COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT
Hawaii

Technical Report No. 4

VEGETATION MAP OF HAWAII VOLCANOES NATIONAL PARK

(at 1 : 52,000)

ST. JOHN PLANT SCIENCE LABORATORY · UNIVERSITY OF HAWAII · HONOLULU, HAWAII 96822

NOTICE: This document contains information of a preliminary nature and was prepared primarily for internal use of the University of Hawaii, Cooperative National Park Service Resource Studies Unit (U. H./ NPS Unit). This information is not for use in the open literature prior to publication by the investigators named unless permission is obtained in writing from the U.H./ NPS Unit Director.

Technical Report No. 4

VEGETATION MAP OF HAWAII VOLCANOES NATIONAL PARK

(at 1 : 52,000)

Dieter Mueller-Dombois

Department of Botany,
University of Hawaii
Honolulu, Hawaii 96822

F. Raymond Fosberg

Museum of Natural History,
Smithsonian Institution,
Washington, D. C. 20550

UH/NPS UNIT

Cooperative National Park Resources Studies Unit

October, 1974

ABSTRACT

The vegetation map of Hawaii Volcanoes National Park (Island Hawaii) is reduced in this report from 53 (70 cm x 70 cm) air photo overlays (at 1 : 12,000) to 25 transparent sheets overlaying contiguous topographic half sheets. These were reduced once more from 1 : 24,000 to 1 : 52,000. The map units are identified by letter symbols denoting dominant species, structural criteria (such as plant spacing and height) and other relevant surface features.

The map is further interpreted by a summary of 31 major vegetation types grouped into six environmental sections.

This map-report is intended as a note-pad for park research and management purposes.

TABLE OF CONTENTS

INTRODUCTION

The vegetation map contained in this report covers the area of the Park shown in FIG. 1. The map was prepared from aerial photographs at the approximate scale of 1 : 12,000 and is here reproduced with only minor loss of detail at the scale of 1 : 52,000 (1 cm on map = 520 m in field).

The vegetation map was initially presented as an appendix to the "Atlas for Bioecology Studies in Hawaii Volcanoes National Park"(Doty and Mueller-Dombois 1966). As an appendix, the map was available in only two sets of transparent overlays on 53 large (70 cm by 70 cm) aerial photographs taken in 1954. The Atlas for Bioecology Studies itself was first printed in 50 mimeographed copies under a National Park Service Contract (No. 14-10-0434-1504) as Hawaii Botanical Science Paper No. 2. Thereafter, because of continued and increasing demand, it was reprinted in 1970 with 300 copies (in essentially unmodified form) as Miscell. Publication 89 of the Hawaii Agricultural Experiment Station, College of Tropical Agriculture. However, the vegetation map itself was not yet reproduced because the 53 map sheets were too clumsy and costly for direct reproduction at that size. Of the two original sets, one is kept at Hawaii Volcanoes National Park Headquarters, the other in the Botany Department, University of Hawaii, Honolulu.

Both, the Atlas and vegetation map have served as baseline documents for a number of park management decisions and research projects including the ISLAND ECOSYSTEMS IRP of the U.S. International Biological Program. On a management level, the map in particular has found use in locating a number of experimental exclosures against goats and pigs in specific vegetation types (Mueller-Dombois and Spatz 1972). The map proved extremely useful in the Endangered Bird Species Project of the Bureau of Sport Fisheries and Wildlife (Winston Banko, personal communication), it served for goat management considerations in the Park (Baker and Reeser 1972), and for generalizing the existing vegetation system in the Park for an environmental management proposal (NPS Draft Env. Statement 1973:20). On a research level, the map has served for orientation in

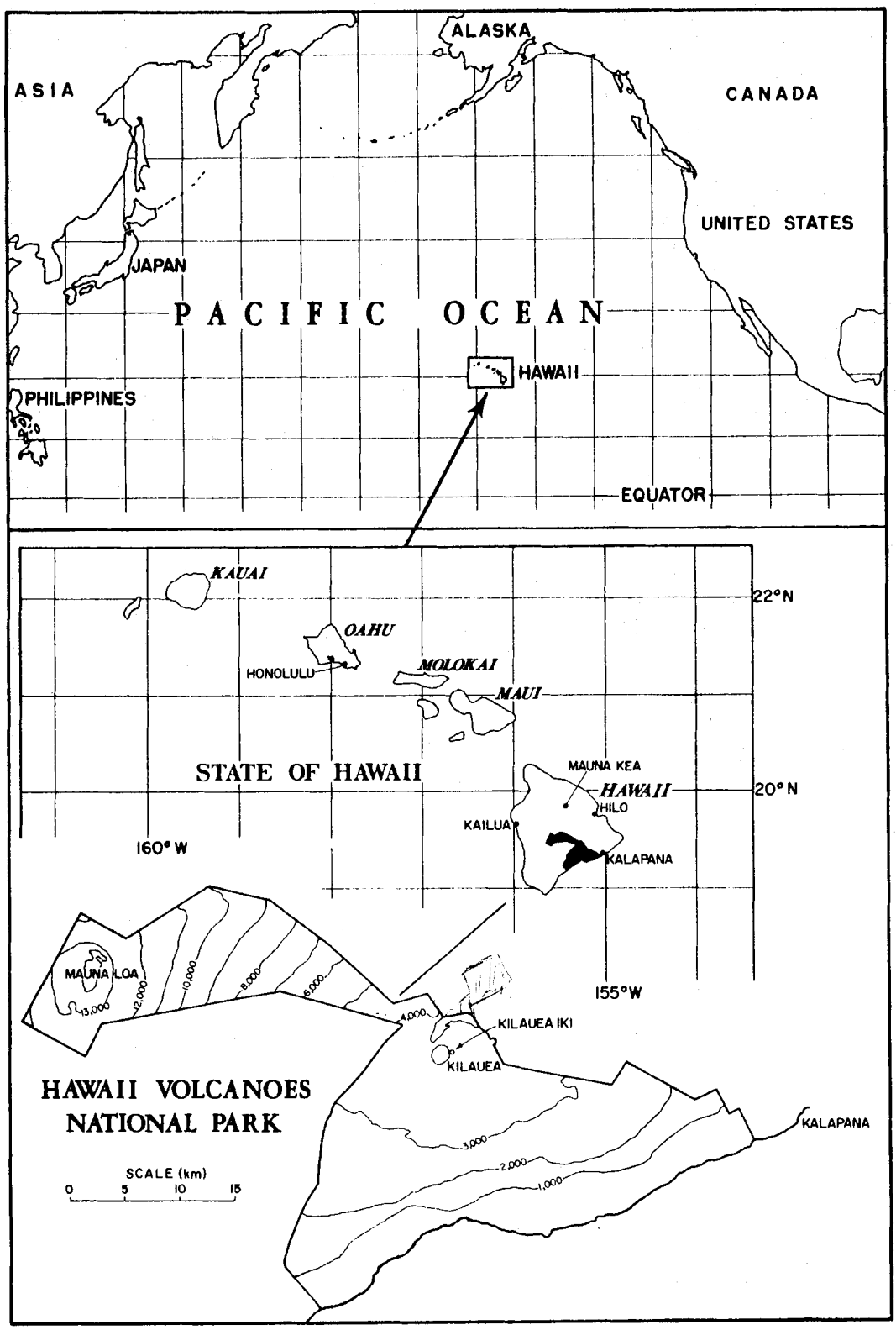


FIG. 1. Location of Hawaii Volcanoes National Park in reference to the State of Hawaii and the Pacific Basin.

floristic and soil sampling throughout the Park (Newell 1968, Rajput 1968), for establishment of vegetation prior to a major volcanic eruption (Smathers 1972, and Smathers and Mueller-Dombois 1972) and for locating the major IBP study sites in the Park and for site coordination of our IRP (Mueller-Dombois 1970:5 and 59, Mueller-Dombois 1972:22 ff.). So far, 162 releves were located for several vegetation studies on the basis of the mapped vegetation units, and the map continues to be useful as a major research tool in spite of its being based on an earlier set of aerial photographs taken in 1954. Since that time the Park area has been rephotographed in 1965 and it would be desirable to readjust this map to the more recent air photo coverage. Major changes have occurred, for example, on map sheets 20 and 21, where since 1968 intensive and almost uninterrupted volcanic activity has very much altered the landscape. The present map can be considered a vegetation image "frozen" in time, which may form the basis for future succession studies. The primary purpose of this map--as said above--is to serve as a research and management tool. It is intended as a field worker's note-pad for entering any relevant information, such as boundary adjustments, sampling locations, experimental plots, collecting sites, more detailed floristic association boundaries, bird sightings, or whatever the user's interest may be. It is hoped that the map will be updated on the basis of more recent air photo information at some future time.

MAP PREPARATION

In preliminary form the different types of vegetation were first outlined by F. R. Fosberg utilizing, indoors, the field knowledge he had accumulated through his years of experience with the Park's vegetation. The preliminary vegetation units so mapped were studied and checked out in the field by D. Mueller-Dombois and modified as necessary in 1965. From the 53 finished maps a revised, partially new, classification of the vegetation units was developed (Mueller-Dombois 1966:391 ff.).

