southwest. Buster Crater within block field ~150 m to northwest. Look for convex escarpments trending to northeast east of Halfway and athwart path in direction of Flag which may provide bedrock sampling targets or require navigation changes.

1.3 West of Halfway Crater

Major escarpment (see above) crosses traverse and may require diversion to northeast to cross. Traverse here is over undulating terrain cratered and locally block-covered. Largest blocks are associated with 30-40 m craters.

1.5 Station 1 (east rim of Flag)

Plum Crater to southwest on edge of Flag's continuous ejecta blanket; ~~which is~~ the latter about 40 m across at this point, and which widens to the north. Boulders in area are probably a mixed suite contributed from North Ray, South Ray, and perhaps local sources. Look for much-degraded layering and probable colluvial features in Flag. Ray material (light albedo) from South Ray is abundant east and west of Flag.

2.9 Station 3

(Return to 50 m west of LM site by same route)

Regolith here appears to be darker and free from South Ray contribution seen to west--look for albedo contrast.

EVA II

0.0 KM Leave LM Site - Azimuth ~173°

Route south to Survey Ridge is over irregular, rather more broken terrain than at LM site. Visible ray material is nearly absent over the route, which has low albedo. The northern half of this traverse leg is lightly cratered; the southern half is among numerous 20-40 m craters both sharp and degraded. Mounds appear northeast of Phantom Crater which

1/ Azimuths given are departure unless otherwise indicated.

require detailed description. Also to the east, more complete description is desired for filigree produced by low, elongate lobes and albedo stripes which are ~~is~~ interpreted to be primary layering in volcanic rocks. There is a possibility that outcrops may be found in areas where the filigree is well-developed.

The immediate approach to Survey Ridge is over a bright patch of regolith believed to be ground disturbed by a block swarm from South Ray. Look for abundant relatively small blocks or ejecta mantle near the crest of the ridge.

1.3 Traverse crest of Survey Ridge - Azimuth 227°

Look for blocks and note lithologic types or explanation of light regolith. Paired, northeast-trending convex scarps facing southeast bound the ridge. Look to south at slopes of Stone Mountain to observe major horizontal layering features along with probable flow structure. Also look east in order to describe best development of filigree where lobate scarps are associated. The filigree to the east may also be ~~is probably also~~ primary layering.

1.7 Leave Survey Ridge - Azimuth ~168°

The traverse from the ridge for a distance of about 1.4 km is over a lightly cratered terrain characterized by particles of high albedo dispersed over a regolith of low background albedo. These particles are probably produced by the same process which affected the ridge crest, therefore blocks are probably abundant. The remainder of this traverse leg in the direction of the major morphologic boundary at the base of Stone Mountain is over regolith with dark albedo where the crater density increases measurably and some large blocks are associated with some small 25-35 m craters. The approach to Stone Mountain is via an embayment in the morphologic boundary believed to represent the major contact between rocks of the Cayley Formation and rocks of the Descartes Mountains. A more complete description of the appearance of this boundary is desirable--especially albedo contrasts and escarpments or subtle topographic breaks that define the actual contact. Describe local filigree ahead and to the east and look for possible associated outcrops.

2.7 Turn right to Azimuth 191°

Route is between two rather fresh, probably secondary craters where blocks are resolvable within or on rims. Regolith looks ~~is rather~~ dark. Major boundary between Cayley Formation and materials of the Descartes Mountains is crossed about 70 m south of the southern crater. Look for convex escarpment or change in albedo of regolith indicating change in subsurface materials. South of the contact the frequency of filigree increases. The following hypotheses to explain the appearance of filigree on the photographs are to be evaluated:

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1. An ~~orbital~~ optical or photographic phenomenon.
2. Colluvial (regolith) flow patterns.
3. Outcrop traces such as lava flows.
4. Relief of layered bedrock benches or lava flows, draped by their regolith.

3.1 Station 6 bypass - Azimuth 161°

Stone Mountain slope increases up to about 10° where regolith is rather dark and sparsely cratered. It is possible that the thickest regolith occurs at the base of the mountain, related to mass wastage of the slope above. Look for evidence for destruction of craters by colluvial transport.

3.5 Station 5 bypass - Azimuth 176°

Base of upper and most prominent Stone Mountain bench. Describe most conspicuous albedo contrast of major units, which occurs at base of steep pitch, at contact between principal units within the Descartes Mountains materials. Look for possible outcrops on the steep pitch.

3.9 200 m west of Cinco Craters - Azimuth 132°

Slope increases to maximum (12°-15°) where crater density, block density, and block size increase.

Regolith thickness probably decreases upward on slope. Describe filigree geometry, compare it to that on lower slopes and explain its genesis. Look for local expression of north- and northwest-trending creases exposed prominently to the east.

4.4 Station 4 (Cinco Craters ~~D~~ d and ~~E~~ e) - Azimuth ~331°

West to north panorama of Descartes landing site. Describe especially wall segments of South Ray, Baby Ray, Stubby, and Wreck. This area provides the only opportunity to see into the craters in the southern part of the landing area. The principal geomorphic features of Smoky Mountain can be described best here. 10-20 m boulders, probably from South Ray are mapped about 50 m to south on the rim of Cinco ~~E~~ e. Cinco ~~D~~ d and ~~E~~ e Craters penetrate the regolith, believed to be thin, and thus provide an opportunity to sample the Descartes materials. Unless outcrops are found, this station provides the best sampling of the Descartes.

Return to Station 5 is over terrain east of Cinco ~~A~~ a, ~~B~~ b, and ~~C~~ c similar to traverse leg from 5 to 4. Continue descriptions of filigree, local and distant creases, blocks, and regolith thickness and albedo.

5.2 Station 5 - Azimuth 341°

Carry out station work within the context of observations made near Station 5 on bypass traverse leg. An explanation for the prominent step and bench topography here is important. Evaluate the hypothesis that the station is at the base of a regional sub-unit of the Descartes. Describe, if possible, the lithologic contrast between the sub-units as well as with the Cayley Formation at the base of Stone Mountain.

Retrace traverse bypass leg.

5.6 Station 6 - Azimuth ~239°

~~Proceed with station work within the context of observations made on bypass legs of traverse.~~ The position of Station 6 is related to regolith contrasts between the slope and the base of Stone Mountain, as well as between Cayley Formation and Descartes materials.

The route to Station 7 approaches the rim of Stubby over sparsely cratered terrain with irregular ejecta from South Ray or somewhat disturbed by a block swarm. An increase in block density and block size toward Station 7 is probable. A convex escarpment believed to be a lava flow front is crossed about halfway between Stations 6 and 7. The escarpment is probably mantled by regolith, but sample bedrock along it. Continue the description of filigree (layering?) which traces off the flank of Stone Mountain into the east part of Stubby. it may b possible t

6.0 Station 7 (BB Crater) - Aziumuth ~302° with block about 10m across on rim

BB Crater (about 50 m across) probably penetrates through the regolith and into the Descartes. It is possible that the underlying Cayley Formation is penetrated also. Blocks in the area could thus represent locally derived Descartes and Cayley as well as Cayley from South Ray. A description of the filigree on the east wall of Stubby is desirable. Evaluate and explain the interpretations that the phenomenon is:

1. Photographic artifact or optical effect
2. Colluvium lobes
3. Lava flows
4. Regolith-mantled lava flows

Station 7 provides (with Station 14) the best opportunity to describe the morphology of the irregular, rimless or low-rimmed craters in order to evaluate their genesis:

1. Endogenic (volcano-tectonic collapse structures)
2. Exogenic (impact craters)
3. Some other process

Route to Station 8 along the north rim of Stubby will probably be over a block-strewn, moderately cratered area where trafficability is likely to become increasingly difficult. Resolvable and smaller blocks are probably from South Ray. Denser ray material will be encountered at the end of the traverse leg near Station 8. The mapped contact between Cayley Formation and Descartes materials is crossed about 0.3 km from Station 7. Describe the morphology and albedo contrast associated with the contact.

6.5 Station 8 (north rim of Stubby) - Azimuth 008°

Station 8 is the closest approach to South Ray Crater and is located upon a probably continuous patch of blocky ejecta of South Ray. Look for a convex northeast-trending escarpment mapped northeast of the station which may project as far as the station. Also look for secondaries from South Ray and Baby Ray Northeast-trending creases are mapped about 200 m northwest of the station which should also be described. One of these latter will probably be crossed on the traverse leg to Station 9. Continue descriptions of the wall morphology, filigree, and the major contact in Stubby begun at Station 7. The first half of the traverse leg to Station 9 is over lightly cratered terrain like that at Station 8, probably with difficult trafficability. The northeast-trending crease separates the light ejecta or disturbed terrain from dark regolith with probably improved trafficability.

6.9 Station 9 - Azimuth 001°

Look for sharp albedo contrast in regolith where cratering density is light. The principal interest at Station 9 is the undisturbed, dark regolith which is to be sampled and described in detail. Return to LM from Station 9 is over lightly to moderately cratered terrain, locally disturbed or overlain by South Ray, Baby Ray, and possibly North Ray blocky ejecta.

7.7 Turn to Azimuth 040°

Traverse leg runs parallel to irregular, faint ray material to the northwest.

8.0 Turn to Azimuth 018°

Turn is made around eastern side of a degraded crater ~40 m across and between SP and Sunset Craters. The southwest end of a northeast-trending, rather prominent ray from South Ray is encountered about 0.6 km beyond the turn. About 175 m north of the ray, the prominent, bright WC Crater is passed on its eastern side. The perimeter of WC Crater is covered by a bright, blocky ejecta blanket where the trafficability may become difficult. Return to LM is via the east side of Double Spot Craters.

9.5 LM, end of EVA II

EVA III

0.0 KM Leave LM - Azimuth 030°

After leaving the smooth, sparsely cratered area at the LM site, this leg climbs a long irregular slope more than 40 m high. A mound about 250-300 m across with a summit crater stands about 150 m west of the north part of the leg; this may be a small volcanic constructional feature, or the mound and the crater may be unrelated impact features.

0.8 Turn to Azimuth ~356°

At beginning of leg, the depression just to west contains some filigree (possible layering). The north half of the leg follows the irregular outer slope of the east rim of Palmetto Crater. Very few blocks large enough to be visible on the photos appear around Palmetto, but many smaller ones probably are present. This east rim area also appears to be crossed by very thin and discontinuous ray material from South Ray, of higher albedo than the previous part of the traverse. The north end of the leg crosses the east slope of another mound with summit crater (End Crater, to be Station 17). This rim should provide a good view of the slope of Smoky Mountain, with filigree on relatively smooth steep slope; observe any evidence of origin of filigree or other features on slope.

2.2 Turn to Azimuth ~002°

First half of this leg is along generally north-trending low ridges. Filigree along sides of ridges may be outcrop traces of bedrock, more or less covered by regolith, and may provide bedrock sampling localities. Increasing amounts of North Ray ejecta probably appear along this leg, although no rays or blocks are visible on photographs.

The north half of this leg crosses a degraded crater with filigree (perhaps a thin light layer) on its walls. It then climbs onto the ray-covered, blocky continuous ejecta mantle of North Ray, of difficult trafficability.

4.7 Turn to Azimuth 304°

This leg is entirely within blocky ejecta of North Ray, of probably very difficult trafficability. The radial orientation of the leg may permit travel between radial concentrations of blocks. Look for single blocks or ray-like groups of different lithologies, for sampling in relation to strata exposed within North Ray.

5.2 Stations 11 and 12, rim of North Ray Crater

Observe very carefully the strata exposed in walls of North Ray, with regard to correlation with ejecta lithologies, structures, and possible appearance of Descartes Mountains materials beneath rocks of Cayley Formation. Look for possible overturned flap of ejecta, as inferred on west rim of crater from photographs. This rim probably is best place for closeup view of slope of Smoky Mountain, to observe filigree, creases, possible bedrock-controlled benches, and major contact between Descartes Mountain materials and rocks of Cayley Formation.

5.4 Leave Station 12 - Azimuth 130

Descend slope of blocky ejecta mantle of North Ray, along previous northwest-bound leg as controlled by trafficability.

6.1 Station 13 - Azimuth ~122

This station is just off continuous ejecta mantle of North Ray as mapped from photographs, in an area of scattered blocky ejecta and numerous small craters. The Descartes/Cayley contact is mapped about 200 m to the east, slightly upslope.

The traverse to Station 14 crosses several filigree lines about midway, and then the Descartes/Cayley contact. Look for any indication of the contact in surface morphology or in character of regolith. The traverse then climbs the ridge on the southwest side of Ravine, probably somewhat blocky.

6.9 Station 14, Cat Crater - Azimuth ~183

This station is on Descartes Mountains materials, which may be compared with those of Stone Mountain seen on EVA II. The station provides a still closer view of the near part of the slope of Smoky Mountain. It also looks directly into Ravine Crater, an example of rimless or low-rimmed depression perhaps of endogenic collapse rather than impact origin. The ridges on its southeast and southwest sides are not believed to be of impact ejecta. The crater and the ridges should be carefully observed with respect to this problem of origin. Cat Crater, 50 m across, samples the material of the southwest ridge. Creases perhaps caused by fractures in bedrock are abundant. The station also should provide a good view downslope across the Descartes/Cayley contact onto the Cayley lowland.

Traverse on way to Station 15 descends from ridge and crosses contact back onto Cayley Formation. It then goes southward across moderately cratered terrain, probably with decreasing amounts of North Ray ejecta, and with apparent thin overlay of ray material from South Ray. North-south filigree lines, like those on the north bound traverse to the west, may be bedrock controlled.

8.2 Station 15, Dogleg Crater - Azimuth 251

This 50 m fresh crater samples the Cayley Formation in a moderately cratered area with many creases (fractures) and filigree lines (layering in bedrock?). The presence of a concentric bench in the crater indicates that the crater penetrated regolith to bedrock.

The following leg of traverse crosses filigree lines and small scarps at nearly right angles; creases are of various orientations. This area is moderately cratered, and thinly overlain by ray material from South Ray.

9.2 Station 16, Dot Crater - Azimuth 152

This is a very fresh 50 m crater, with a bright and probably blocky ejecta ring. It samples an irregular north-south ridge; filigree lines extending north-south are shown shortly to the north. This area probably is covered by thin degraded ejecta from Palmetto. The next traverse leg passes along the northeast side of a degraded 250 m crater, which occurs on the degraded rim of Palmetto.

9.7 Station 17, End Crater - Azimuths 176 and 210

This fresh 60 m crater is on the summit of a smooth mound 250-300 feet wide, passed on the east on the northbound traverse. Observations should be made on the origin of mound and crater--whether they constitute a related volcanic cone and crater, or whether the crater is of impact origin and not related to the mound. If the mound is not of volcanic origin, it probably is part of the degraded rim of Palmetto. The station also permits observation of Palmetto Crater, its degraded rim and walls and its central mound.

Return south to LM parallel to northbound traverse.

11.9 LM, end of EVA III

RATIONALE FOR LOCATION OF CORE TUBES:

1) STATION 4: CINCO-CRATER

This double-core will provide us with information concerning the petrographic make up, history and development of pure Descartes regolith. Together with the penetrometer tests it will aid in characterizing slump movement on slopes, a result which is hopefully applicable to other lunar areas. This is the main reason why it is tied in with the penetrometer tests.

The location of an area suitable for both activities is up to your judgment. It should be on "typical" Descartes and outside an obvious disturbance by a recent impact event.

LOCATION CRITERIA:

a) More than one crater diameter distance from Cinco-Crater.

b) In center of Penetrometer "diamond".

c) Away from any recent cratering event larger than 5 m diameter.

2) STATION 8: S-RAY CRATER RAY

The purpose of this double-core is to hopefully encounter the contact of ray material and underlying Cayley. The materials not only will allow detailed petrographic characterization of both units, but especially the upper section (i.e. S-Ray "regolith") is very young and thus permits detailed study of small scale lunar surface processes like mixing and gardening of regolith, track-studies, noble gases, volatiles, etc. Ideally all these results will represent averages over extremely recent geologic times which then can be contrasted with "older" materials. We may get a feeling about the constancy - or lack thereof - of small scale processes as a function of geologic time.

It follows that we are primarily interested in the "S-Ray" materials. If the contact of the underlying Cayley, however, would be encountered, we could place more rigid time boundaries on these processes. Furthermore, detailed knowledge of the local regolith will allow to determine more accurately whether the layering observed is an extremely local effect (e.g. 10-50 m distance) or whether materials are transported from further distances e.g. 1-10 km. Thus it is highly desirable that the core be taken at a location with high probability to encounter this contact.

It is also advisable to stay away from big boulders for two reasons: 1) The "contamination" problem by erosion products of boulders and 2) if many boulders on the surface, there may be many <u>in</u> the regolith. Consequently an interboulder area is recommended.

If no obvious differences in "soils" from S-Ray and Cayley, take a core anyhow in an interboulder area: the probability is high that you encounter S-Ray ejecta.

Important: Take core <u>on</u> S-Ray ejecta if observable. Otherwise in interboulder area.

LOCATION CRITERIA:

1) <u>ON</u> S-Ray ejecta

2) Hopefully penetrate S-Ray ejecta to also collect underlying Cayley.

3) In interboulder area, especially if S-Ray ejecta are not obvious.

4) Away from any recent cratering event of 5 m and larger diameter.

3) STATION 9: CSVC

The purpose of this single core is to collect the upper layer of typical Cayley regolith. In connection with the surface sampler we will have collected five different depths at one stop. Because this drive tube is put in the CSVC it will be clean of hopefully all contaminants.

Remember: Do not drive the tube in all the way because then it will not fit into the CSVC.

LOCATION CRITERIA:

1) Overall stop: typical Cayley devoid of S-Ray ejecta.
2) Away from any recent cratering event larger than 5 m diameter.
3) As close as you wish to the surface sample area.

4) STATION 10: Close to LM

Apart from all the petrographic information, etc. with respect to Cayley, there are three other reasons for taking a double core at this location:

a) Comparison with the deep drill (50 m distance) permits to establish correlation - or lack thereof - of cm-sized regolith layers. Are they continuous or not? Are some of them?

b) Again this core will yield significant calibration points for the interpretation of the penetrometer data.

c) The soil mechanics trench will be a 3rd point ($\approx$ 20 m away) to investigate the change or continuity in small scale layering.

LOCATION CRITERIA:

1) $\approx$50 m E of deep drill core hole

2) $\approx$20 m SE of soil mechanics trench

3) Very close to a variety of soil mechanics tests (plate, .2 and .5 cone).

4) Try to stick as close to the outlay in the cuff check list as possible.

5) Stay away from any recent crater larger than 5 m in diameter.

5) STATION 14: CAT CRATER

Similar to the rake sample, this is an area which promises to yield quite a mixed bag of samples of Smoky Mts., Cayley and possibly Ravine materials. Apart from their petrographic characterization, the possible interbedding of the above materials would yield valuable information on regolith transportation processes and rates.

LOCATION CRITERIA:

1) More than one diameter away from Cat Crater.

2) North of Cat Crater to ensure incorporation of Smoky Mountain materials.

3) Stay away from any recent cratering event larger than 5 m diameter.

7

GENERAL REMARKS

Due to the limited amount of drive tubes available (total of 9), the present planning ensures that the following regolith materials are collected. Thus their surface history can potentially be revealed:

1) Pure Descartes: Station 4
2) Pure Cayley: Station 9, Station 10
3) Pure S-Ray Ejecta: Station 8
4) Mixed bag of Smoky Mts., Cayley and Ravine material: Station 14

If no? double tubes can be driven at the designated stops, the following single cores should be taken:

1) Station 4: Descartes
2) Station 5/6: Descartes
3) Station 8: <u>On</u> Ray!!!
4) Station 8: <u>Off</u> Ray!!!
5) Station 9: Cayley
6) Station 10: Cayley
7) Station 14: Mixed sample
8) }
9) } At crew's discretion

RAKE SAMPLES:

Attached are some figures from Apollo 15 demonstrating the usefulness and importance of rake/soil samples. The lithologies indicated are based on macroscopic and binocular observations during PET. Thus the quality of the descriptive data may differ. Furthermore, many observers have contributed to this compilation and their terminology is not always necessarily consistent. In short: an accurate comparison will only be feasible after detailed petrographic thin-section work.

Principally, three grain sizes from ± the same sampling stop are compared: 1) the total hand specimen return from an entire station, 2) the total population of "rake-samples", i.e. ideally walnut sized rocks and 3) coarse fines (4-10 mm) of the soil taken together with the rake sample and where possible, a second sample. Three rake samples were taken on Apollo 15: at St. George, at Spur Crater, and at the Rille. The following points need to be made:

ST. GEORGE: Notice that the hand specimens only contain 1 crystalline rock, while 7 specimens were recovered from the rake, which in addition, can be classified in 3 groups. Thus an obvious increase in "variety" is evident. Notice also how the 2 coarse soil fractions differ. That difference is not easily explained at present.

SPUR CRATER: Again only 1 crystalline hand specimen was picked up, though - admittedly - anorthosite was an excellent selection. In contrast, 17 crystalline walnuts were sampled with the rake. The presence of mare basalt at Spur Crater indicates that the South Cluster event tossed mare material up the slope, which is a significant geological result, otherwise, not readily inferred. In addition, the nonmare basalts and a "dunitic" green rock may become important nonmare samples, the latter possibly coming from depth. The coarse fines are also composed of a variety of materials and they compliment the rake samples.

RILLE-STOP: Though a variety of basaltic rocks, i.e. 4 different types, is represented in the hand specimens, a much larger variety (about 10 different types) is obtained in the rake samples. All of them may compliment each other in studying the evolution from the Imbriam basalts.

GENERAL:

1. The rake/soil sampling technique is by far the best to collect a representative variety of rocks in the shortest time possible as well as within a reasonable weight limit. Therefore, it is the most effective sampling technique for characterizing a regolith and thereby possibly stratigraphic units, ray-materials, etc. Not only will it cover many rock types for detailed analysis, but - in the absence of outcrops - it is also the best "geological" sampling tool for structural relationships, etc. Furthermore, there is always a realistic chance to pick up exotic fragments from far distant sources, thus improving our global understanding of the moon.

2. Present analytical micro-techniques allow to extract from a walnut size rock, i.e. about 2 gr mass, basically any information one wishes to obtain. This is not necessarily true for the coarse 4-10 mm fines, which typically weigh .2 to .5 gr. In addition, individual coarse lithic fragments may not accurately represent their parent rock. This would only be the case

for very fine-grained rocks; however, with increasing grain-size, larger and larger specimens are needed to have a "representative" sample. Thus there is a real need for walnut size rocks.

3. The soil samples collected together with the rake will hopefully compliment and corroborate the walnut-rock-populations. Chances for even greater "variety" are offered. In addition, the increased number of "specimen" will allow reliable statistical analysis to reconstruct, which of the walnut and hand specimens are from local or distant sources. Such statistics depend of course largely on the number of "specimen" and therefore a large soil sample is required (1000 gr)

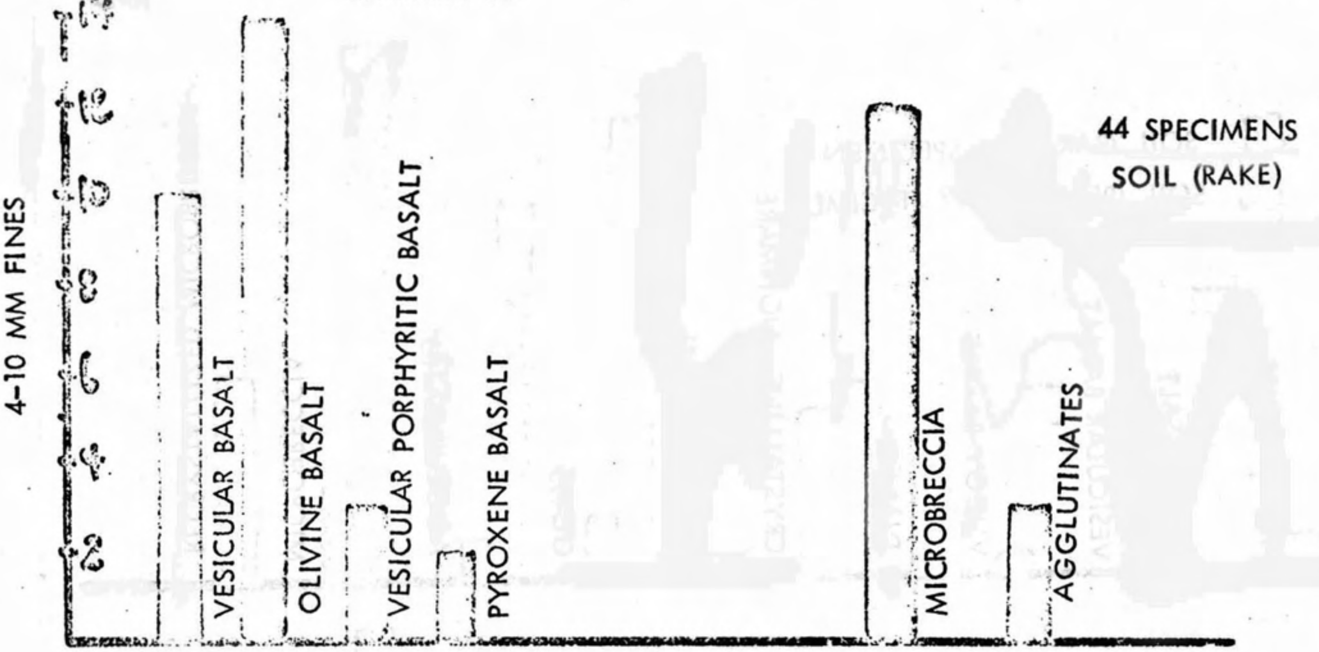
It follows that

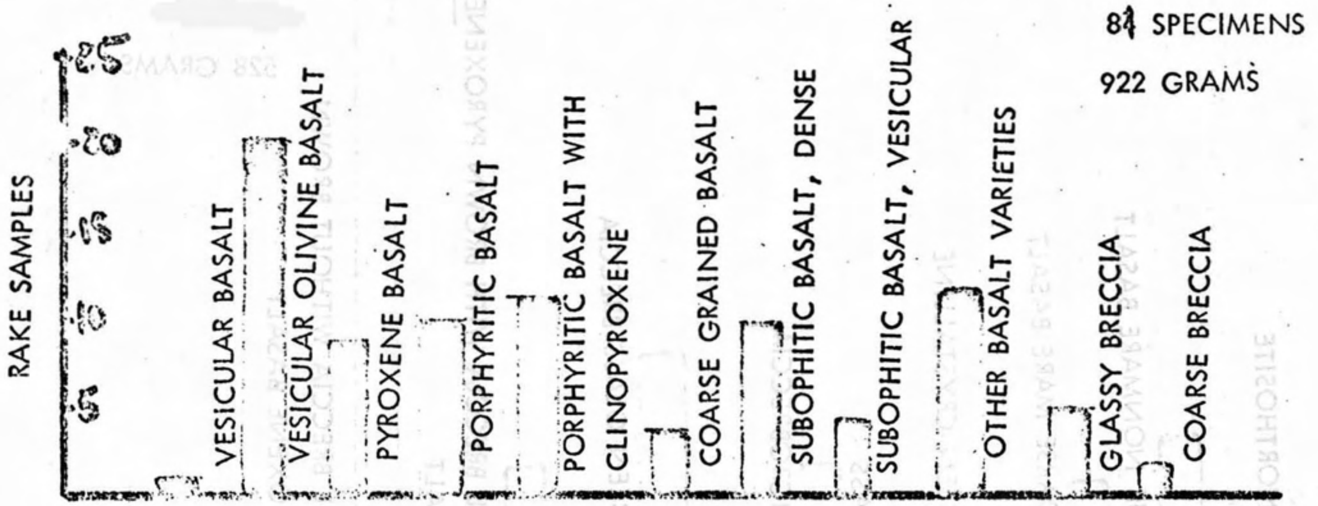
1. An attempt should be made to collect per each rake area a full bag of walnut sized rocks (about 1000 gr). If such rocks are scarce, do the best possible and try at least 5 swaths. The abundance (or scarcity) of such rock sizes may have geological significance and therefore it would be good if you could comment on how many swaths you took per rake area.

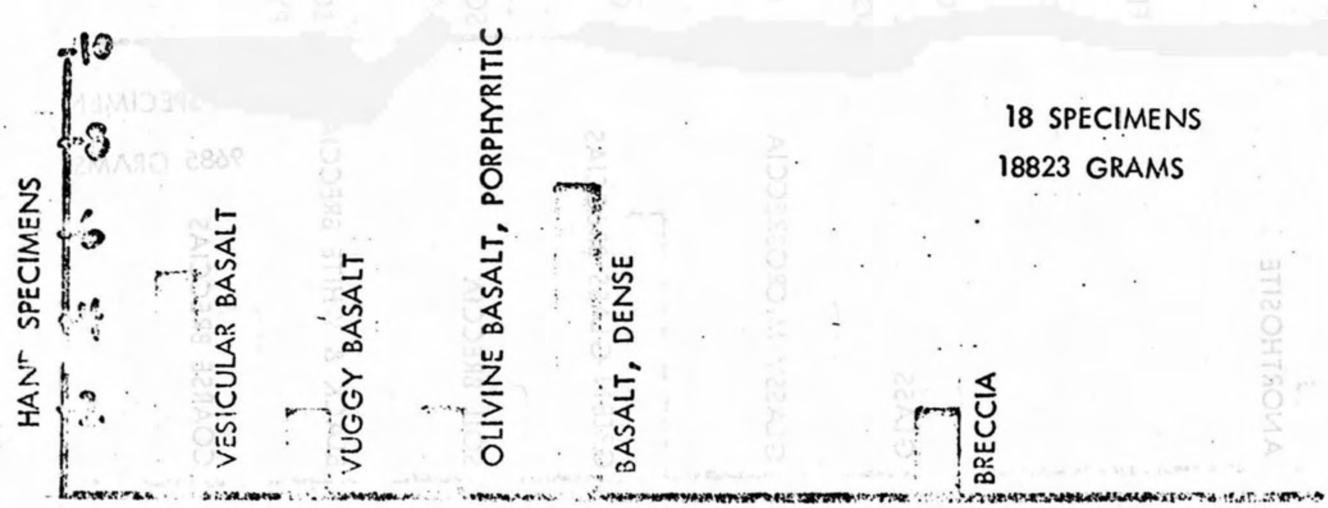
2. Regardless of the abundance of walnut size rocks, you should take a large, 1000 gr, soil sample.

3. The rake/soil procedures should be used as often as possible to statistically characterize the landing site. If time is too short, a large soil may at least partially fulfill this objective and is highly recommended.