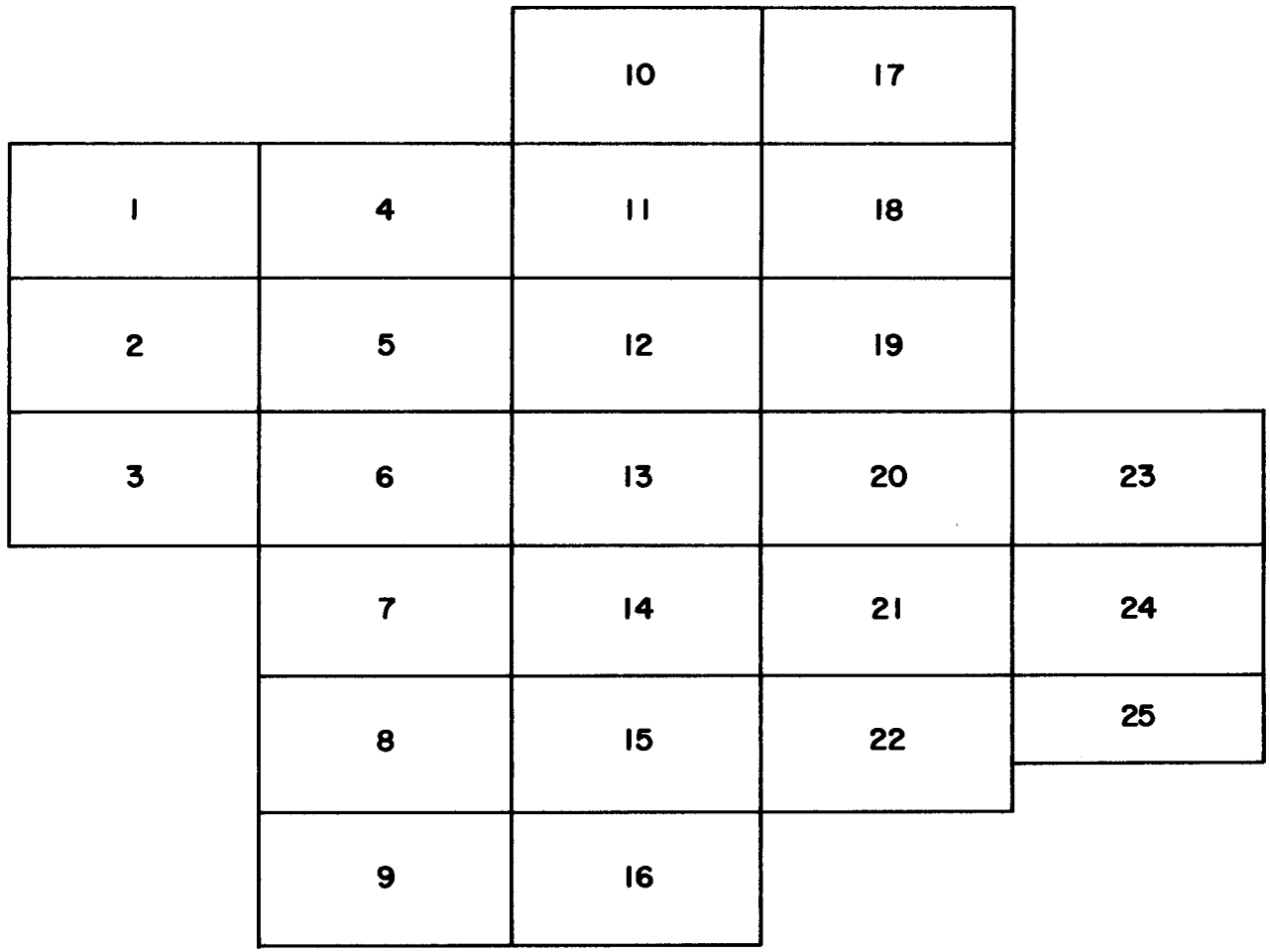
Field mapping involved correlating ground conditions with the patterns found on the photographs. This was done by exploring all unknown photographic patterns in the field and by running transects through those areas that showed a maximum of variation in pattern on the photographs. The vegetation types were defined by structural and floristic criteria and in some instances in relation to topographic and substrate features. Extrapolation was kept to a minimum in the more accessible areas, where all major variations were investigated. In the less accessible areas, which involved about 20% of the total, vegetation was determined by matching photographic patterns. Indirect mapping was necessary for the higher altitude vegetation on Mauna Loa, where vegetation cover is not dense enough to show on the photos. Here topographic lines and substrate types were matched to approximate the correct vegetation limits.

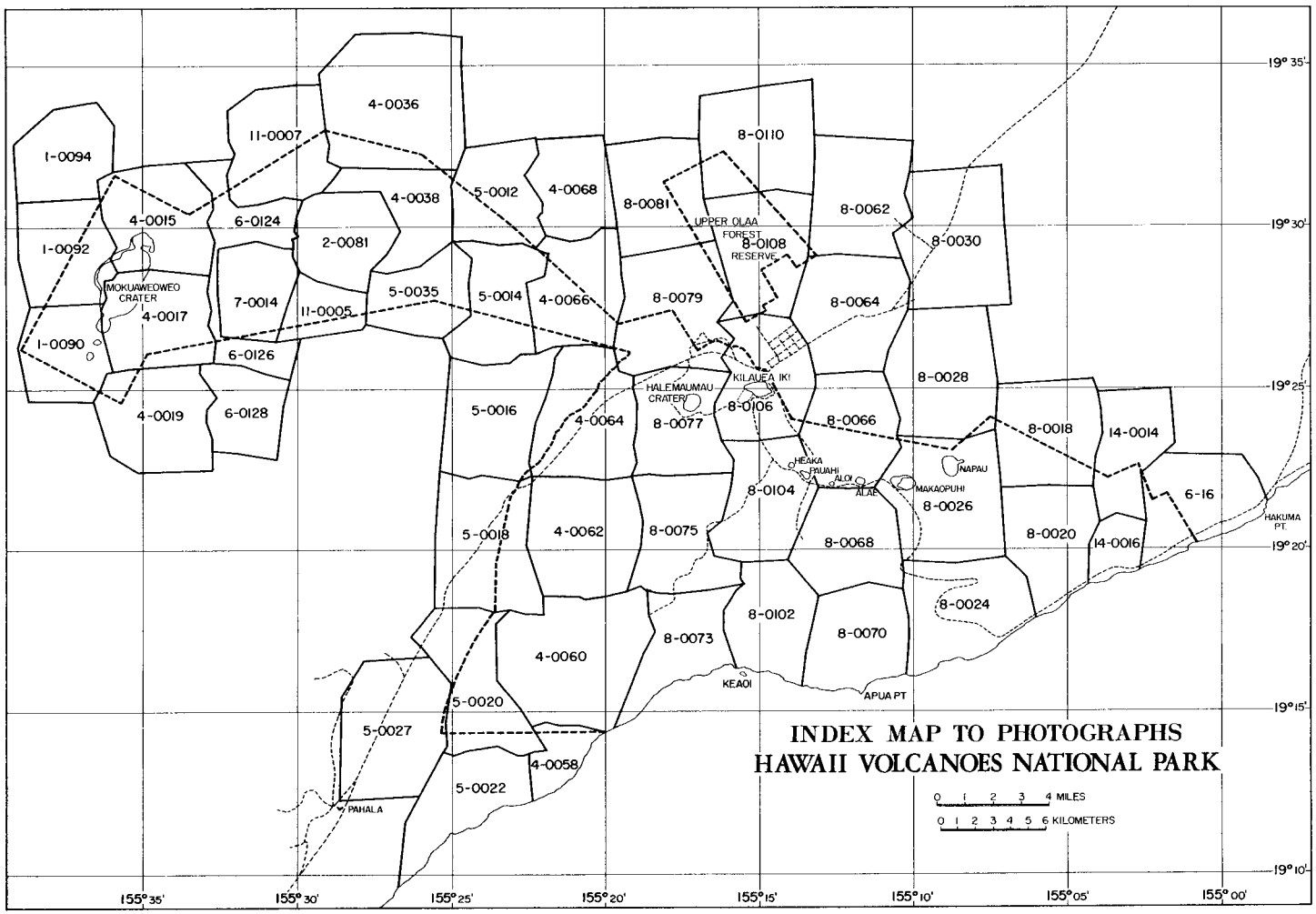
The aerial photographic set used for the vegetation map was described in detail by Doty (1966:11 ff.). Before field use, the distortion on each photograph was eliminated by establishing a relatively undistorted polygon over the center. Vegetation boundaries were drawn only within the undistorted polygons. In addition a second plastic overlay sheet was prepared before field mapping, which showed the topography on each air photo by 100 foot contour lines.

After completion of the vegetation map on the 1 : 12,000 air photos, Mr. Tomotsu Nakata carefully transferred all boundaries onto new plastic overlays on the 1 : 24,000 Topographic Map sheet series of the Park. These served as the originals for the reproduction of this map at the reduced scale of 1 : 52,000.

MAP COVERAGE AND THE INDEX MAP

The vegetation map consists of 25 transparent sheets that are each attached as overlays to the standard 1 : 24,000 topographic map sheets of the area. These topographic map sheets were cut in half (i.e., into a north and south half each) for convenience


10
17
1
4
11
18
2
5
12
19
3
6
13
20
23
7
14
21
24
8
15
22
25
9
16


INDEX MAP TO PHOTOGRAPHS
HAWAII VOLCANOES NATIONAL PARK
0 1 2 3 4 MILES
0 1 2 3 4 5 6 KILOMETERS
1-0094
1-0092
1-0090
4-0015
4-0017
4-0019
6-0124
6-0126
6-0128
11-0007
4-0036
4-0038
2-0081
7-0014
11-0005
5-0035
5-0012
4-0068
5-0014
4-0066
5-0016
4-0064
5-0018
4-0062
4-0060
5-0020
5-0027
4-0058
5-0022
8-0110
8-0081
8-0079
8-0077
8-0075
8-0073
8-0062
8-0030
8-0064
8-0028
8-0106
8-0066
8-0104
8-0068
8-0102
8-0070
8-0018
8-0026
8-0024
8-0020
14-0014
14-0016
6-16
UPPER OLAA FOREST RESERVE
8-0108
MOKUAWEOWEO CRATER
HALEMAUMAU CRATER
KILAUEA IKI
HEAKA
KUAHI
ALOY
ALAE
NAPAU
MAKAOPUHI
HAKUMA PT.
KEAOI
APUA PT
PAHALA
19° 35'
19° 30'
19° 25'
19° 20'
19° 15'
19° 10'
155° 35'
155° 30'
155° 25'
155° 20'
155° 15'
155° 10'
155° 05'
155° 00'

of reproduction. Moreover, the topographic half sheets were reduced in scale by one half so that all information is here represented at the more generalized scale of 1 : 52,000 (i.e., 1 cm on the map represents 520 m in the field).

The individual map sheets are preceded by an index map, which shows the exact coverage of the 25 map sheets in relation to the 53 aerial photographs that were used for the original mapping. The index map also shows the outline of Hawaii Volcanoes National Park by a dashed line. Note that the Park includes a separate area, the upper Olaa Forest Reserve, north of the Kilauea Iki Crater. It can be seen on the index map that the map sheets and aerial photographs extend beyond the borders of the National Park. This means that the vegetation map covers the entire Park and a certain area outside. The largest outside-Park coverage extends into the rain forest north of the Kilauea Caldera (signified by Halemaumau Crater and Kilauea Iki on the index map).

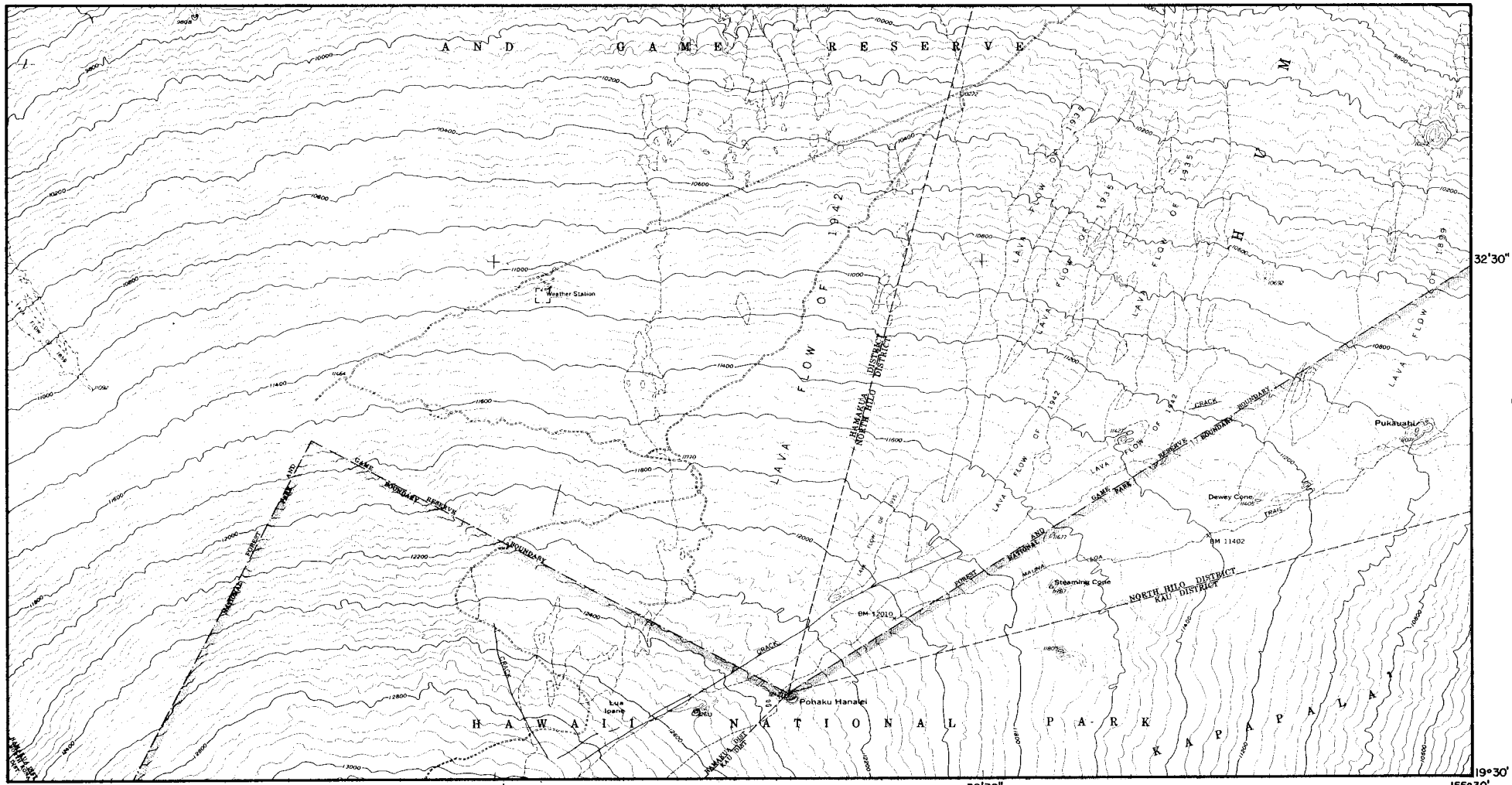
However, it should be clear also that the marginal map sheets contain vegetation information only where they cover the outline of the original aerial photographs. For this reason, map sheets 10 and 17 contain no vegetation information. They were added to the set for providing base map orientation relative to access in the rain forest terrain.

A further peculiarity may be worth explaining. Many of the vegetation boundaries are open-ended on the map sheets marginal to the National Park. The reason for this is that the underlying air photo coverage stopped at those open-ended lines. These boundary lines can only be completed on the existing map sheets with a wider air photo coverage than was available for preparing the Park map.

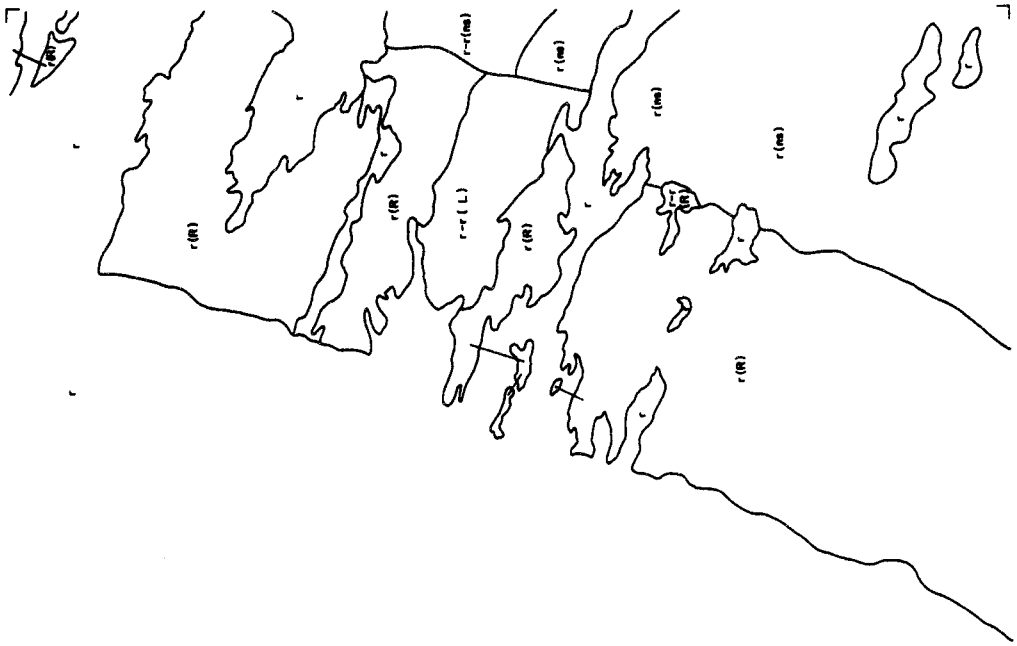
OUTLINE OF MAP SHEETS

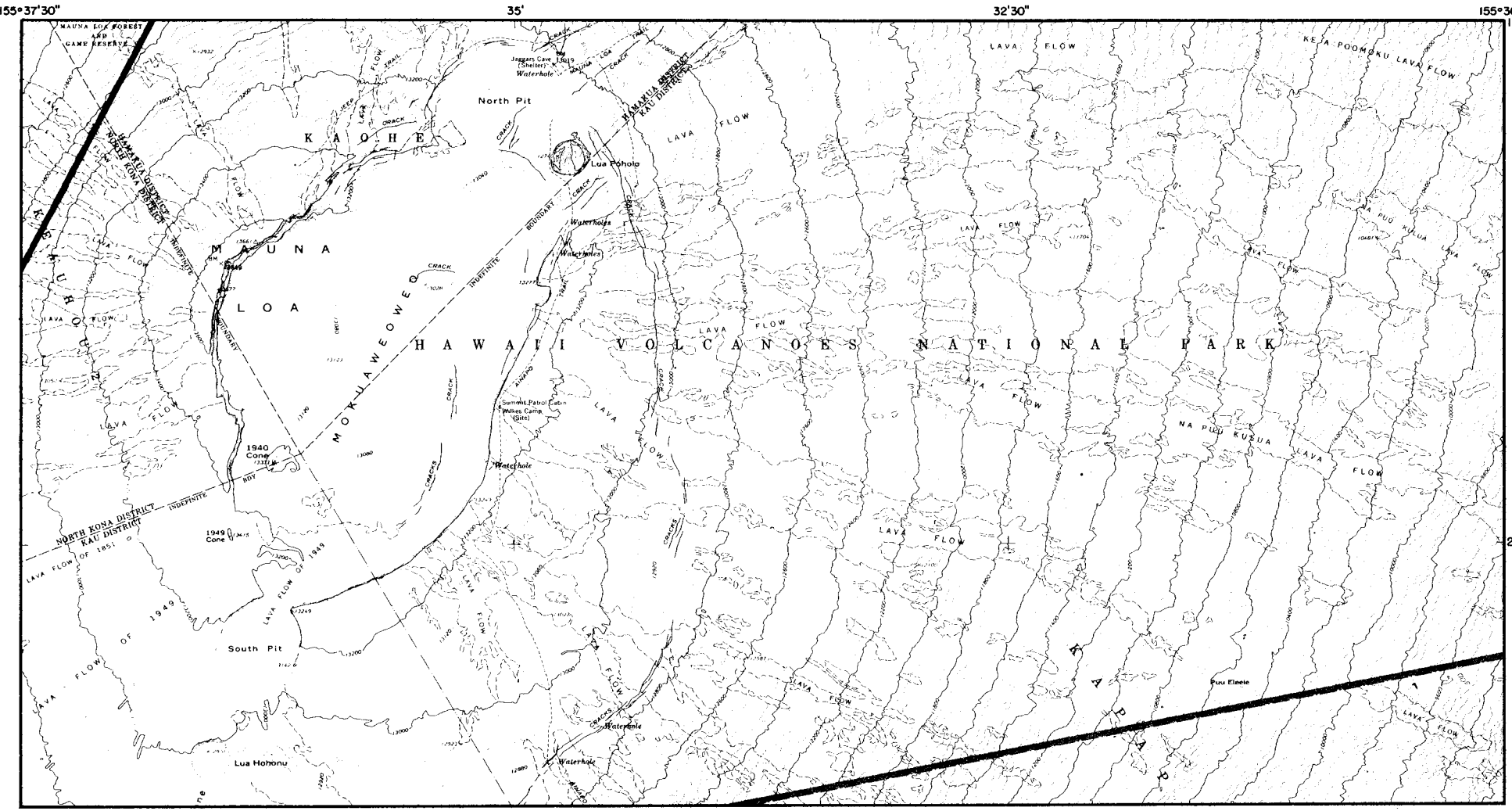
(as numbered on Index Map p. 5)


r(R)
r(R)-
(ns)
r(R)
r(R)
r
(R)
r(R)
r(R)
r(R)
r(R)
r(R)
r(R)
r(R)
r(R)