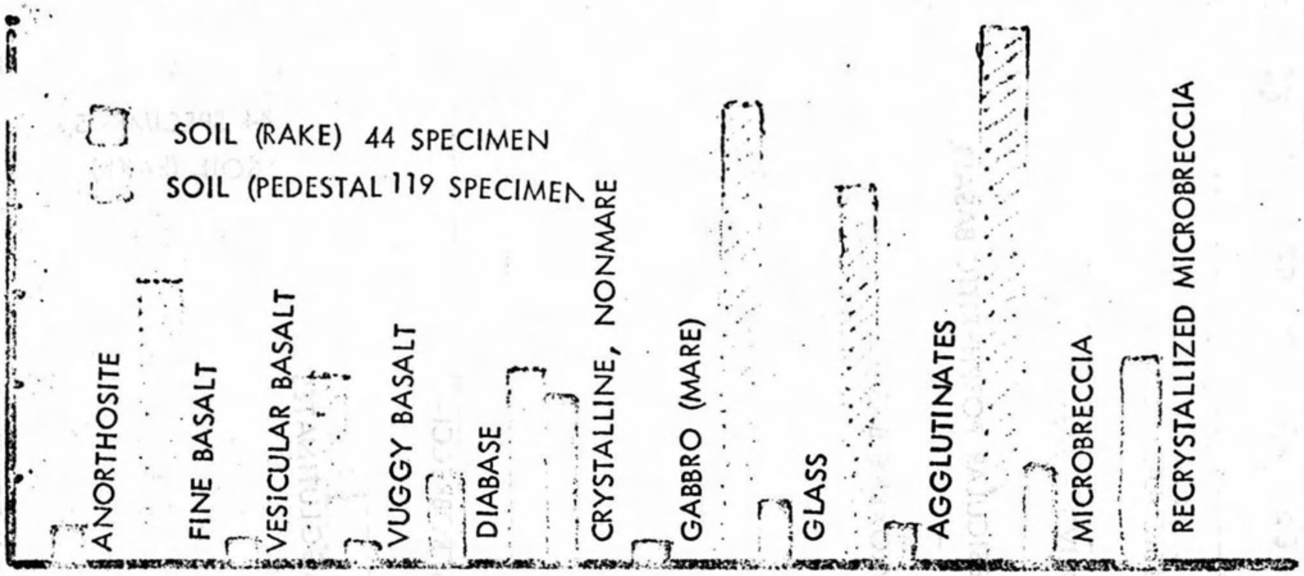
HADLEY RILLE
STATION 9a

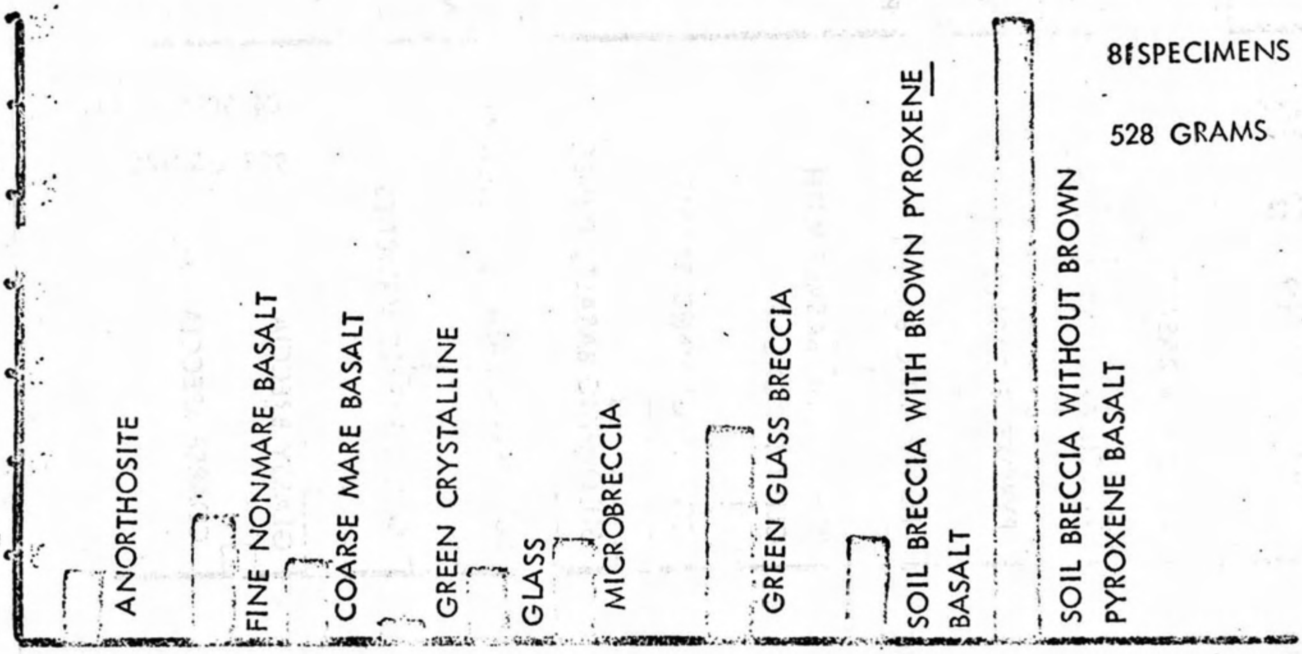


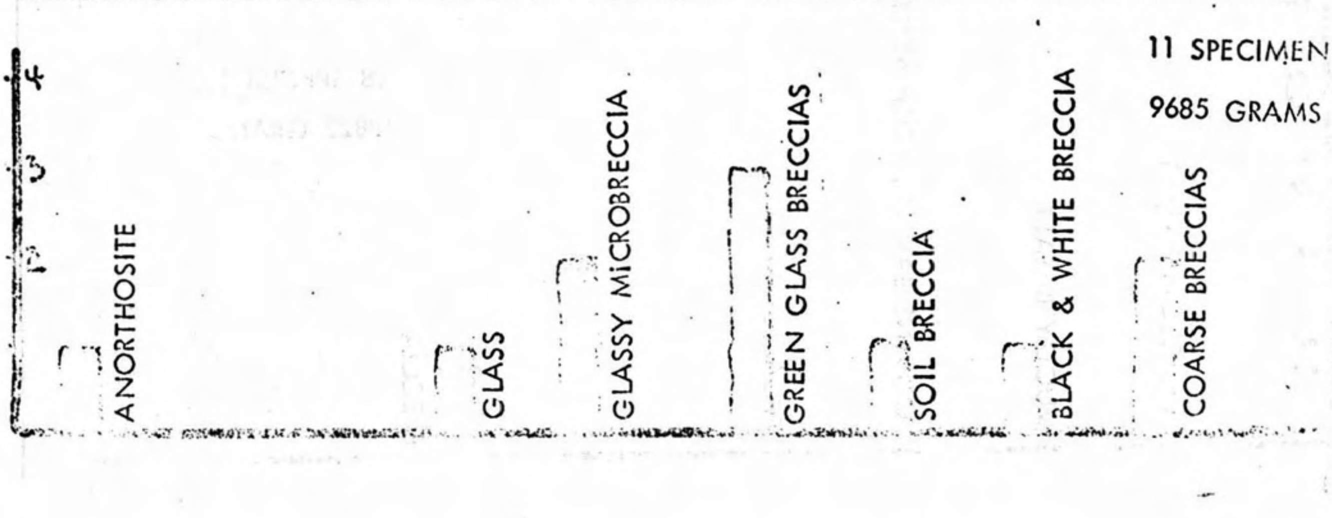




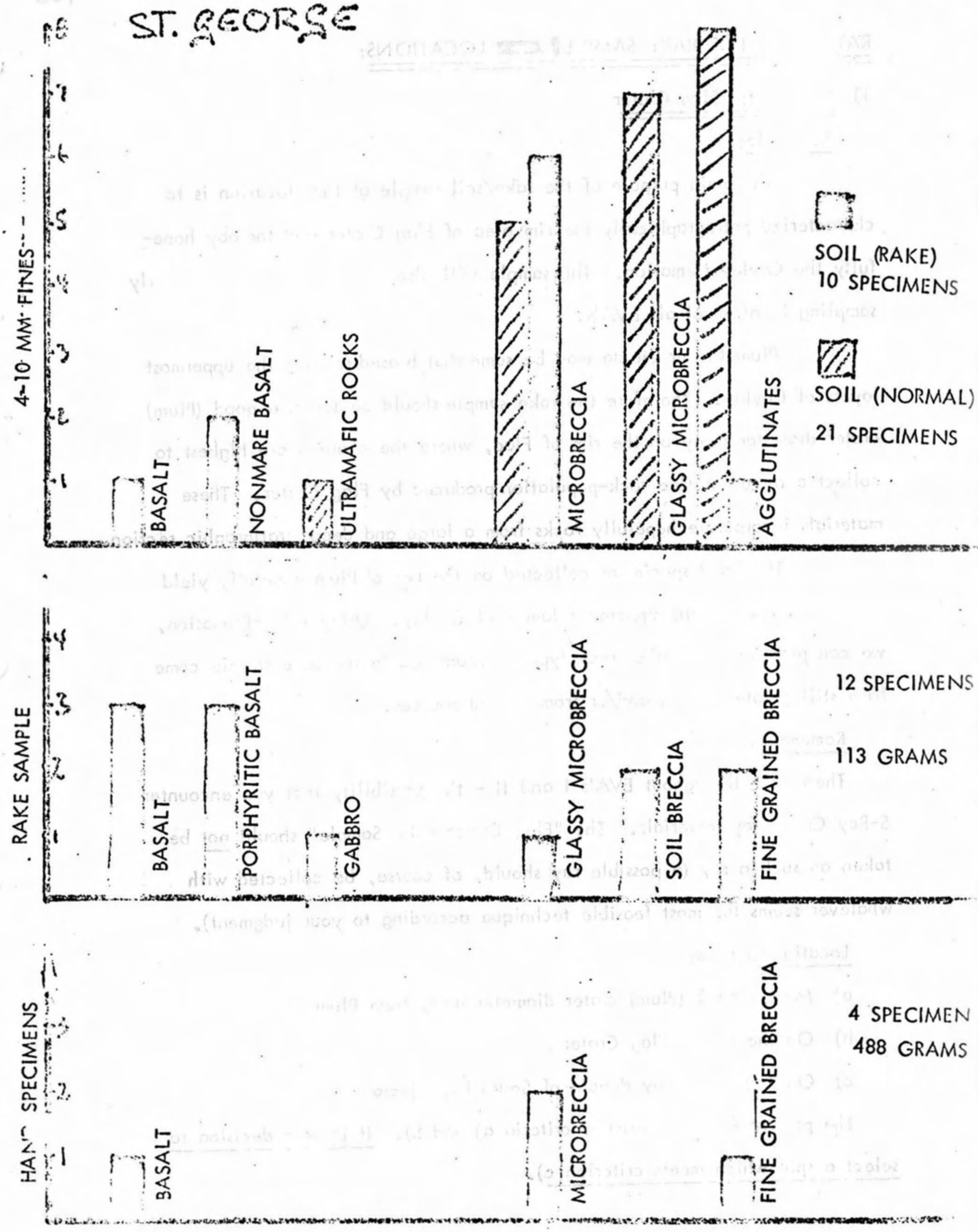
SPUR CRATER 15B







ST. GEORGE


4-10 MM FINES
BASALT
NONMARE BASALT
ULTRAMAFIC ROCKS
MICROBRECCIA
GLASSY MICROBRECCIA
AGGLUTINATES
SOIL (RAKE)
10 SPECIMENS
SOIL (NORMAL)
21 SPECIMENS
RAKE SAMPLE
BASALT
PORPHYRITIC BASALT
GABBRO
GLASSY MICROBRECCIA
SOIL BRECCIA
FINE GRAINED BRECCIA
12 SPECIMENS
113 GRAMS
HAND SPECIMENS
BASALT
MICROBRECCIA
FINE GRAINED BRECCIA
4 SPECIMEN
488 GRAMS

RATIONALE FOR RAKE SAMPLE [redacted] LOCATIONS:

1) Station 1: Flag Crater

Rationale:

The main purpose of the rake/soil sample at that location is to characterize petrographically the rim area of Flag Crater and thereby hopefully the Cayley formation. This sample will also represent the most westerly sampling location of all EVA's.

Plum Crater ejecta may be somewhat biased towards the uppermost layers of Cayley. Therefore the rake sample should be taken a good (Plum) crater diameter away on the rim of Flag, where the chances are highest to collect a representative rock-population produced by Flag Crater. These materials incorporate hopefully rocks from a large and deep stratigraphic section.

The hand specimens collected on the rim of Plum hopefully yield some clues towards the uppermost layers of Cayley. Using this information, we can postulate that other rock types encountered in the rake sample come from still greater depths and/or from distant sources.

Remember:

There is – throughout EVA's I and II – the possibility that you encounter S-Ray Crater ray materials. The "Flag Crater Rake Sample" should not be taken on such a ray (a possible ray should, of course, be collected with whatever seems the most feasible technique according to your judgment).

Location Criteria:

a) More than 1 (Plum) crater diameter away from Plum

b) On the rim of Flag Crater

c) On "pure" Cayley devoid of South-Ray ejecta

The present location satisfies criteria a) and b). It is your decision to select a spot which meets criterion c).

2) Station 4: Cinco Crater

Rationale:

This rake sample clearly characterizes the materials making up the higher elevations of the Stone Mountain Massife. We hopefully collect samples from further uphill than the actual station 4 location.

Similar to Flag Crater, we want to stay away at least 1 crater diameter from the crater (Cinco Crater) you are investigating in more detail to avoid a biased population. The sampling of Cinco Crater gives us some clues on the local bedrock. All other rock types in the rake samples possibly originated from layers further up the slope. Consequently, this rake sample should give us some good information about Stone Mt. in general and specifically the higher elevations not accessible during the traverse.

Location Criteria:

At least 1 diameter away from Cinco Crater on what appears to be typical Stone Mountain material in your judgment.

3) Station 8: S-Ray Crater Ray

Rationale:

Station 8 is located on a ray from S-Ray. The precise location is up to your judgment assessing boulders, etc. (See general station rationale.) The purpose of the rake sample is to characterize the ray materials. Therefore the sample should be taken on the ray (not in Cayley off the ray). Because there will be many boulders, chances are high that a lot of materials are laying around which were actually chipped off these boulders. It is highly desirable to get away from such erosion products by selecting a rake location in a relatively large "inter-boulder area". However: under no circumstances should you move off the ray.

If the "ray" is characterized only by boulders and no obvious difference in the soil is recognizable between "Ray" and genuine "Cayley", then sample again in an inter-boulder area. This will still be the most suitable spot to encounter some "South-Ray Crater" samples.

Location Criteria:

a) On ray

b) Large inter-boulder area, i.e. chips should not(predominantly) originate from nearby boulders.

4) Station 12: North Ray

This rake sample, of course, characterizes the ejecta of North-Ray Crater and thereby hopefully a very large stratigraphic section, including very likely the most deep seated materials of the entire mission.

We know about the existance of very large blocks and boulders on N-ray rim. Therefore especially care should be taken that the rake is not taken too close to any big boulder(s), the erosion products of which could possibly bias the rock-populations observed. Try to select the largest inter-boulder area you can conveniently locate.

Location Criteria:

Largest inter-boulder area at station 12.

5) Station 14: Cat Crater

Because we are at the contact of Caley and Descartes, this rake sample will be an especially mixed bag. Furthermore, there is the possibility that Ravine is an endogeneous crater, which may have produced some lithologies of its own. Thus the rake may ideally contain

a) Caley, Most easterly location

b) Descartes, Hopefully all layers making up Smoky Mtn.

c) Ravine-Materials?

This mess will be most difficult to unravel and we need all the field observations you can give about possible source areas for different lithologies.

Location Criteria:

1) About one crater diameter away from Cat Crater to prevent biassing of population by Cat event.

2) It also should be to the N. of Cat, to ensure that Smoky Mtn. materials are present.

7

Station 17: End Crater

One of the main objectives of stop 17 is to radially sample End Crater. Ideally we would like to have three rake samples (1 diameter, ½ diameter, rim). But time is too short. Consequently, the rake sample presently planned is part of a radial sample. It should be at about one diameter distance from End Crater. We hope to collect thereby materials representing part of the Palmetto-section.

Location Criteria:

1) About 1 diameter away from End Crater.

2) Towards Palmetto rim, to possibly recover even larger "Palmetto" variety.

GENERAL REMARKS

The rationale and objectives why each individual rake is planned at a specific station was outlined below. However, there are additional considerations if one looks at the rake/soil samples collectively:

A) Lateral Continuity of Caley:

Flag: Most westerly location

S-Ray: Most southerly location

N-Ray: Most northerly location

Cat: Most easterly location

Thus it will hopefully be possible to study the lateral continuity of Cayley units. The End Crater sample is placed in the "middle" of a triangle formed by Flag, N-Ray and Cat, thus giving an additional opportunity to check on the continuity of Caley. The sequence "station 8", Flag, End and N-Ray gives us a N-S running section with sampling points spaced about 2-3 km.