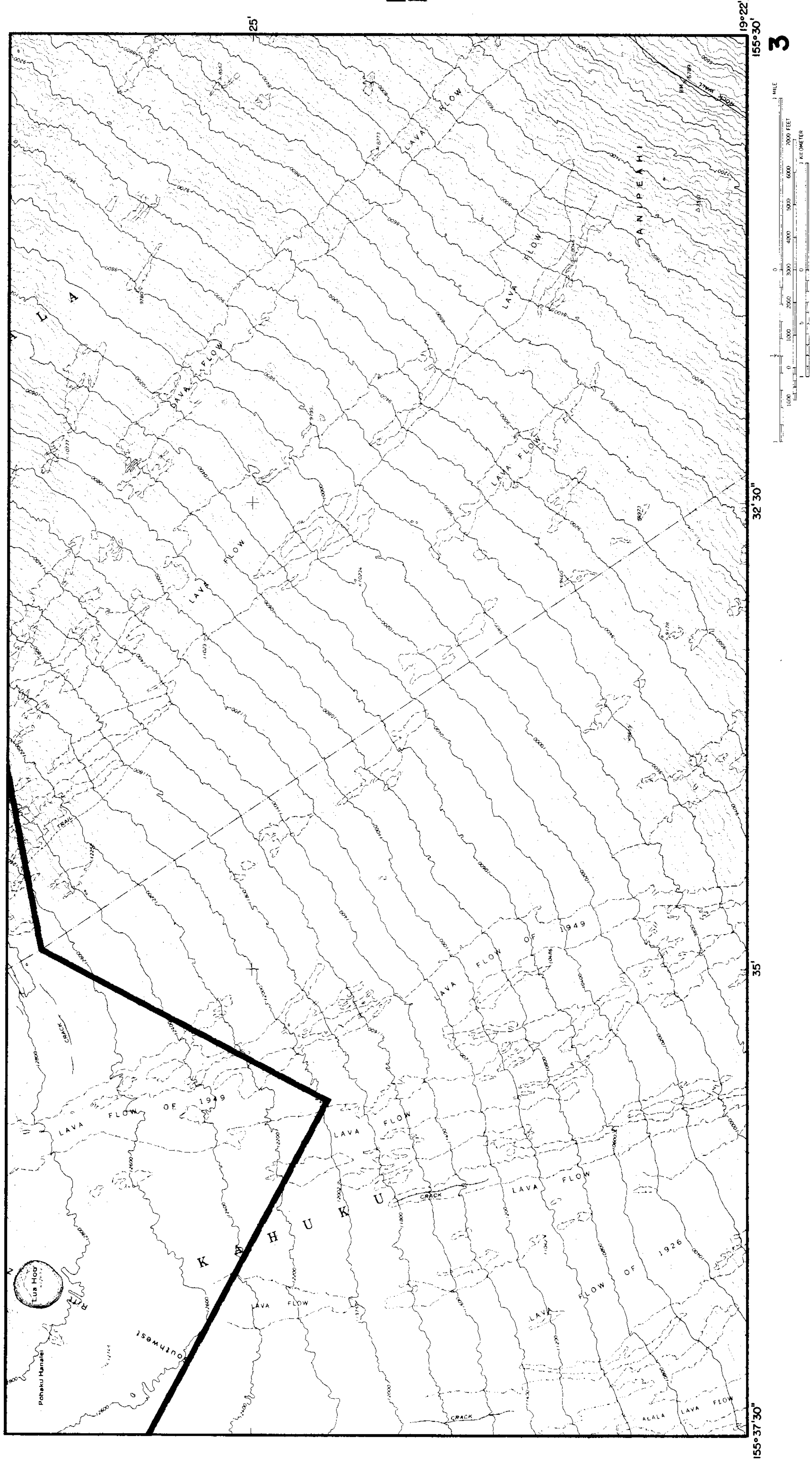

AND GAME RESERVE
Weather Station
LAVA FLOW OF 1942
HAWAII NATIONAL PARK
KAPAPALA
Pohaku Hanaiei
Lua Ipana
Dewey Cone
Steaming Cone
Pukaualii
BM 12010
BM 11402
CRACK
TRAIL
155°37'30"
35'
32'30"
155°30'
19°30'
32'30"

9

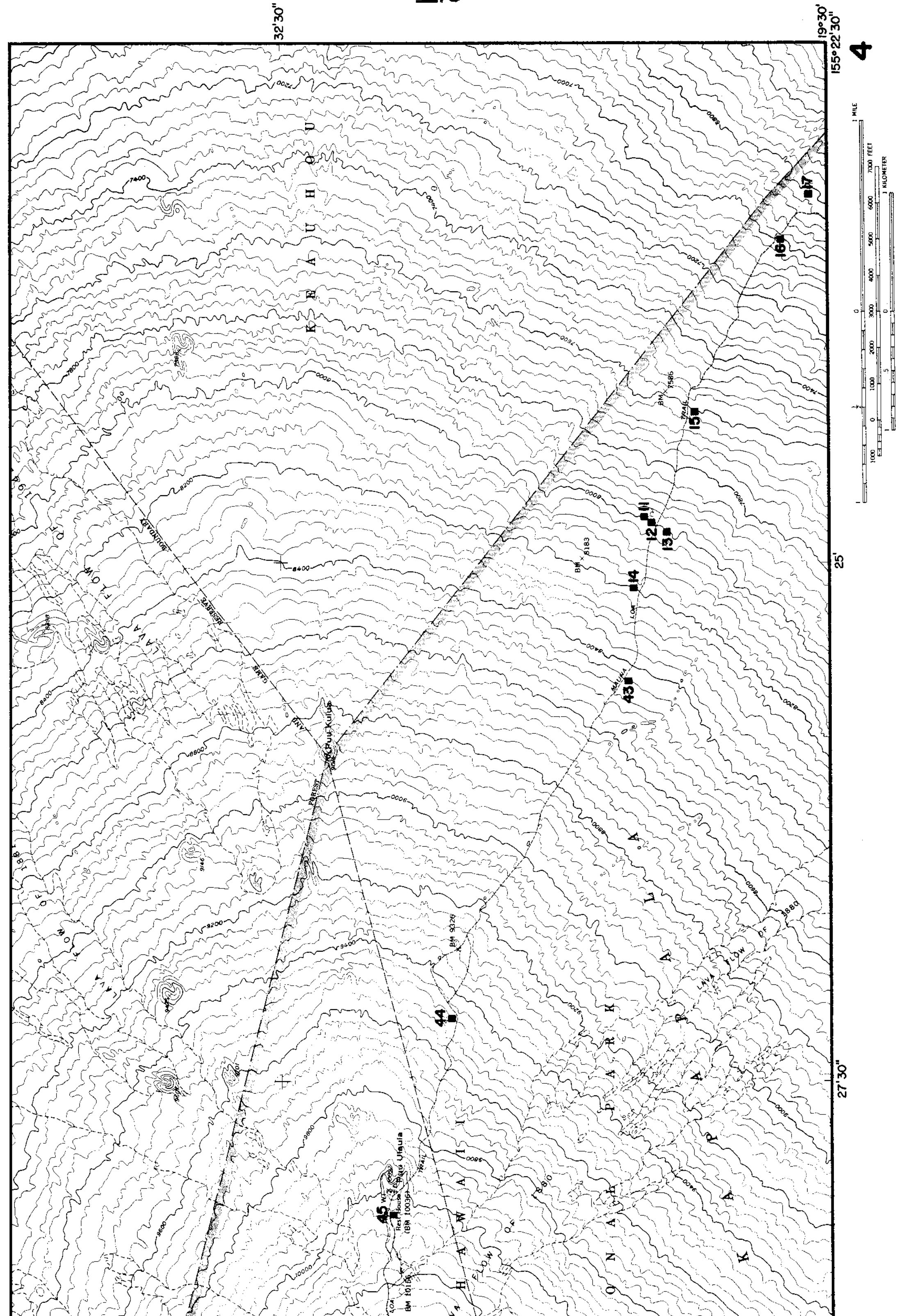

r(R)
r-r(ns)
r(ns)
r(ns)
r(ns)
r(R)
r-r(L)
r(R)
r(R)
r(R)

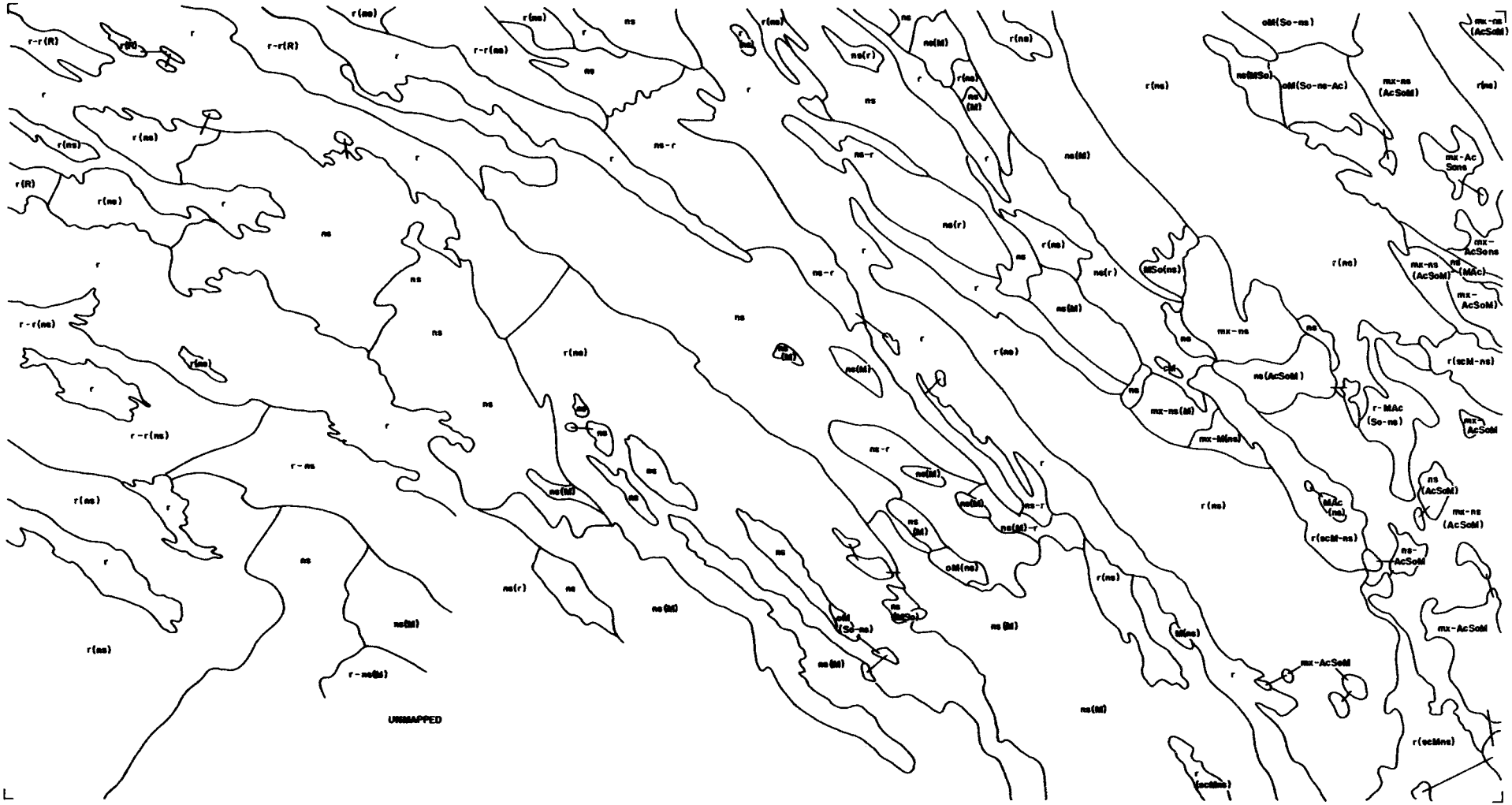

155°37'30"
35'
32'30"
155°30'
19°30'
27'30"
MAUNA LOA FOREST AND GAME RESERVE
KAOHE
MAUNA LOA
HAWAII VOLCANOES NATIONAL PARK
KAHUKU
MOKUAWEOWEO
North Pit
South Pit
Lua Hoholo
Lua Hohonu
Jaggars Cave (Shelter)
Waterhole
Waterholes
Summit Patrol Cabin
Hikes Camp (Site)
1940 Cone
1949 Cone
LAVA FLOW OF 1949
LAVA FLOW OF 1851
HAMAKUA DISTRICT
NORTH KONA DISTRICT
KAU DISTRICT
BOUNDARY
INDEFINITE
TRAIL
JEEP TRAIL
CRACK
CRACKS
KEA POOMOKU LAVA FLOW
NA PUU KULUA
Puu Eleele
KAPAPA
10
2