B) Vertical Extend of Caley:

According to the chart illustrating depths of certain craters, the rim materials of Flag, N-Ray, Palmetto (= End) and Ravine (= Cat) Craters are derived hopefully from different depths in the Caley formation. The stratigraphic location of the S-Ray Crater Ray is unknown. Nevertheless, it may be possible to reconstruct the Caley stratigraphy from the four locations mentioned above: with increasing crater depth new rock types may be encountered which should be reflected in the rake sample. Thus we can possibly reconstruct the Cayley stratigraphy to a depth of more than 150 m, should the direct attempt on N-Ray fail.

C) Crater Ages, Lunar Surface Processes:

According to their state of degradation, relative ages of S-Ray, N-Ray and Palmetto can be established with S-Ray being the youngest, Palmetto being the oldest one. Thus there is the theoretical opportunity to eventually come up with formation ages of three different craters after detailed investigations of the rake-samples. If we can age date these events, we came a long way to better understand lunar surface processes and can apply this knowledge to other lunar surface areas.

D) Lateral Extend of Descartes:

The rake samples taken at Cinco and Cat Craters will provide us hopefully with a statistically significant sample to make comparisons between the two Descartes locations and thereby give us an idea about their lateral continuity.

It follows that not only individual rake samples will give us a lot of information, but especially the combination and comparison of selected rake areas are important clues to better reconstruct the local geologic picture.

Remember: 1) Always try to avoid close proximity of big boulders, because their erosion products may highly bias the rock populations collected.

2) If no time for a rake sampler, take a 1000 gr soil sample in any case.

SPECIAL PROCEDURES

LIST OF PRIORITIES

SPLIT BOULDER SAMPLE:

PRIME OBJECTIVE: Dating of specific cratering event

ADDITIONAL OBJECTIVES: Small scale lunar surface processes of all kinds (micrometeoroids, isotope studies, tracks, noble gases, thermoluminescence, etc.). The combination of these studies lead to a better understanding of such surface processes as erosion rates, gardening of the regolith, etc.

REQUIREMENTS:

A) Roughly equidimensional (1m) boulder, crystalline rock having a nearly vertical split no more than 5 cm apart running roughly through its center.

B) Unambiguous association with cratering event.

C) One half of boulder has to be overturnable.

D) If no crystalline boulder of that size is encountered the experiment may be performed on a very hard breccia.

PRIORITIES:

A) Chip "top"

B) Chip "bottom" Chip weight: ~100 gr or larger

C) Chip "center"

D) Chips "E" or "W"

E) Chips "S" or "N"

F) Soil underneath

G) Reference soil

MINIMUM RETURN:

A) Chip "top"

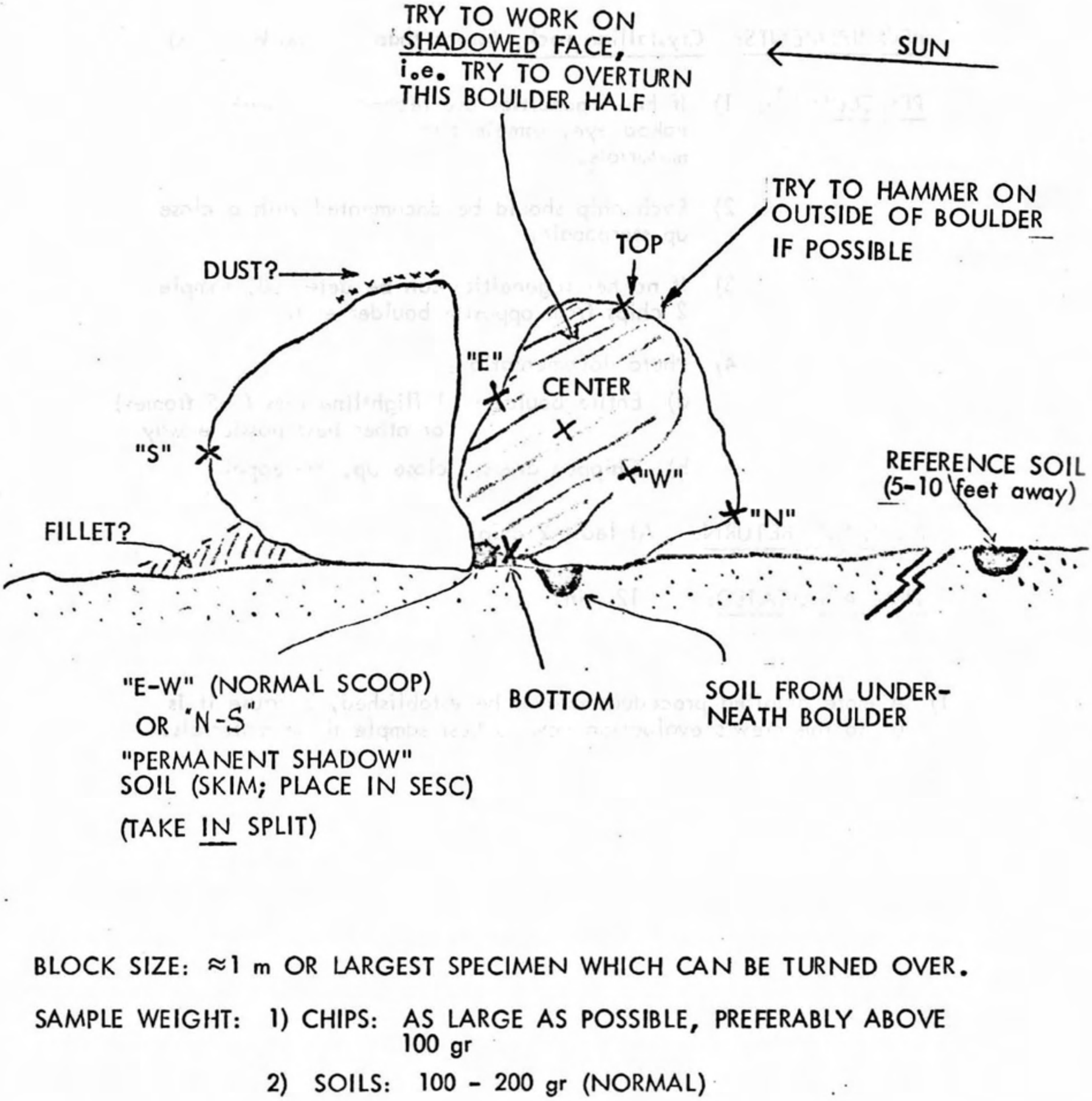
B) Chip "bottom"

SPLIT BOULDER PROCEDURE

TIME	SAMPLE	CDR	LMP	PHOTOS
:03		7', XS, stereo "before" Assessment of tasks: 1) Can boulder be turned over? 2) Is dust present on boulder top?[1] 3) Does boulder qualify for fillet sample?[2] 4) Does split strike EW or NS?[3]		2
:01		3 additional 7', XS stereo pairs	DS, locator ← 1 * ← 2 *	8
:02	"N" chip	Chip face to be turned over "N"- face	Same + Close up, stereo	
:02		Turn over rock	Same	
:02	soil	7', XS (stereopair) "before" 7', XS, "after"	← 3 * Collect soil from underneath	3
:08	6 chips	Chip in the following order: 1) Top chip 2) Bottom chip 3) Center 4) "W" chip 5) "E" chip 6) "S" chip	Same + docu- ment each chip with close up (stereopair)	
:05	soil	Reference soil, standard procedure Collection of other rocks is encouraged		5

1) If yes: brush dust off boulder top (no special photography).
2) If yes: collect fillet soil (7' stereo "after").
3) If EW: collect E-W split sample; soil from "underneath" is still to be collected in addition (7', "after").
   If NS: collect permanent shadow sample; soil from "underneath" is to be collected in addition (7', "after).

* insert activity



BLOCK SIZE: ≈1 m OR LARGEST SPECIMEN WHICH CAN BE TURNED OVER.

SAMPLE WEIGHT: 1) CHIPS: AS LARGE AS POSSIBLE, PREFERABLY ABOVE 100 gr

2) SOILS: 100 - 200 gr (NORMAL)

5

GIANT BOULDER SAMPLE:

OBJECTIVE: 1) Variation of igneous units

2) Erosion rate, exposure history, etc.

REQUIREMENTS: Crystalline rock, larger than 5m, (no breccias)

PROCEDURE[1]: 1) If heterogeneities are recognizable with the naked eye, sample and document representative materials.

2) Each chip should be documented with a close up stereopair.

3) If no heterogeneities can be detected, sample 2 chips from opposite boulder ends.

4) Photo documentation:

a) Entire boulder: 1 flightline pan (3-5 frames) or other best possible way

b) Chipped areas: close up, stereopair

MINIMUM RETURN: At least 2 chips

TIME ALLOCATED: 12 min.

1) A more detailed procedure cannot be established, because it is up to the crew's evaluation how to best sample these materials.

RADIAL SAMPLING OF FRESH, 20-50m SIZE CRATER:

OBJECTIVES:
1) To reconstruct three dimensional target stratigraphy.
2) To possibly date cratering event.
3) To reveal dynamics of small scale surface processes like horizontal transport of regolith and erosion of small craters.

REQUIREMENTS:
1) Fresh crater (20-50m diameter)
2) Crater should barely penetrate bedrock, i.e. have blocky rim
3) Best statistical sample reflecting changes in ejecta lithologies.

PROCEDURE A (IDEAL CASE): Changes in lithologies in ejecta blanket are obvious to the naked eye.

1) Collected rock specimens representative of various lithologies.
2) Collect soils together with rocks.
3) Assess the original target position of the samples collected and/or document position of samples with respect to overall crater by taking Part. Pan. "after" radial sampling.
4) If time permits and operational feasible, collect specimens from crater center.

Minimum time: 30 Min.

PROCEDURE B: Changes in lithologies of ejecta blanket cannot be recognized.

1) Plan at least 3 sampling locations:
   a) on crater rim
   b) 1/2 crater diameter
   c) 1 crater diameter
2) Take rake/soil sample at all 3 locations and rock grab samples.

3) Take Part. Pan. after radial sampling.

4) Collect specimen (grab sample/soil sample from center of crater) if feasible.

Minimum time: 30 Min.

STATION PRIORITIES:

1) rim

2) 1 radius

3) 1/2 radius

4) inside crater

SHORT CUT PROCEDURE:

If not sufficient time, the rake/soil samples may be replaced by large soil samples (1000 gram).

8

CHEMICALLY ULTRACLEAN SOIL SAMPLE (CSVC):

OBJECTIVE: Sample devoid of potential sources of contamination.

REQUIREMENTS:

1) Single drive tube on "typical" Caley
2) CSVC container
3) Distance to LM: at least 1 km

PROCEDURE:

1) Standard single drive tube and standard photo documentation
2) Store in CSVC

TIME ALLOCATION: 8 Min.

9

SOIL SURFACE MATERIALS ("SURFACE SAMPLER"):

OBJECTIVE: Interaction of solar wind and cosmic radiation with lunar surface, yielding a better understanding of:

A) Solar and galactic radiation

B) Small scale lunar surface processes

C) Implications for remote sensing

REQUIREMENTS:

A) Flat, "typical" soil surface

B) Approach area with utmost caution to keep soil contamination at a minimum or collect "behind" a boulder

C) Distance to LM: larger than 1 km

PRIORITIES:

A) Velvet cloth sampler

B) Beta cloth sampler

C) Skim sample

D) Scoop sample

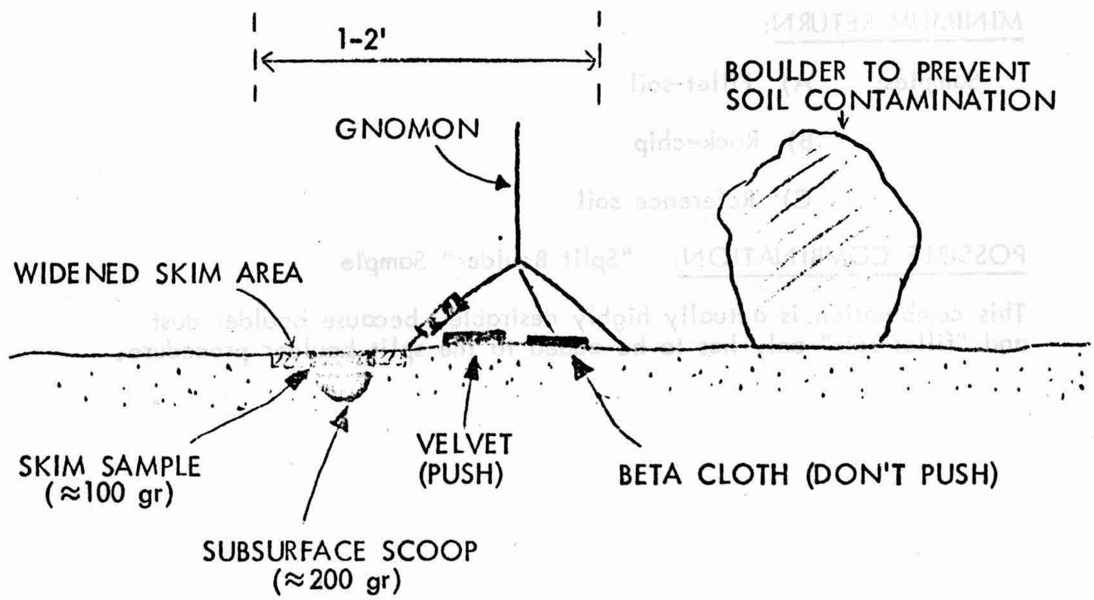
MINIMUM RETURN:

A) Velvet cloth sampler

B) Beta cloth sampler

SURFACE SAMPLER PROCEDURE

TIME	SAMPLE	CDR	LMP	PHOTOS
:03		Assessment of Tasks Prepare Surface Sampler Approach area with utmost caution or select suitable boulder for shielding		
:03	surface sampler 1	Put "beta cloth" sampler down, <u>don't push</u> Retrieve beta cloth sampler		
:03	surface sampler 2	<u>Push</u> "velvet" sampler down <u>Retrieve</u> "velvet" sampler		
:01		Put gnomon over sampling area 7', XS, stereo-pair "after"	DS, locator	4
:02	skim sample	Take skim sample 7', XS stereopair, "after"	Widen skimmed area	2
:02	scoop sample	Take scoop sample underneath skimmed area 7', XS, "after"		1



11

FILLET-SAMPLE:

OBJECTIVE:
A) Erosion mechanism and rate
B) Regolith transport mechanism
C) Surface history of rock

REQUIREMENTS:
A) Boulder larger than 30 cm.
B) Crystalline rock or very tough breccia
C) Must have fillet which is equally developed around entire rock; markedly assymetric fillets are undesirable. Best opportunity: on flat terrain.
D) Distance to LM: larger than 1 km

PRIORITIES:
A) Fillet-soil
B) Rock-chip
C) Dust from top of boulder
D) Reference soil

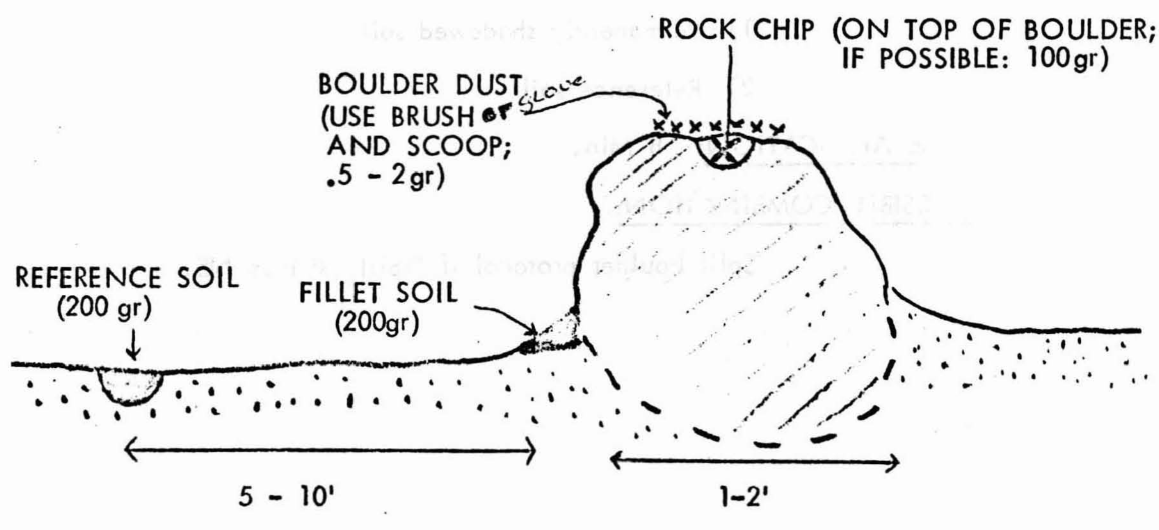
MINIMUM RETURN:
Samples:
A) Fillet-soil
B) Rock-chip
C) Reference soil

POSSIBLE COMBINATION: "Split Boulder" Sample

This combination is actually highly desirable, because boulder dust and "fillet-soil" only has to be added to the split boulder procedure.