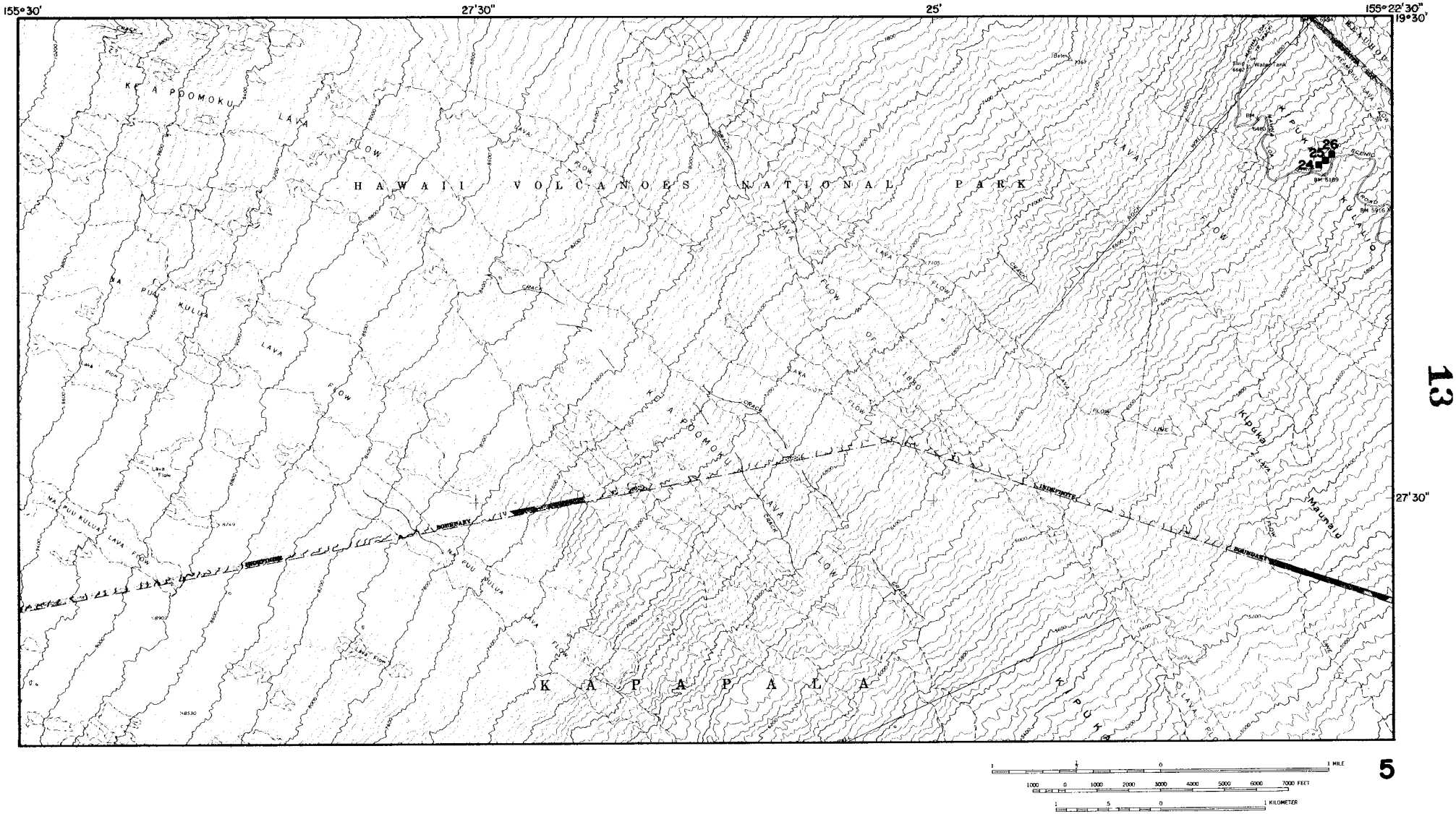

r(R)
r(ns)
r(R)
ns
r(R)
r(ns)
ns(M)
r(R)
r(R)-r(ns)
ns
r(R)
r(ns)
r(R)
r-r(R)
r(ns)
r-ns
r(R)
r(R)-r(ns)
r(R)-r(ns)
ns
r(ns)
r(ns)
r(ns)
r(ns)


3
19°22'30"
155°30'
25'
32'30"
35'
155°37'30"
LAVA FLOW
LAVA FLOW OF 1949
LAVA FLOW OF 1926
ALALA LAVA FLOW
K A H U K U
CRACK
TRAIL
Lua Hou
Pohaku Hanalei
Southwest
1 MILE
1 KILOMETER
7000 FEET


r(R)
r(ns)
r-r(ns)
r-r(R)-
r(ns)
r(R)
r-r(ns)-r(R)
ns
ns(bl)
r(ns)
r(R)
ns(bl)
ns(MSo)
r(ns)
ns
ns
(MSo)
r(ns)
ns
r(R)
ns(bl)
ns(MSo)
r(ns)
ns
odl(So-ns)
r(ns)
ns(bl)
r(R)
ns(MSo)
ns(MSo)
odl(So-ns)
r-r(R)
r(ns)
r(ns)
ns
ns
r(R)
ns(bl)
r(ns)
mx-ns
(Ac
Sol)

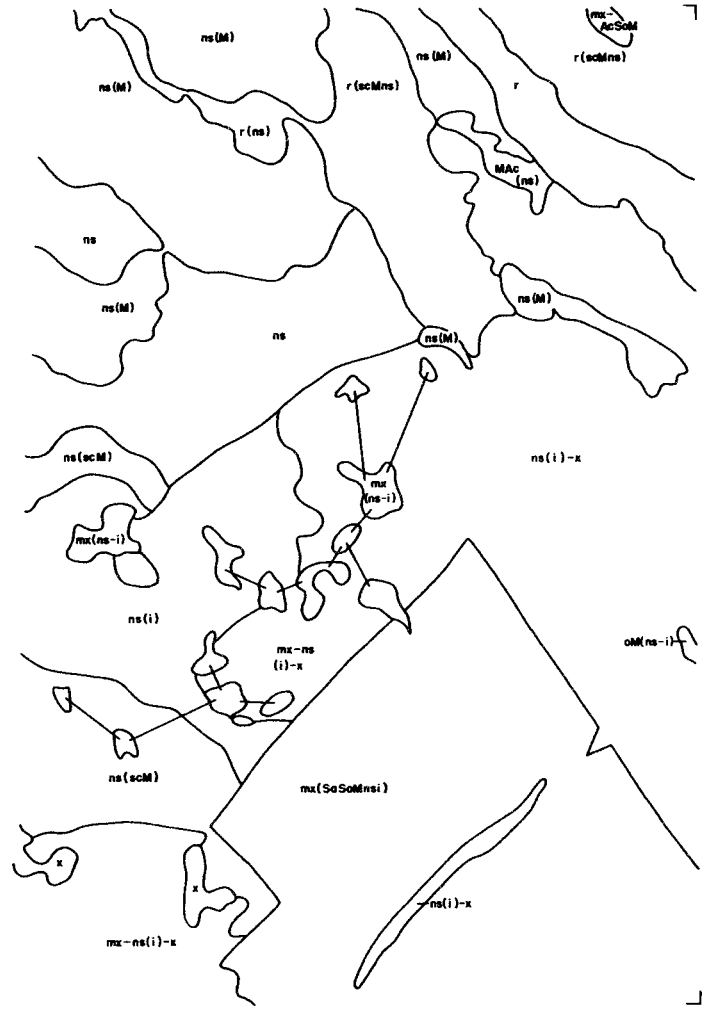

4
19°30'
155°22'30"
32'30"
25'
27'30"
155°30'
K E A U H O U
N A T I O N A L   P A R K
H A W A I I
Puu Ulaula
NORTH HILO DISTRICT
KAU DISTRICT
LAVA FLOW OF 1880
LAVA FLOW OF 1899
1 MILE
1 KILOMETER
7000 FEET

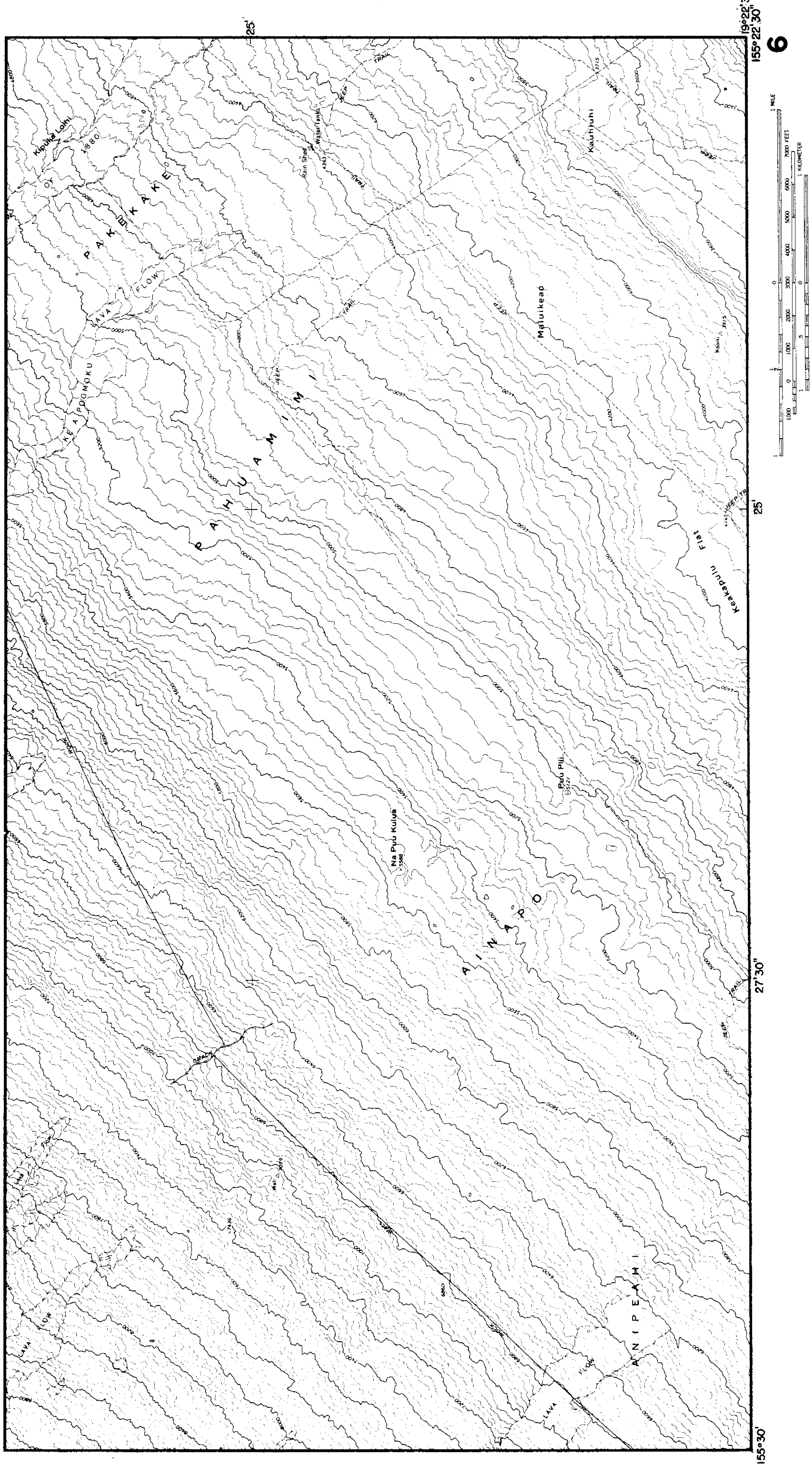

r-r(R)
r(ns)
r(R)
r-r(ns)
r-ns
r(ns)
r-ns(bl)
UNMAPPED
ns(r)
ns-r
ns(bl)
r(ns)
old(So-ns)
ns(blSo)
old(So-ns-Ac)
mx-ns
(AcSoM)
mx-Ac
Sone
mx-
AcSone
ns-ns
(AcSoM)
(MAc)
mx-
AcSoM)
r(scM-ns)
r-MAc
(So-ns)
mx-
AcSoM
ns
(AcSoM)
mx-ns
(AcSoM)
ns-
AcSoM
mx-AcSoM
r(scMns)

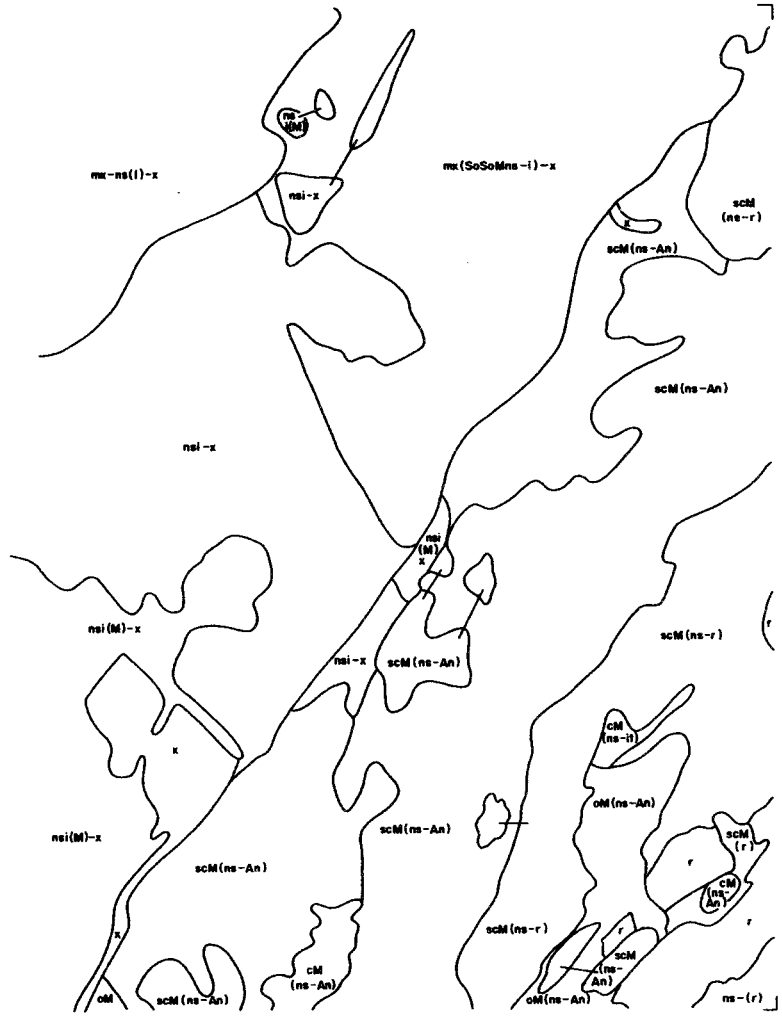

155°30'
27'30"
25'
155°22'30"
19°30'
27'30"
HAWAII VOLCANOES NATIONAL PARK
KAPAPALA
KA POMOKU LAVA FLOW
MA PUU KULUA LAVA FLOW
1880 LAVA FLOW
KIPUKA
MAUMAU
26
25
24
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER

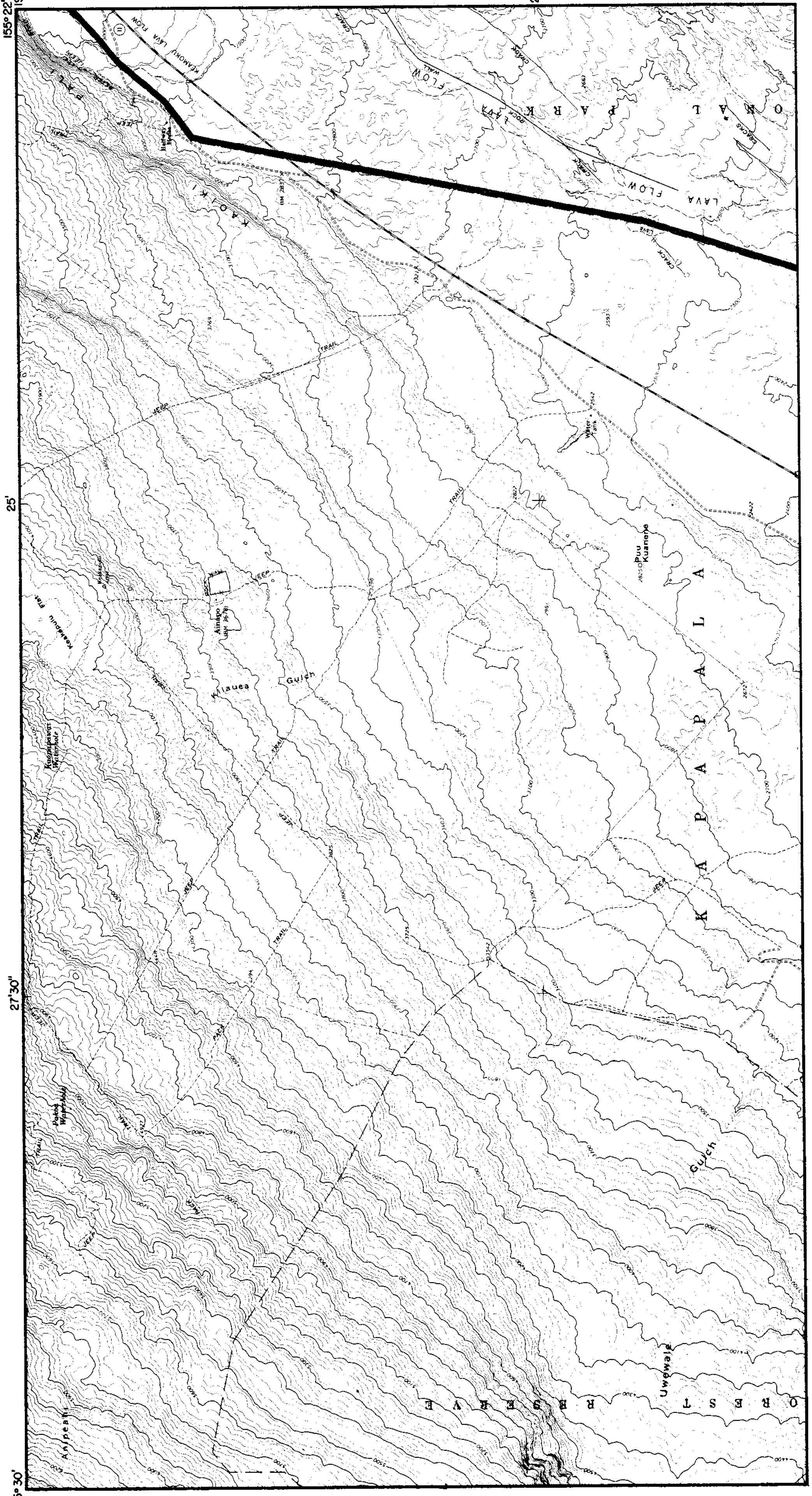
13

5

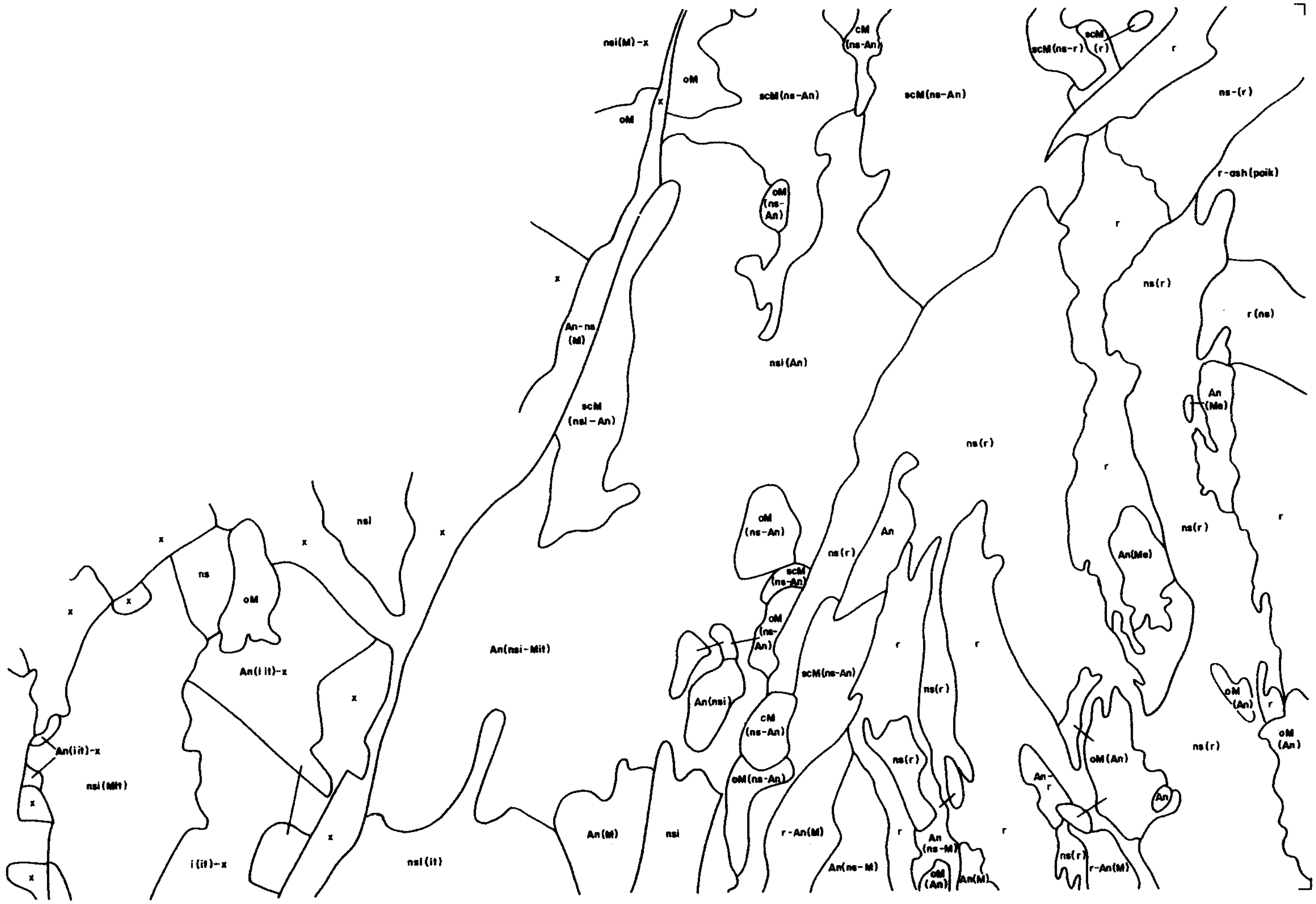

ns(M)
ns(M)
r(scMns)
r(ns)
ns(M)
r(scMns)
r
mx-
AcSoM
r(scMns)
MAc
(ns)
ns
ns(M)
ns
ns(M)
ns(M)
ns(scM)
ns(i)-x
mx
(ns-i)
mx(ns-i)
ns(i)
mx-ns
(i)-x
oM(ns-i)
ns(scM)
mx(SoSoMnsi)
x
x
-ns(i)-x
mx-ns(i)-x