FILLET-SAMPLE
PROTOCOL AND TIMELINE

TIME	SAMPLE	CDR	LMP	PHOTOS
:02		Assessment of Tasks Approach Area with Caution 7', XS-stereo, "before", of fillet to be collected; 2 other 7' shots, illustrating extent of fillet around rock	DS, loc.	6
:02	soil	Collect dust on boulder surface (if present) by brushing)		
:02	soil	Collect fillet soil 7', XS, stereo "after"	Close up,	2
:03	chip	Chip surface of boulder 7', XS, "after"	Close up, stereo "after"	
:05	soil	Collect Reference Soil, 5-10 ft. away Standard Procedure		



PERMANENTLY SHADOWED SOIL:

OBJECTIVE: To investigate the migration and redistribution of volatiles and semi-volatiles in permanently shadowed areas which act as "cool-traps".

REQUIREMENTS:

1) Overhang on boulder or pile of boulders which generate permanently shielded cavity partly filled with regolith. This implies that the overhang, etc., should be facing roughly S for the Descartes landing site.

2) Distance to LM: larger than 1 km

PROCEDURE:

1) If "permanently shadowed" area has been identified, photodocument sampling area and procedure by standard photo documentation as best as possible.

2) Take skim sample of soil surface and place sample in normal SESC container (7' "after").

3) Collect reference soil underneath skimmed area (7' "after")

PRIORITIES:

1) Permanently shadowed soil

2) Reference soil

MINIMUM RETURN:

1) Permanently shadowed soil

2) Reference soil

TIME ALLOCATION: 8 Min.

POSSIBLE COMBINATION:

Split boulder protocol if "split" strikes NS.

E-W SPLIT:

OBJECTIVE: To investigate the implantation of rare gases that are accelerated and redistributed by the solar wind electric field.

REQUIREMENTS:

A block of any lithology which is broken in half or 2 adjacent blocks which satisfy the following geometrical situation.

1) The "split" trends EW

2) The width of the split is no more than the height of the "walls", i.e. a "shielding angle" of 45° is required.

3) Soil contamination should be kept at a minimum.

4) Distance to LM: More than 1 km

PROCEDURE:

1) Approach area with caution.

2) 7', stereopair, "before", along EW split.

3) Skim sample in EW split ($\approx$150 gr)

4) 7', "after"

5) Reference soil, standard procedure. However taken along E-W line, about 10-20' away from split boulder on level, i.e. "unshielded" ground.

PRIORITIES:

1) Soil in E-W split.

2) Reference soil.

MINIMUM RETURN:

1) Soil in E-W split

2) Reference soil

TIME ALLOCATION: 10 Min.

POSSIBLE CONTAMINATION:

This sample may be combined with the "split boulder" procedure, if "split" strikes EW.

RATIONALE FOR LOCATION OF SPECIFIC SAMPLES:

STATION 4: CINCO CRATER

PADDED BAGS:

There is no compelling scientific reason why padded bag samples need to be taken at this Station. They are planned at this station because of time line considerations.

Take the samples whenever and wherever it is convenient, e.g. Stations 5 and 6 are also O.K. The objective of this task is to preserve the pristine surfaces of a rock.

Remember:
- a) The samples should be igneous if possible.
- b) They should be hand specimen laying around. Chips hammered off a boulder are unsuitable because the hammering may have destroyed the pristine nature of the surfaces.
- c) Handle the sample and the bags with tender loving care.
- d) Pull Velcro-strap as tight as possible.
- e) Storage in seat pan is recommended during EVA.
- f) Store in special pouches inside the LM.

STATION 8: S-RAY CRATER RAY

SPLIT-BOULDER

Because the main purpose of this experiment is to date the event which formed S-Ray Crater, the task had to be planned on a S-Ray Crater Ray.

Remember:

1) The boulder should be of crystalline nature.
2) The boulder has to be uniquely associated with S-Ray. You have to establish that criterion in real time, e.g.
   a) secondary projectile still sitting in its crater?
   b) characteristic lithology for S-Ray ejecta?
   c) characteristic of S-Ray boulders?
3) Possible combinations with other samples like fillet, boulder dust, E-W split and permanently shadowed soil.

STATION 9: VACANT LOT

SURFACE SAMPLERS AND CSVC:

The rationale for placing station 9 where it presently appears is strictly based on photo interpretation; however, the final choice of location is up to your judgment.

a) Station 9 should be on pure Cayley. AVOID any visible contamination by S-Ray Crater ejecta.

b) Station 9 also has to be at least 1 km away from LM, to avoid LM-contamination and descent engine blast effects.

Another real time decision:

If you can walk around without kicking up dust, then select relatively smooth area free of big boulders, etc. If you can't avoid kicking up dust, use a boulder for protection. Approach this boulder from the side facing the LM, so that you can collect the soil on the other side of the boulder, i.e. soil unaffected by LM.

The location of the CSVC is not critical in relation to surface sampler area and left at your discretion.

4

STATION 12: N-RAY CRATER

GIANT BOULDER, E-W SPLIT, PERMANENT SHADOW:

The rationale for placing these activities at station 12 is due to our knowledge concerning the size and frequency of blocks. They are there in adequate sizes and frequencies. Further arguments are time line considerations, i.e. we have a total of 109 minutes station time at N-Ray during which we can hopefully collect some of the above samples. The actual location of suitable sample areas within station 12 for the above samples is up to your real time assessment. They are genuine targets of opportunity. Anywhere and any time during station 12 activities these samples can be collected.

STATION 1?: END CRATER

A radial sample is planned at E-Crater by taking 1 rake/soil and 2 large soil samples and as many hand specimen as time line permits. The rationale for picking End Crater for radial sampling is largely due to time line considerations.

Scientifically we have the unique opportunity to collect hopefully all rock units which were excavated by the Palmetto event, because End crater will re-excavate the overturned flap of Palmetto. While the rake and large soils at 1/2 diameter yield rocks from deeper horizons, the sample on the rim of End will characterize the local, upper Cayley units. It may be difficult to reconstruct the precise, 100 m deep stratigraphy, but we should have all rock types involved in the Palmetto-Event. Thus in a way, a radial sample of End will help us to learn about Palmetto.

The reason for having the radial sampling line running roughly W-E is largely operational, i.e. the 70 mm pan should be pointing inside Palmetto. After shooting that pan, the LMP can start the radial sample right where he is standing. Principally, it does not matter along which direction the radial sample is taken; after all, we deal with an (ideally) centrosymmetric phenomenon.

SAMPLING RATIONALE FO... NORTH RAY CRATER

Major Objective: Obtain samples from the various units in the stratigraphic succession observed in the Crater. These would be used for correlation with other sampling at this landing site; ages, chemical fractionation, cooling history, and source region for igneous rocks; and location, size, source material, and mixing history of cratering events for breccias.

Data for Real Time Decision: Large blocks are the easiest to relate to observable crater stratigraphy either in real time or through later photo studies comparing albedo, polarimetry, and 500mm textures and structures of near field and far field. If (I) there are no large boulders (>1m) in locations allowing comparisons, (II) only one large boulder type occurs on rim, or (III) the number of boulder types on rim is small compared with number of units seen in crater wall, then rim sampling may not allow a good sampling of stratigraphy and the next stop should be radial rather than lateral. Following are some of the sampling situations which might be expected.

ALL BRECCIAS

If there are many large boulders (>1m) try to relate to units in crater and sample by:

- a) chipping representative population of large clasts or chunks containing many coarse clasts from boulders. Similar coarse clasts may be collected from hand specimen fragments if they can be positively related to the large boulders. (Coarse clasts >2 to 3 cm allow a variety of detailed studies.)
- b) pick up several hand specimens of same type as boulders but with smaller clasts. (To allow statistical study of clast population as well as matrix.)
- c) repeat for each type of large block that can be related to crater units or can be observed to be significantly different than others on basis of overall color, coherence, clast shape, or clast size.
- d) sample hand specimen size fragments for any additional variety: e.g. least coherent breccias may occur only in this size fraction.

If only a few large boulders occur, make initial evaluation of variety of boulder types and proceed with sampling as in 1. above.

If only small fragments (<1m) are present, collect as many types as can be found including:

- a) variety of coarse clasts (for ease of sample analyses).
- b) variety of color, coherence, clast shape, clast size, and ratio of clast/matrix

This size fragment will be difficult or impossible to correlate with crater strata.

Things to keep in mind during sampling:

Do not spend much time describing breccias. Clasts may be quite varied and difficult to describe. Give overall color, clast size and shape, coherence, and ratio of clasts to matrix. Also give frequency of occurrence of each type in the local breccia population.

Look at boulders for such structural features as layering, cross-bedding, gradational clast size, and preferred orientation of clasts. Photograph any of these.

Coherence variations relate to degree of crystallization or recrystallization which in turn relates to size and distance of cratering events which produced the strata. Least coherent types may be local soil breccias.

Clast shapes may range from angular, which denotes a simple history perhaps related to fracturing of rocks in nearby cratering events, to rounded, which denotes a more complex surface history and perhaps derivation from a more distant source by reworking through several events.

Look for breccias within breccias and collect large enough samples to study secondary clast population for comparison with other units.

Clast size may range from coarse, which allows a variety of analyses, through fine, which allows statistical analysis of types, to micro, which is mostly matrix. Various combinations of these sizes relate to size and proximity of cratering events, simple vs. complex mixing history implying single to multiple events.

The ratio of clast/matrix relates to various strata which derive from different source areas.

MIXED BRECCIAS AND IGNEOUS

1. If all large boulders are igneous, and breccias occur only among the smaller fragments:
   - a) use ALL IGNEOUS procedure.
   - b) collect representative samples of breccias describing color, coherence, clast size and shape.
   - c) note whether any observable igneous clasts in breccias are the same as large boulders.
   - d) note whether large igneous blocks contain veins or irregular patches of breccia or glass.
2. If all large boulders are breccias and igneous rocks occur only among the smaller fragments:
   - a) If igneous fragments are the same as breccia clasts, utilize ALL BRECCIA procedure.
   - b) If igneous fragments are not the same as breccia clasts or it is impossible to tell whether they are the same, utilize ALL BRECCIA procedure and collect representative samples of igneous fragments as in ALL IGNEOUS 3.
3. If large blocks are both igneous and breccias as are the smaller fragments:
   - a) combine ALL BRECCIA and ALL IGNEOUS procedures in attempt to collect representative sampling of each type.
   - b) note whether igneous clasts in breccias are the same as the large igneous boulders.
   - c) note whether large igneous boulders contain veins or irregular patches of breccia or glass.
   - d) note whether there is any pattern to the frequency of igneous hand specimens or small blocks in relation to large breccia boulders to suggest that the igneous rocks are dislodged from breccias.
4. No large blocks. Small fragments only consisting of breccias and igneous rocks.
   - a) If igneous rocks are same as breccia clasts use ALL BRECCIAS procedure number 3.
   - b) If igneous rocks are different from breccia clasts or it is impossible to tell whether they are the same, try to collect as many types as possible as discussed under items 3 of ALL IGNEOUS and ALL BRECCIAS. Give particular attention to the igneous fragments and coarse clast breccias.

Things to keep in mind during sampling:

A major problem of this mixed category is to determine whether some or all of the igneous boulders were originally large clasts in very coarse ejecta (as would be deposited close to the rims of large craters). Some criteria which can be used are: similarity of clasts in breccias to boulders, presence of veins or irregular patches of breccia or glass in igneous blocks, occurrence of igneous fragments or small blocks around large breccia boulders as if dislodged from boulder.

ALL IGNEOUS

1. If there are many large boulders (>1m) try to relate to units in crater and sample by:
   - a) chipping fragments from each block type. Alternatively, collect hand specimen fragments of the same type if they can be positively related to the large boulders. Variations in types may be based on color, porosity (vesicularity), grain size, porphyritic vs. non-porphyritic, or other obvious textural differences.
   - b) looking for layering, inclusions, dikes, or any other heterogeneities in the blocks and sampling each rock type involved.
   - c) using giant boulder procedure on one boulder.
   - d) sampling hand specimen size population for additional variety not seen in large boulders.
2. If only a few large boulders occur make initial evaluation of variety of boulder types and proceed as in 1. above.
3. If only small fragments (<1m) are present collect as many types as possible based on color, porosity, grain size, porphyritic vs. non-porphyritic, or other obvious textural differences. This size fragment will be very difficult to correlate with crater units.

Things to keep in mind during sampling:

Look for patterns of angular or rounded boulders. These may relate to the nature of jointing, fracturing, or other mechanical property of a unit in North Ray Crater. If a given rock type always displays the same angularity, it probably represents North Ray ejecta rather than ejecta from a variety of events. This is particularly important to note if small fragments form the bulk of the size population.

CRATERS IN CAYLEY:

(See attached plot)

Definitions:

"Predicted Depth" Based on laboratory impact experiments and related cratering scaling laws defined as the depth to which crater material was excavated.