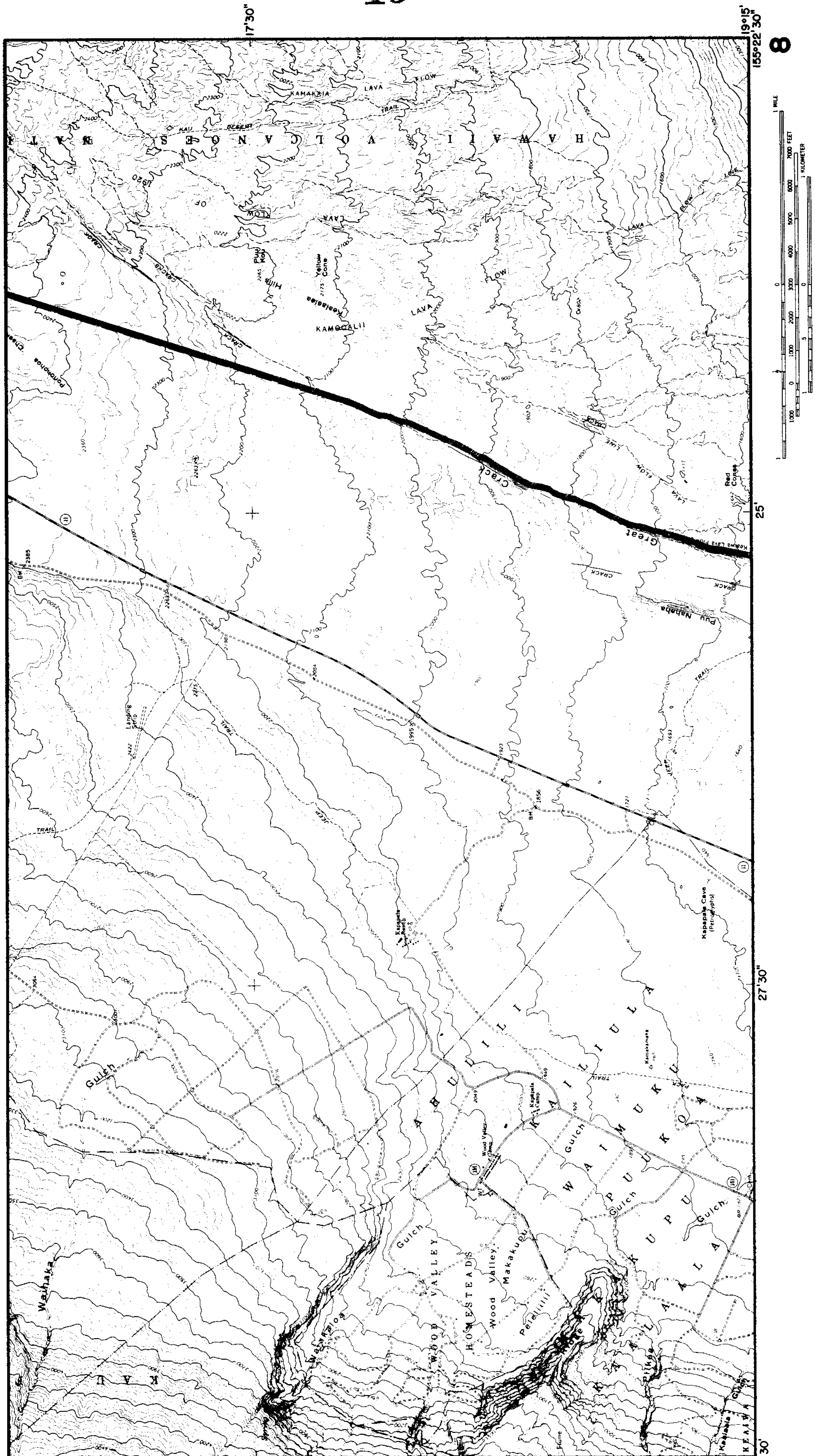

6
19°22'30"
155°22'30"
25'
27'30"
155°30'
Kipuka Lohi
1880
PAHUAMIMI
AINAPO
ANIPEAHI
LAVA FLOW
Na Puu Kulua
Puu Pili
Maluikeao
Kauhuhu
Flat
TRAIL
JEEP
1 MILE
1 KILOMETER
7000 FEET

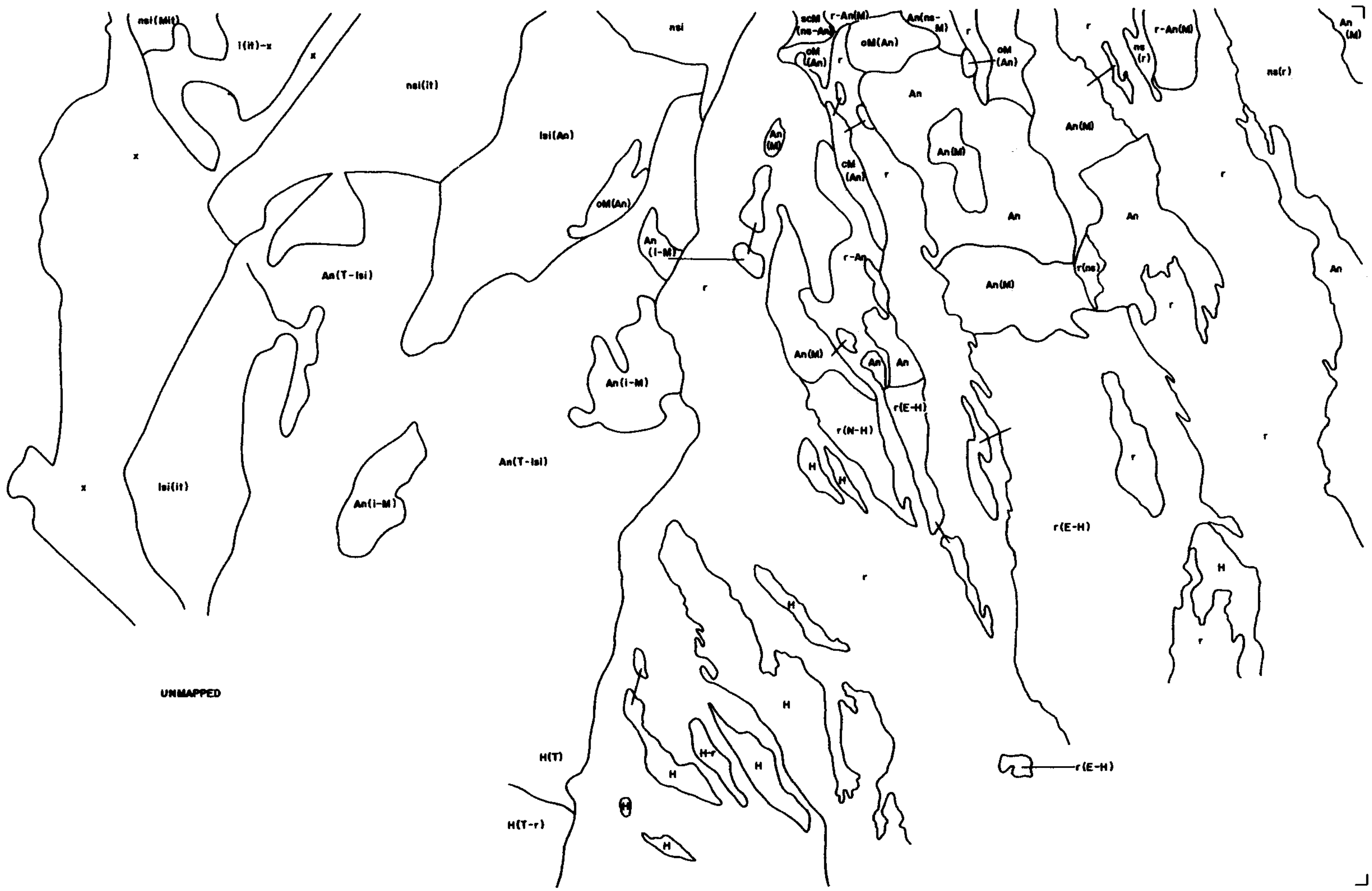

mx-ns(i)-x
mx(SoSoMns-i)-x
nsi-x
scM (ns-r)
scM(ns-An)
scM(ns-An)
nsi-x
nsi (M) x
nsi(M)-x
nsi-x
scM(ns-An)
scM(ns-r)
x
cM (ns-it)
oM(ns-An)
nsi(M)-x
scM(ns-An)
scM(ns-An)
scM (r)
r
cM (ns-An)
scM(ns-r)
r
scM (ns-An)
x
oM
scM(ns-An)
cM (ns-An)
oM(ns-An)
ns-(r)