"Present Day Depth" As measured from TOPO COM - map

"Diameters" As measured by Flagstaff (rim-to-rim-distance)

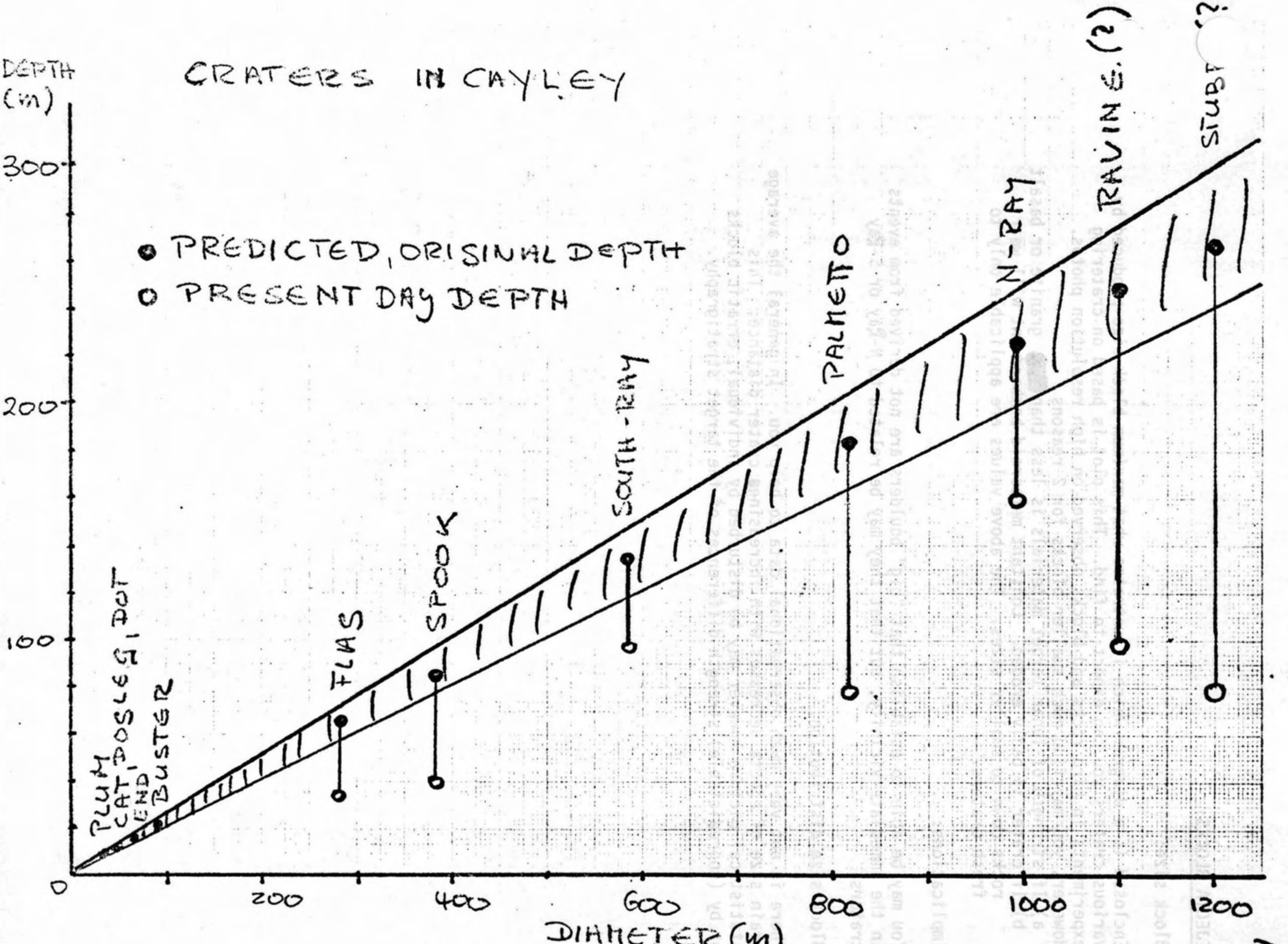
NOTE: a. The difference between present day and prepicted depth is of course due to subsequent crater erosion and infill.

b. However you see, that even S-Ray crater has some infill, though it is extremely young. This is due to the fact that immediately following excavation, the fall back ejecta and possible slumping of crater walls fill to part of the crater bottom. Thus even the youngest craters display some fill.

c. The degree of infilling is of course a good measure for relative ages, however only, if one compares craters of ~~different~~ identical size. ...rent sized craters are difficult to asses (however there are good theoretical models), because small craters fill in much faster.

Implications:

The plot is included, because it demonstrates that the various craters visited during the EVAs have produced rim materials from different depths and there - by they may help to reconstruct Cayley - Stratigraphy. According to Oberbeck, Plum, Cat-Dog Leg - Dot and End craters may or may not have penetrated to hard bedrock, i.e. Cayley. The importance of Buster is obvious, because its size guarantees, that the upper Cayley layers were excavated.


CRATERS IN CAYLEY
DEPTH (m)
300
200
100
0
● PREDICTED, ORIGINAL DEPTH
○ PRESENT DAY DEPTH
PLUM
CAT, POSLE G, DOT
END
BUSTER
FLAS
SPOOK
SOUTH-RAY
PALMETTO
N-RAY
RAVINE (?)
STUBBY (?)
200
400
600
800
1000
1200
DIAMETER (m)

EJECTA BLOCKS:

Block size:

Enclosed is a diagram which illustrates what maximum block size produced by various craters you can expect to find. This plot is based on cratering experiments in hard rocks and blocks observed on high resolution photos. However, you may find much smaller blocks for 2 reasons

a) If strength of lunar target materials is less than [redacted] granite or basalt
b) If crater is badly eroded. Constant meteoroid bombardment will wear rocks down to smaller sizes. The above values are applicable only to fresh craters.

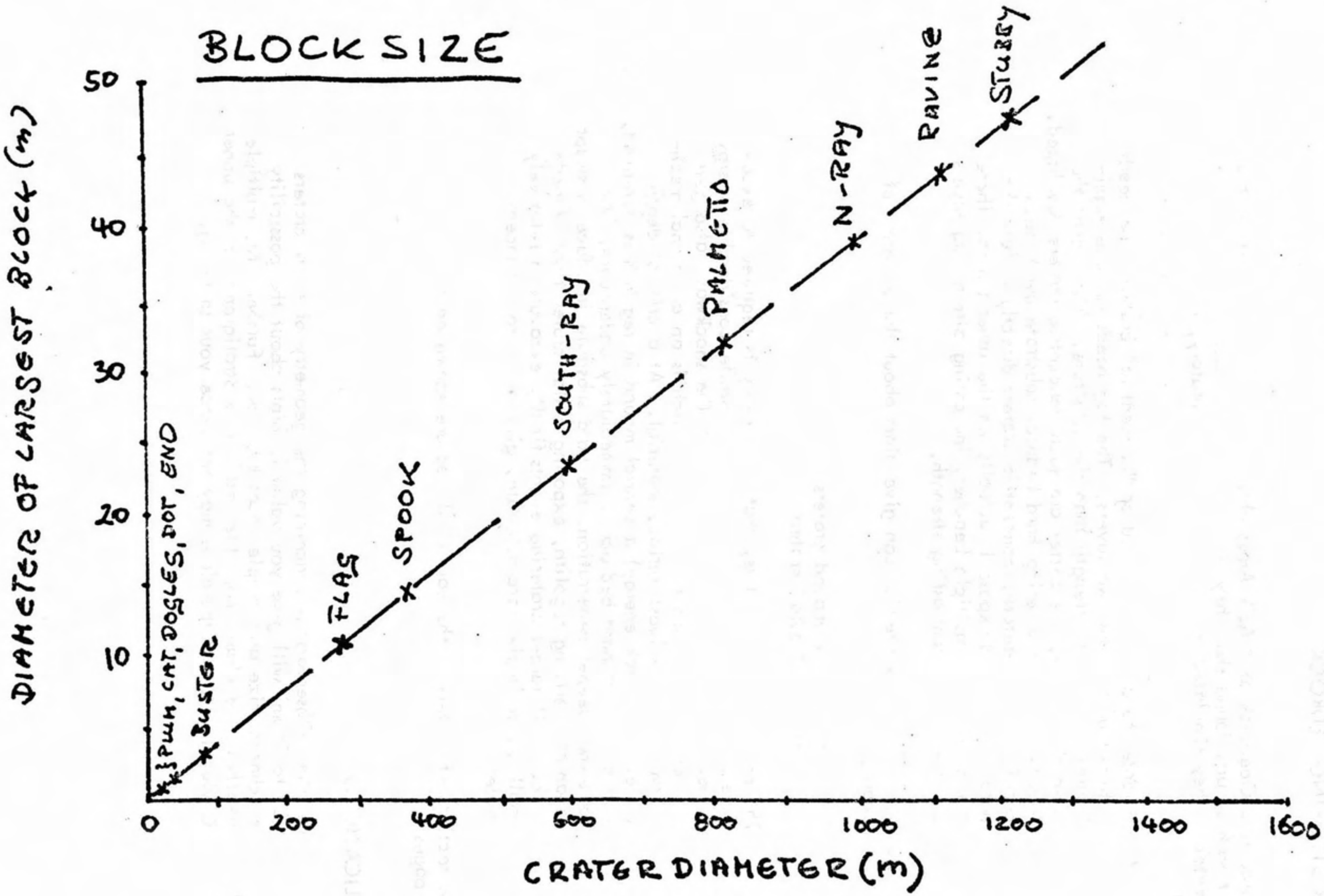
Implications:

You may be able to establish that "big" boulders are not derived from events in the immediate vicinity, but that they may be related to N-Ray or S-Ray craters.

Block size distribution:

There is not very much observational data to help you. In general the average grain size of ejecta decreases with increasing crater distance. This statistical picture however may be disturbed by individual, erratic blocks or by (unpredictable) strength differences of the target stratigraphy.

BLOCK SIZE


DIAMETER OF LARGEST BLOCK (m)
50
40
30
20
10
0
200
400
600
800
1000
1200
1400
1600
CRATER DIAMETER (m)
SPWM, CAT, DOGLES, DOT, END
BUSTER
FLAG
SPOOK
SOUTH-RAY
PALMETTO
N-RAY
RAVINE
STUBBY

SMALL CRATERS AS A SAMPLING TOOL AND OBSERVATIONAL TARGETS FOR STUDYING BEDROCK

Quaide and Oberbeck at NASA Ames observed concentric craters on the lunar surface and found that they are confined to craters less than 300m diameter. They simulated such craters in the laboratory, and conclude that:

1. In order to produce benched or "concentric" craters, one needs a target of at least two layers. The top needs to have significantly less shear strength than the substrate. The higher the strength contrast, the better are such concentric craters developed. A loose regolith covering hard bedrock substrate meets such conditions. Therefore, concentric craters directly reflect the hard bedrock and expose it actually on the inner bench. There are craters with multiple benches, indicating alternating layers of materials of contrasting strength.

2. Other crater geometries can give hints about the presence of bedrock:

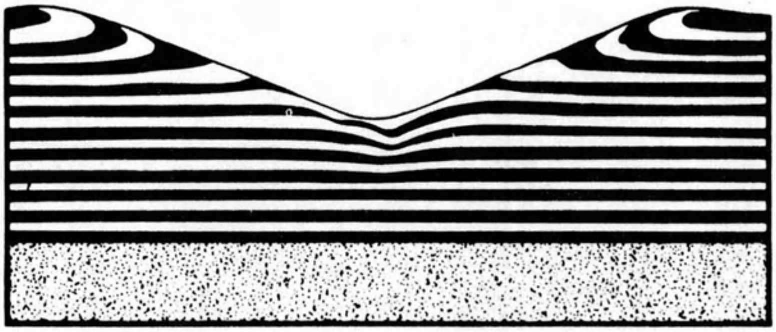
   (1) Central mound craters
   (2) Flat floored craters

   The explanation offered is, that less energy is required to excavate in essentially strengthless regolith while considerable energy is needed to excavate hard bedrock. The shockwave also gets reflected at the hard rock surface, which is an additional mechanism to remove loose surface material. At a critical depth (= level of shock energy) a central mound in regolith is achieved, indicating that hard bedrock is immediately underneath. At somewhat deeper penetration, the hard substrate interface is swept clean of overlying regolith, exposing a flat crater floor of bedrock. Still larger cratering events finally excavate a relatively small crater in the hard substrate, giving rise to a concentric crater.

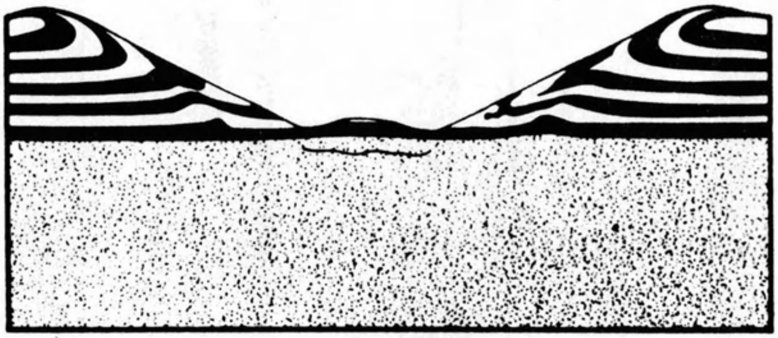
Cross sections of craters of the various shapes are shown on the following two pages.

IMPLICATIONS:

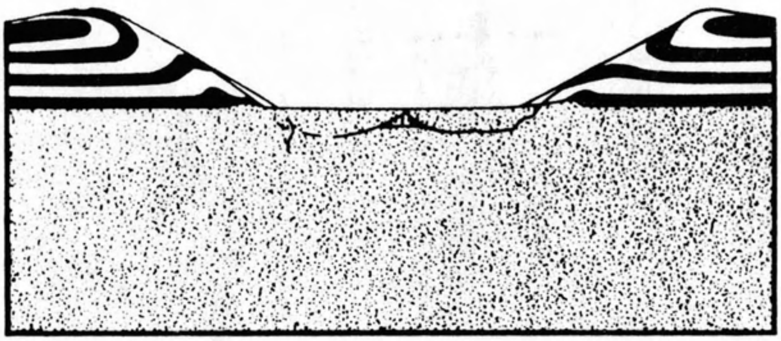
Detailed Observations concerning the geometry of small craters (20 to 200m) will give you valuable hints about the possibility to characterize and sample local bedrock. Furthermore, multiple benches give clues about the small scale stratigraphy of the upper Cayley layers and therefore may influence your sampling.



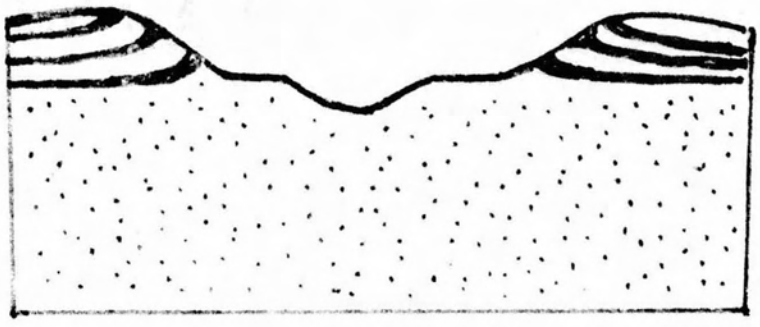
"NORMAL"



"CENTRAL MOUND"



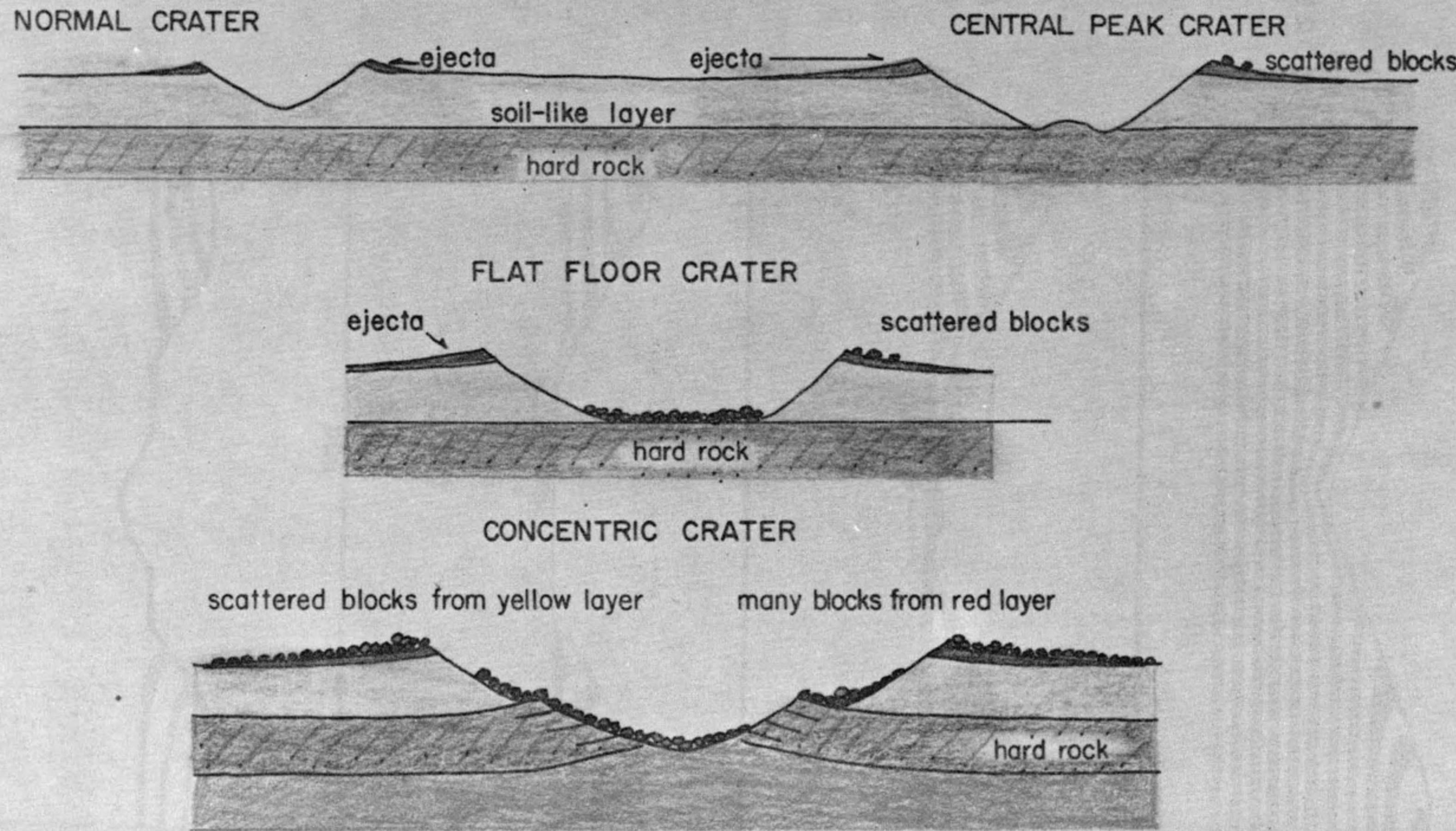
"FLAT FLOOR"



"CONCEN-
TRIC"

OBERBECK + QUAIDE

PROFILES OF FRESH CRATERS ILLUSTRATING INVERTED STRATIGRAPHY & EFFECT OF HARD ROCK UNDER-LAYERS ON CRATER SHAPE



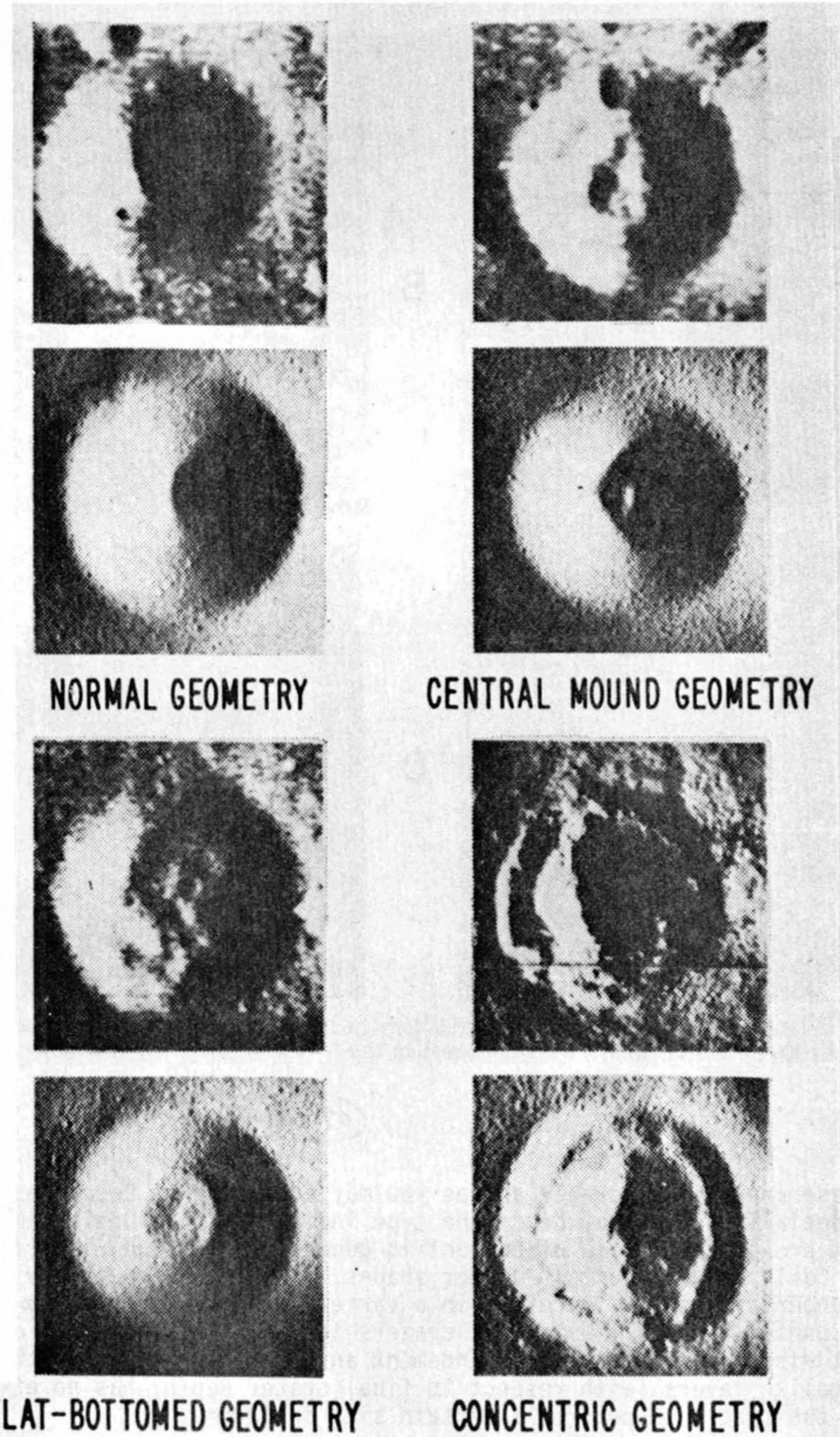
H. MOORE

MOON

LABORATORY

MOON

LABORATORY



DIFFERENT CRATER GEOMETRIES ACCORDING TO
OBERBECK AND QUAIDE

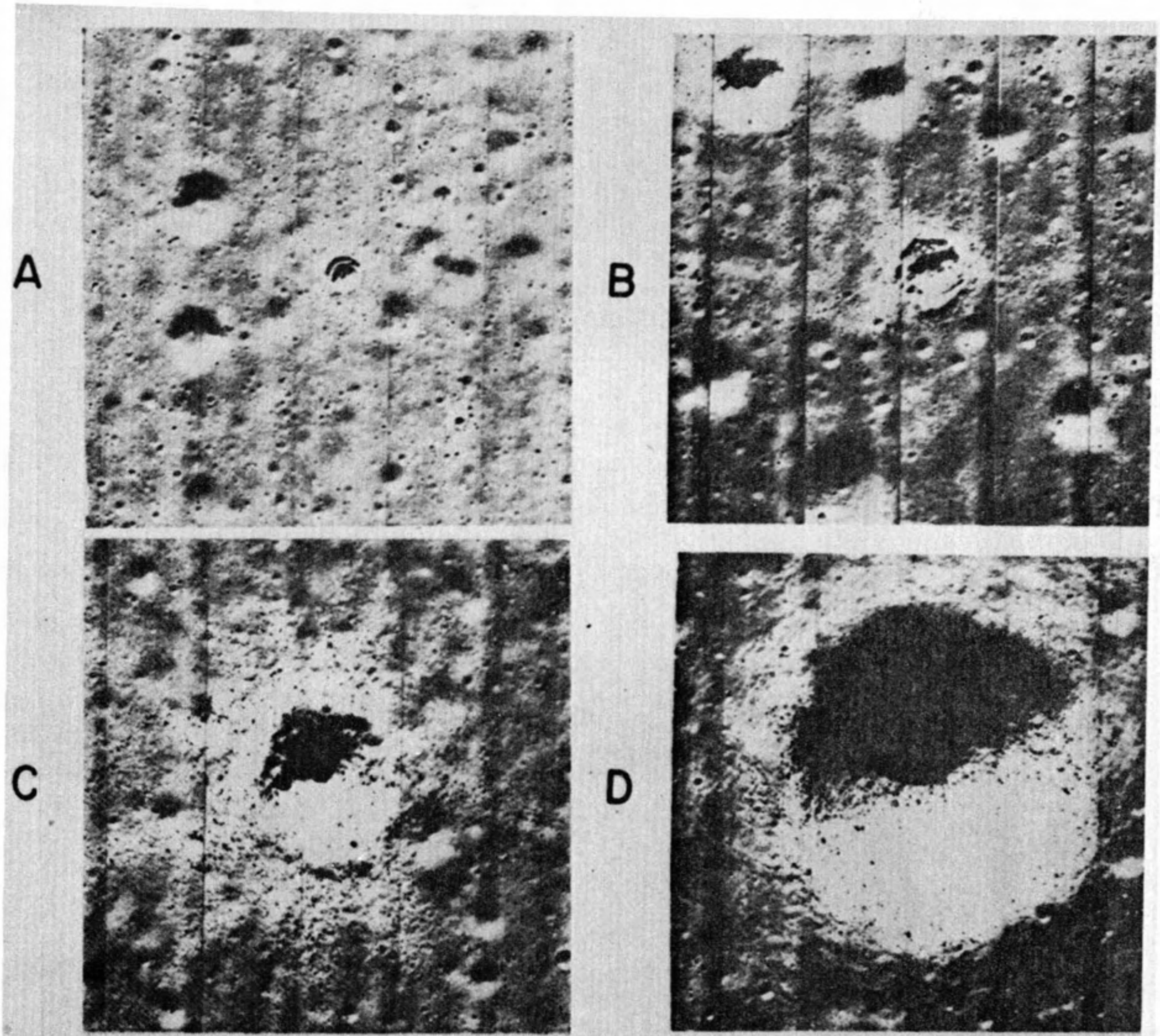


Fig. 18. Relationships between size and morphology of fresh craters with diameters between 70 and 400 meters in an area where the median thickness is of the order of 5 meters.

of regolith

These are typical crater shapes you may encounter at Descartes. Especially Buster may be of the type indicated in A; Dogleg and Dot are probably also of concentric geometry. Cat and End craters probably posses "normal" crater shapes. Cinco is very likely a "concentric" one. Therefore in a variety of locations you may encounter bedrock. Note that craters larger than about 300m do not display a concentric arrangement anymore. The relative thin regolith layers (with respect to final crater depth) has no effect on the crater shape from a certain size on (200m).

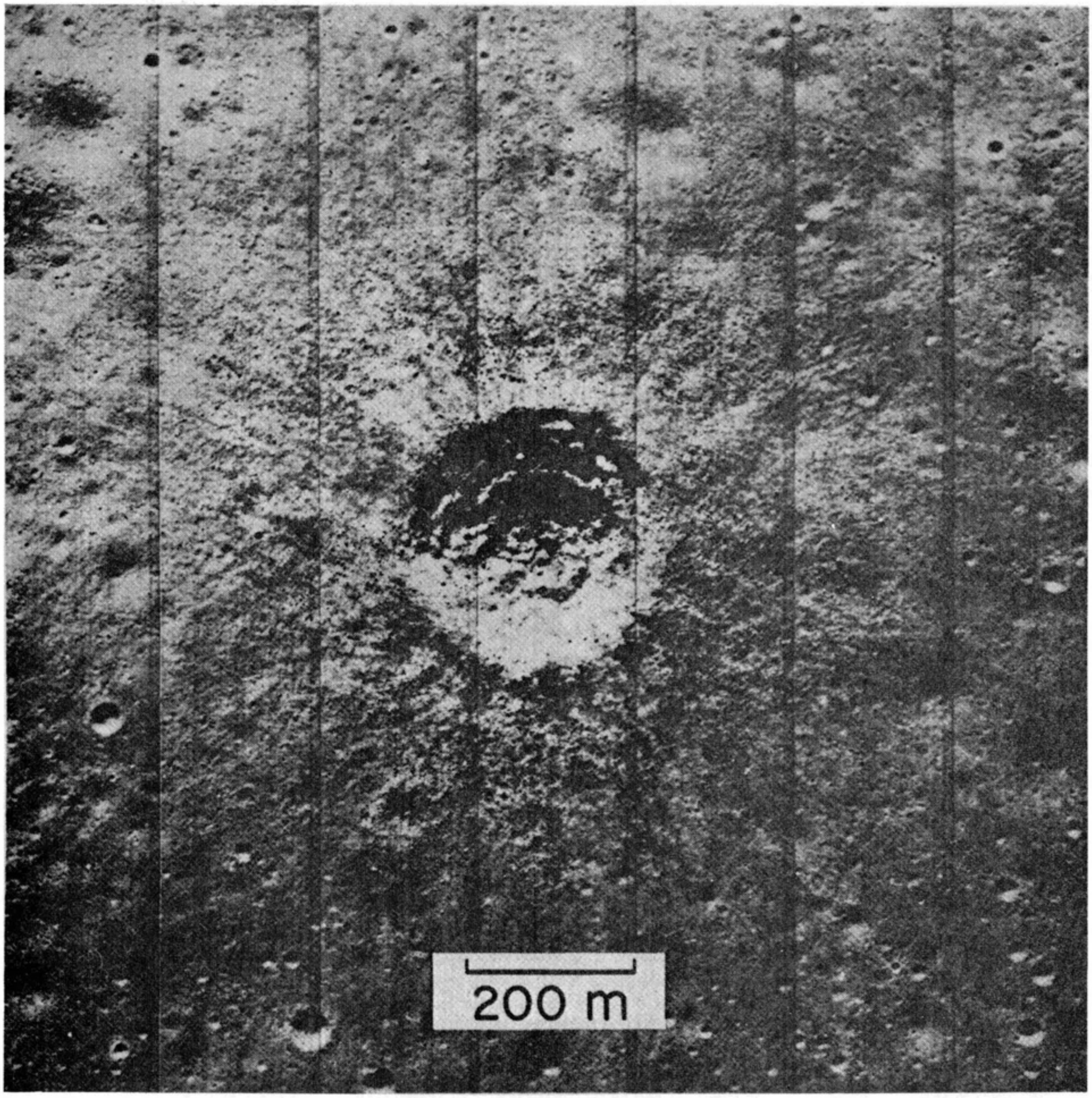


Fig. 20. Concentric crater with a multiplicity of nested central craters suggesting the presence of interbedded strata of varying strength in the substrate.

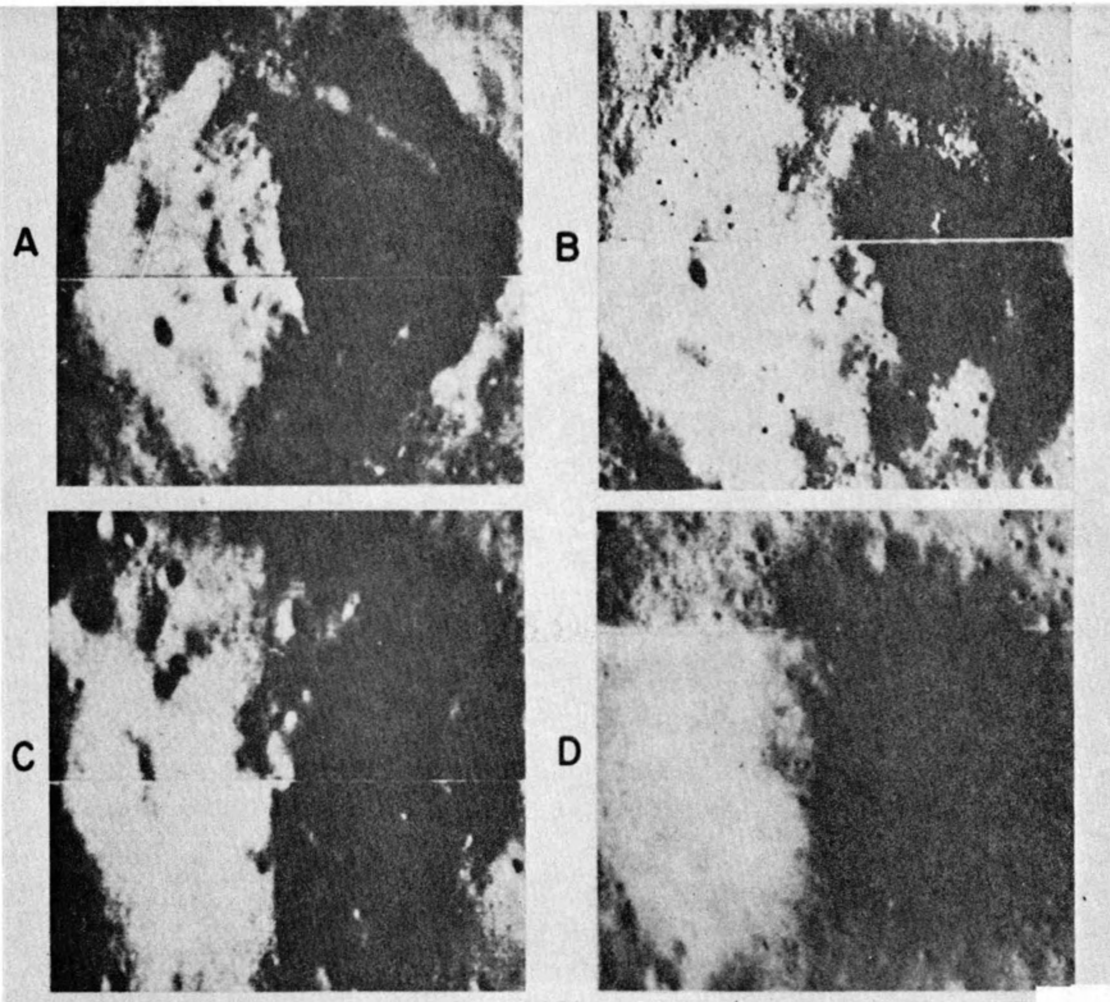


Fig. 19. Interpreted stages of modification of a concentric crater. The craters shown are of the same size (~190 meters) and occur close to one another in a region where the median thickness of the surface layer is of the order of 5 meters. (*A*) Sharply defined concentric crater, square in plan with fans of ejecta blocks originating from the inner crater. Few small craters are superposed on the crater and ejecta. (*B*) Slightly modified concentric crater with square plan shape, inner crater and blocky ejecta still evident. Greater numbers of small superposed craters are present. (*C*) Substantially modified concentric crater with inner crater and square outline faintly visible. Blocky debris is rare and appears to be randomly distributed. Small superposed craters are numerous. (*D*) Highly modified concentric crater with a faint indication of a square shape. Large blocks are rare and no trace of inner crater remains. A large population of small superposed craters is evident.

[redacted] 198a

TABL. 2

SIZES OF VARIOUS CRATERS NE. THE APOLLO 16 LANDING SITE
AND THEIR RELATION TO VARIOUS TERRESTRIAL STRUCTURES

Crater	Diameter Kilometers - Miles		Depth Kilometers - Miles		Comparisons
Theophilus	100 km	62 mi.	?		≈Austin to San Antonio
Descartes	50 km	31 mi.	?		≈Clear Lake City to Galveston
North Ray	1 km	0.62 mi. 3280 ft	150-220 m	492- 622 ft	CRATER DIAMETER - George Washington Bridge - 3500' Baytown Tunnel - Houston Channel - 3009' ABOUT THE SAME DIAMETER AS METEOR CRATER CRATER DEPTH - The following structures could be placed within North Ray: Vertical Assembly Bldg. (VAB) - 525' Washington Monument - 555' San Jacinto Monument - 570' Humble Oil Bldg., Houston - 606' ABOUT THE SAME DEPTH AS METEOR CRATER
Gator	860 m	2820 ft	135 m	440 ft	CRATER DIAMETER - 12 Boeing 747's parked end to end (231' each) - 2775' About 1/3 the length of the Main Ellington Runway - 9000' CRATER DEPTH - Saturn V - 363' Cheops Pyramid - 450' Guided Missle Destroyer - ≈437' Destroyers - General - 350-450'
Palmetto	775 m	2540 ft	100 m	328 ft	CRATER DIAMETER - San Francisco Bay Bridge - 2310' CRATER DEPTH - Saturn V - 363'
Spook	370 m	1210 ft	40 m	130 ft	CRATER DIAMETER - Height of Empire State Bldg. - 1250' U.S.S. Forrestal Aircraft Carrier - 1036' 26 T-38's parked end to end CRATER DEPTH - Boeing 727 length - 133'
Flag	280 m	920 ft	50 m	164 ft	CRATER DIAMETER - Ocean Liner Queen Elizabeth II - 963' More than 3 football fields Aircraft Carriers (CVB-CV) - 850-950' U.S.S. Hornet Aircraft Carrier - 899' CRATER DEPTH - Boeing 707 length - 153' Niagara Falls - 193'

CRATER RAYS AT DESCARTES:

I. BACKGROUND:

- A. Continuous Rays
- B. Discontinuous Rays
- C. Cratering Mechanics

II. RAY SYSTEMS AT DESCARTES:

- A. South Ray Crater
  - 1. Flag and Spook Craters
  - 2. Stubby/Station 8
  - 3. Others
- B. North Ray Crater

I. BACKGROUND:

One can distinguish two types of "rays":

A. Continuous Rays

B. Discontinuous Rays

A. Continuous Rays:

They are irregular, long stretched protrusions of the continuous ejecta blanket and thus are an integral part of the ejecta blanket itself.

Because of the inverted stratigraphy within an ejecta blanket the continuous rays are from the uppermost target strata. As a rule of thumb: they are derived from the uppermost 20% of the total stratigraphic column excavated. Thus, the variety of rock types encountered in these rays is dependent on the lithological heterogeniety--or lack therof--of the uppermost target layers. Chances are relatively high, that they are of monolithologic character.

Such continuous rays may extend twice as far as the average continuous ejecta blanket, i.e. up to 5 crater diameters as a rough rule. They protrude out of the ejecta blanket without any topographic break; they never "overlay" the ejecta blanket. Their grain size and block distribution is similar to that of the "average" fringes of the ejecta sheet.

Consequently sampling of such rays does not yield significant results which could not be obtained at other parts of the ejecta blanket. Stratigraphic information, i.e. rock types as a function of crater distance, is more readily obtained on the continuous ejecta blanket, because less radial distance has to be covered to encounter different lithologies. It is even less promising to obtain stratigraphic information by traversing along a concentric path and thereby intersecting a variety of continuous rays: they all should be more or less alike.

B. Discontinuous Rays:

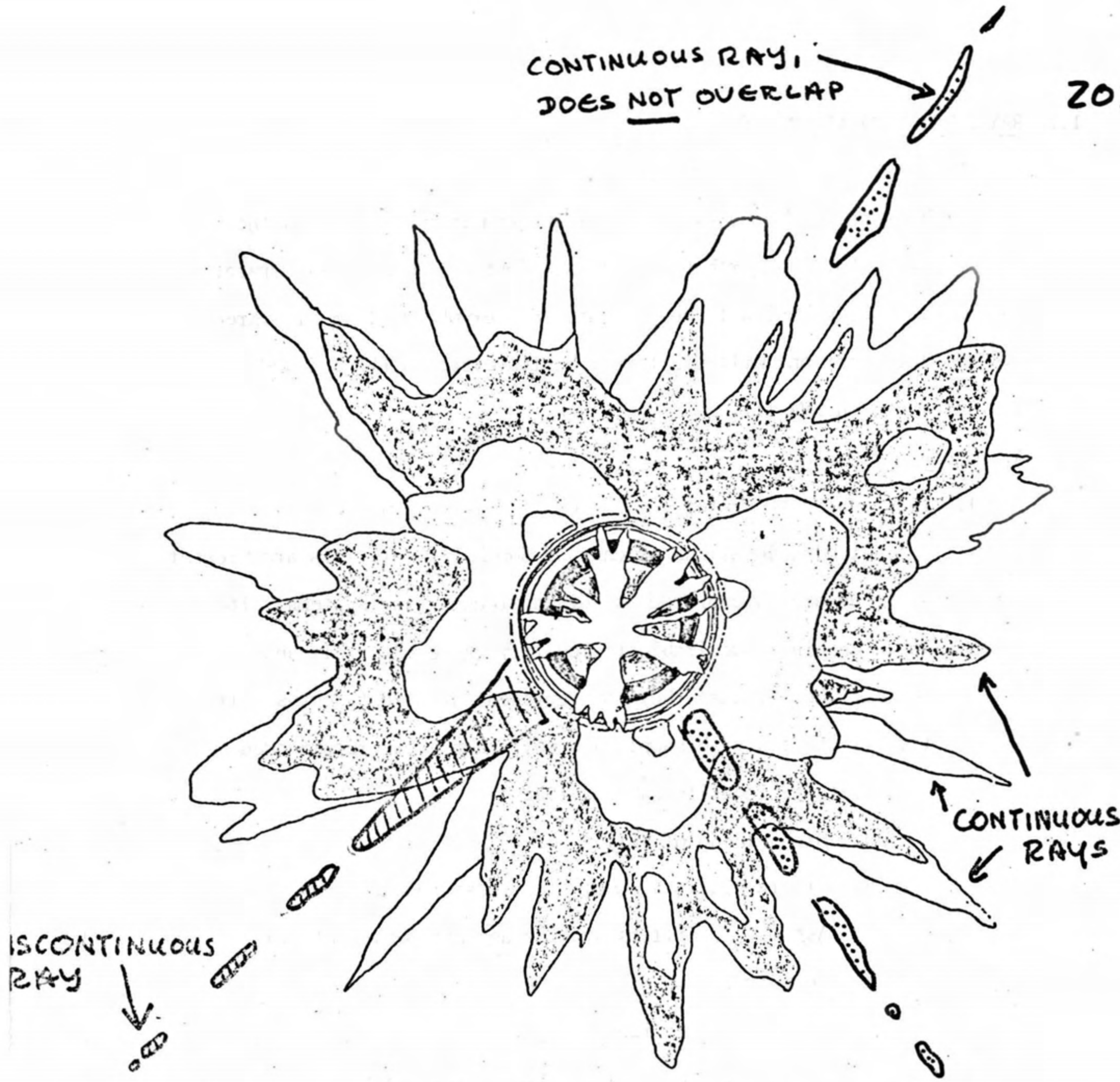
Discontinuous rays are--in contrast to continuous ones--much more complicated structures, because they can principally be derived from all stratigraphic horizons involved in the cratering event. However the majority of discontinuous rays seems to originate from the upper 50% of the column excavated.

They represent discontinuous, discrete patches of ejecta materials aligned radially to the crater. Each individual ray represents a discrete (small) volume of the stratigraphic column. All individual patches making up one ray are composed of the same materials, i.e. relatively homogeneous. However each individual ray may be derived from different depths. Consequently, ranging radially along discontinuous rays is not a very promising sampling approach, while the visiting of a variety (= concentric traverses) of discontinuous rays yields very likely a lot of "variety." However, it is impossible to place these materials in their proper stratigraphic sequence, unless other supporting evidence is gathered on the continuous ejecta blanket or on the crater rim.

The extent of discontinuous rays may be up to 20-30 crater diameters. With increasing distance the patches become more infrequent and more irregular, probably also much thinner, i.e. there is not very much mass ejected this far. "Discontinuous" rays close to the crater may be "continuous" masses of ejecta; however they are distinguished from genuine continuous rays by the fact, that they overlay the ejecta blanket. Discontinuous rays may start directly at the crater rim as continuous ridges etc., which will thin out with crater distance and finally end up with intermittent patches of ejecta. Quite often these patches are caused by individual clods of material, which broke apart upon landing.

C. Cratering-Mechanics:

Detailed knowledge about impact crater rays is truly scarce. There is presently no quantitative understanding of the phenomena and the above guidelines are derived from a few small scale impact cratering experiments as well as a few explosive (nuclear and chemical) craters. It appears that the "continuous" rays are protrusions which may be caused by various degrees of turbulance in the ejecta cloud. They are omnipresent in the above experiments. Discontinuous rays however appear only, if significant mechanical heterogenieties exist in the target. Such heterogenieties cause a disturbance in the shock front which results in rare faction and reflection of waves which may locally concentrate shock wave energy and thereby accelerate the materials above "average." Such mechanical disturbances may be rock units of vastly different densities (= compressive strength), but also faults may have such effects. This is the reason--we think--why "discontinuous" rays can basically originate everywhere in the target and why they are so unpredictable!



SKETCH OF PLAN VIEW OF CRATER SHOWING
DISTRIBUTION OF EJECTA AND UNITS IN CRATER WALL

TALUS	
UNIT 1	UNIT 1 EJECTA
UNIT 2	UNIT 2 EJECTA
UNIT 3	UNIT 3 EJECTA
UNIT 4	UNIT 4 EJECTA

II. RAY SYSTEMS AT DESCARTES:

The following discussion neglects purposely all ray systems emanating from small, fresh, craters (20-50m) and focuses only on the rays of South-Ray and North-Ray craters. South- and North-Ray crater ray materials can basically be encountered everywhere along all three EVA's. The first one will positively be traversed on EVA's I and II; the latter one on EVA III.

A. South-Ray Crater:

1. Flag and Spook Crater

At both locations patches of South Ray materials are present and they are interpreted as "discontinuous" ray systems. It would be highly desirable to identify these materials and to collect them because they may represent different depths. If time is short a grab sample and soil sample are recommended.

Hints to identify Ray materials:

a. High albedo of soil.

b. If big blocks around: the least rounded ones.

c. Asymmetric fillets banking against S-side of big boulders.

d. Coarser grain size of soil.

e. "secondary" craters pointing towards S-Ray.

f. Patches of loose material, i.e. "mounds."

g) Relative abundance of blocks, boulders etc.

2. Stubby/Station B

It is impossible to tell whether these materials are continuous or discontinuous rays. Critical observations to solve this question:

Do rays emanate out of continuous ejecta blanket (= continuous ray) or do rays overlap ejecta blanket (= discontinuous rays)? Photograph!!

Try hard to make these observations, becuase they are critical to place the materials back into their stratigraphic position, if part of a continuous ray.

Hints to identify and sample ray materials:

a. Soil:

(1) High albedo.

(2) Coarse grain size.

(3) Fillets banking against boulders.

(4) Mound-patches.

The main soil sample we want at station 8 is the double core tube; it should be placed such that it hopefully penetrates the ray material and ends up in the underlying Cayley. If mounds are present, take scoop samples of them.

b. Boulders

(1) Hopefully not well rounded because of young age of S-Ray.

(2) Boulders associated with "secondaries," either still sitting in little crater or broken up and scattered around.

(3) Boulders at the end of tracks pointing towards S-Ray.

(4) Boulders aligned along radial from S-Ray.

The sampling should focus to recover "variety" of rock types. Therefore if you can, do select a boulder field which offers "variety." However be not too surprised if you don't encounter this option; rays just tend to be "homogeneous."

We do not know, whether the boulders are igneous or breccias. Work as best as possible along the guidelines developed for the sampling of N-Ray crater rim.

While your hand specimen sampling may include the one or other "odd-ball," try to pick an area for the rake/soil sample which is representative for the ray materials.

3. Others

There are no other sampling stations planned on S-Ray materials, however you may comment while driving on their occurrence etc. at:

a. Between Spook and LM.
b. At Survey Ridge.
c. Between Stations 6, 7 and 8.
d. All the way back from station 8 to the LM.

B. North-Ray Crater:

There is no specific sampling spot planned on any North-Ray crater ray system. However detailed observations enroute from N-Palmetto (where you may start to encounter N-Ray boulders) may help you in getting some ideas about the lithologies coming out of N-Ray and thereby may give you valuable clues about what to expect at the rim. It also will help the SSR to better help you in exploring the N-Ray complex. You will actually select an interray area for trafficability reasons. If feasible it is recommended to swing from one ray to another and look, whether the lithologies are similar ~~to~~ or different. Such observations become critical on the rim, if you ~~observe~~ detect that some rock types you observed on the rays are not present in the rim materials. Thus, these observations may heavily influence the sampling and stay time on the rim proper. Of course, the same kind of observations should be gathered, once you have encountered the continuous ejecta blanket.

On the 500mm Apollo 14 photos we can see, that you are in the area of N-Ray crater ejecta or ray systems from shortly N of Palmetto, through stations 11, 12, 13 and 14; very likely also on stations 15 and 16.

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