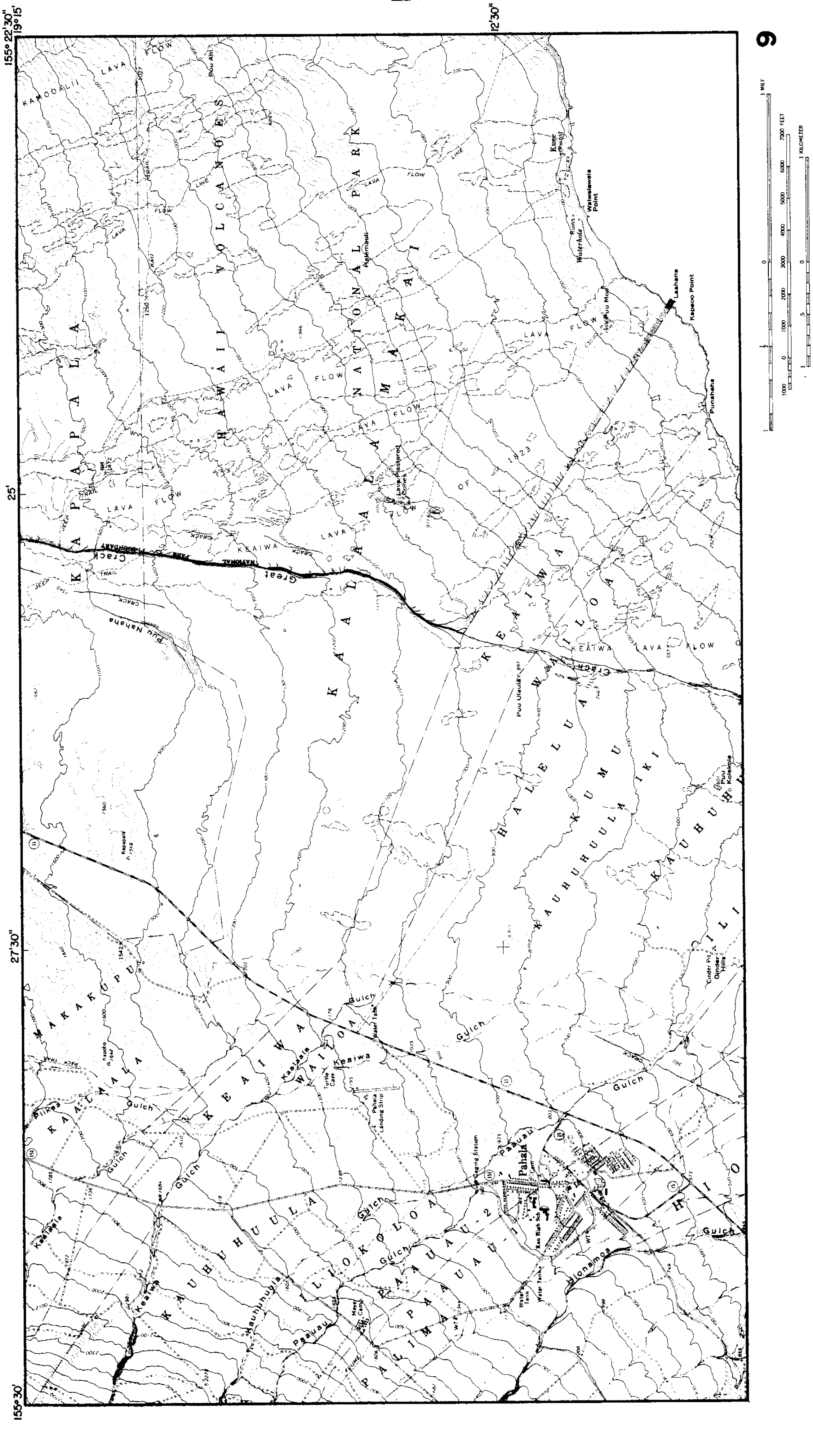

155°22'30"
19°22'30"
20'
25'
27'30"
155°30'
KAPAPALA
Kilauea Gulch
Gulch
TRAIL
JEEP
LAVA FLOW

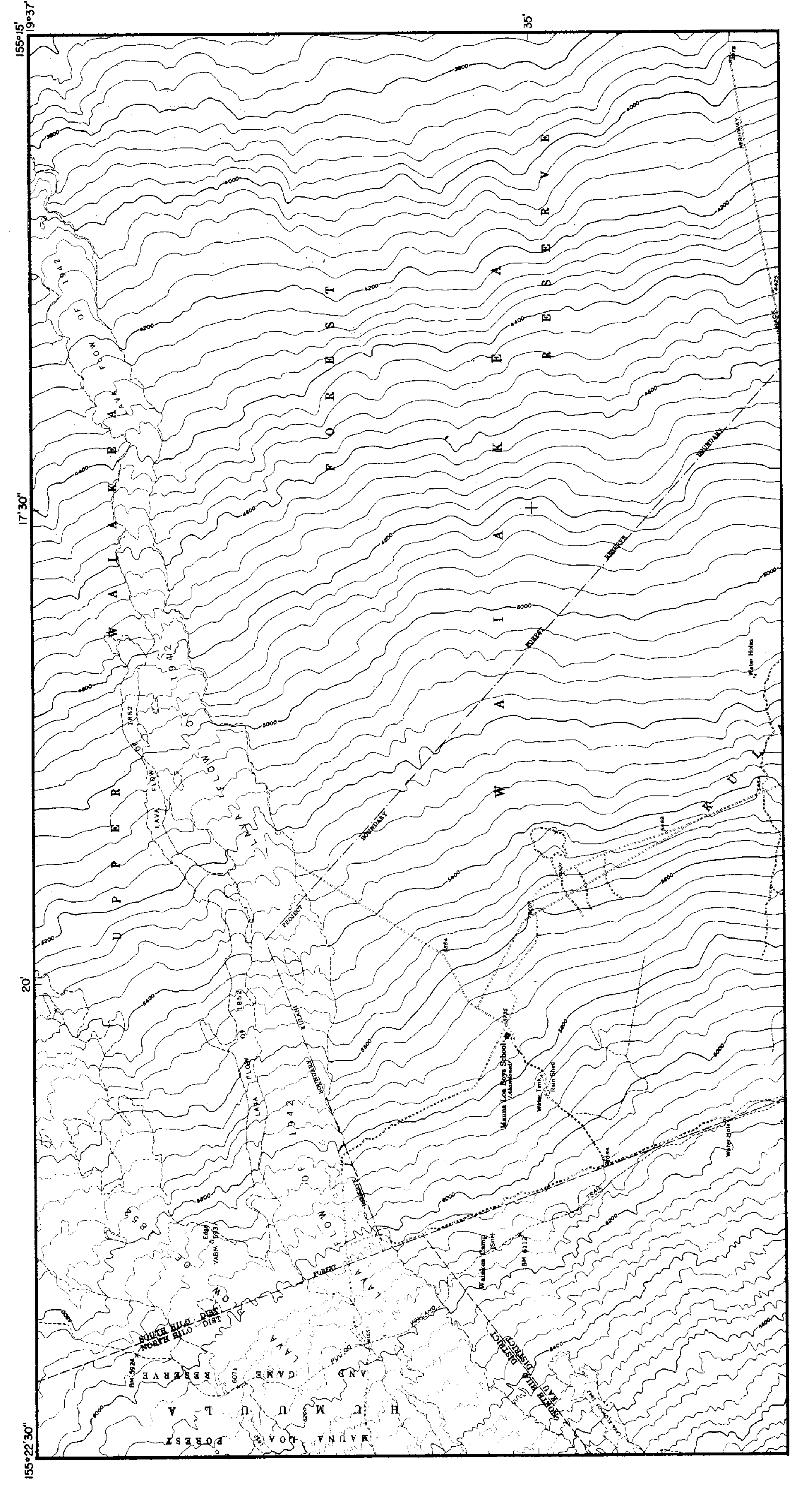
7


nsi(M)-x
oM
scM(ns-An)
cM (ns-An)
scM(ns-An)
scM(ns-r)
scM (r)
r
ns-(r)
r-ash(poik)
oM (ns-An)
x
An-ns (M)
nsi(An)
ns(r)
r (ns)
An (Me)
scM (nsi-An)
r
nsi
x
x
oM (ns-An)
An
ns(r)
An(Me)
r
ns
oM
scM (ns-An)
An(nsi-Mit)
oM (ns-An)
r
r
ns(r)
An(iit)-x
x
An(nsi)
scM(ns-An)
oM (An)
r
An(iit)-x
nsi(Mit)
cM (ns-An)
oM(ns-An)
ns(r)
oM(An)
ns(r)
oM (An)
An-r
An
x
An(M)
nsi
r-An(M)
r
An (ns-M)
r
ns(r)
r-An(M)
x
i(it)-x
nsi(it)
An(ns-M)
oM (An)
An(M)

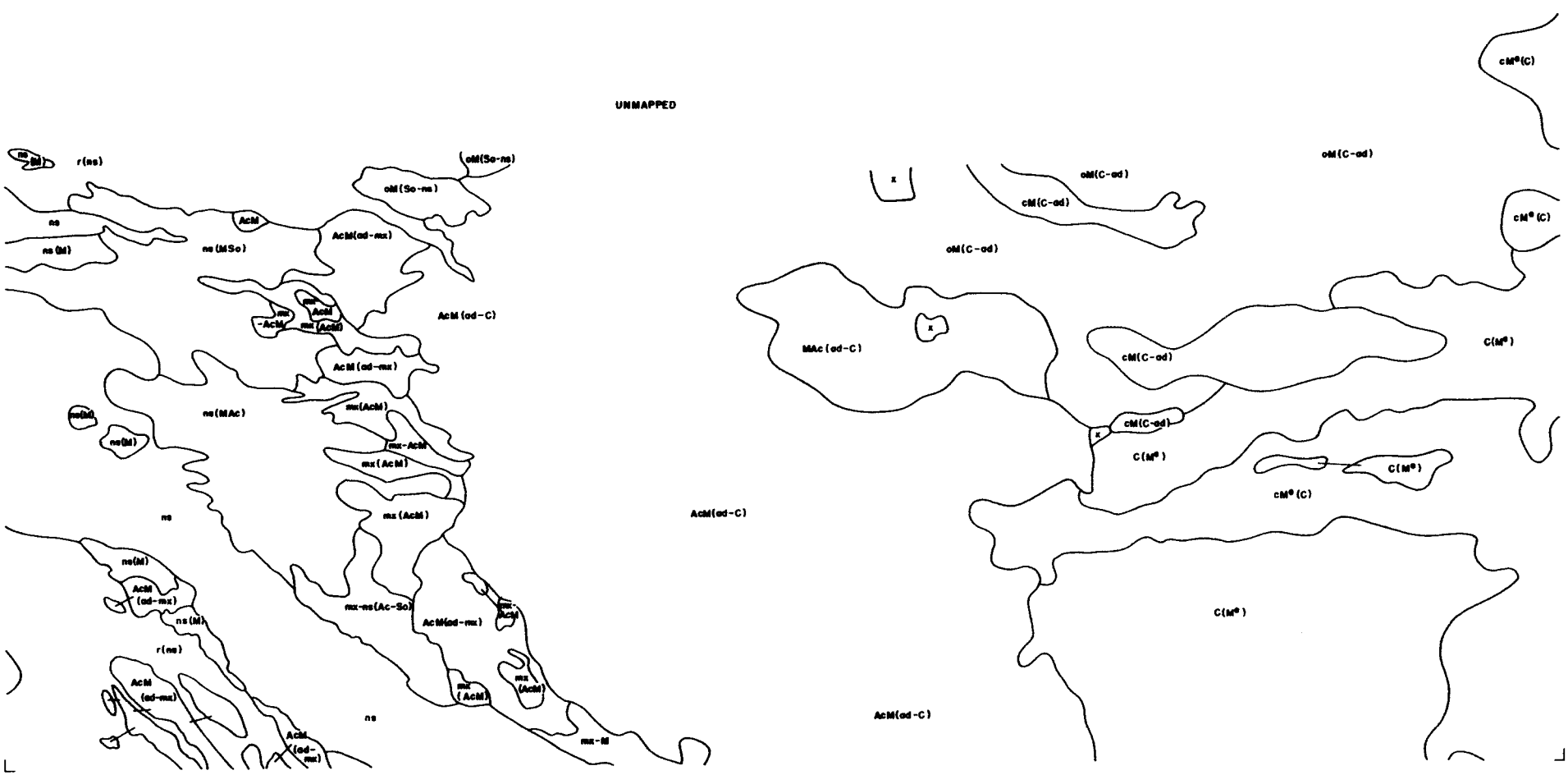

17'30"
19°15'
155°22'30"
8
HAWAII VOLCANOES
KAMAKAIA LAVA FLOW
KAU DESERT TRAIL
KAMOOALII LAVA FLOW
Great Crack
Red Cones
Puu Nahaha
25'
Kapapala Cave (Petroglyphs)
27'30"
KAILIULA
WAIMUKU
PUUKOA
KUPU
KAALAALA
WOOD VALLEY
HOMESTEADS
Wood Valley
Makakupu
Pelelilili
Gulch
Waihaka
KAU
155°30'

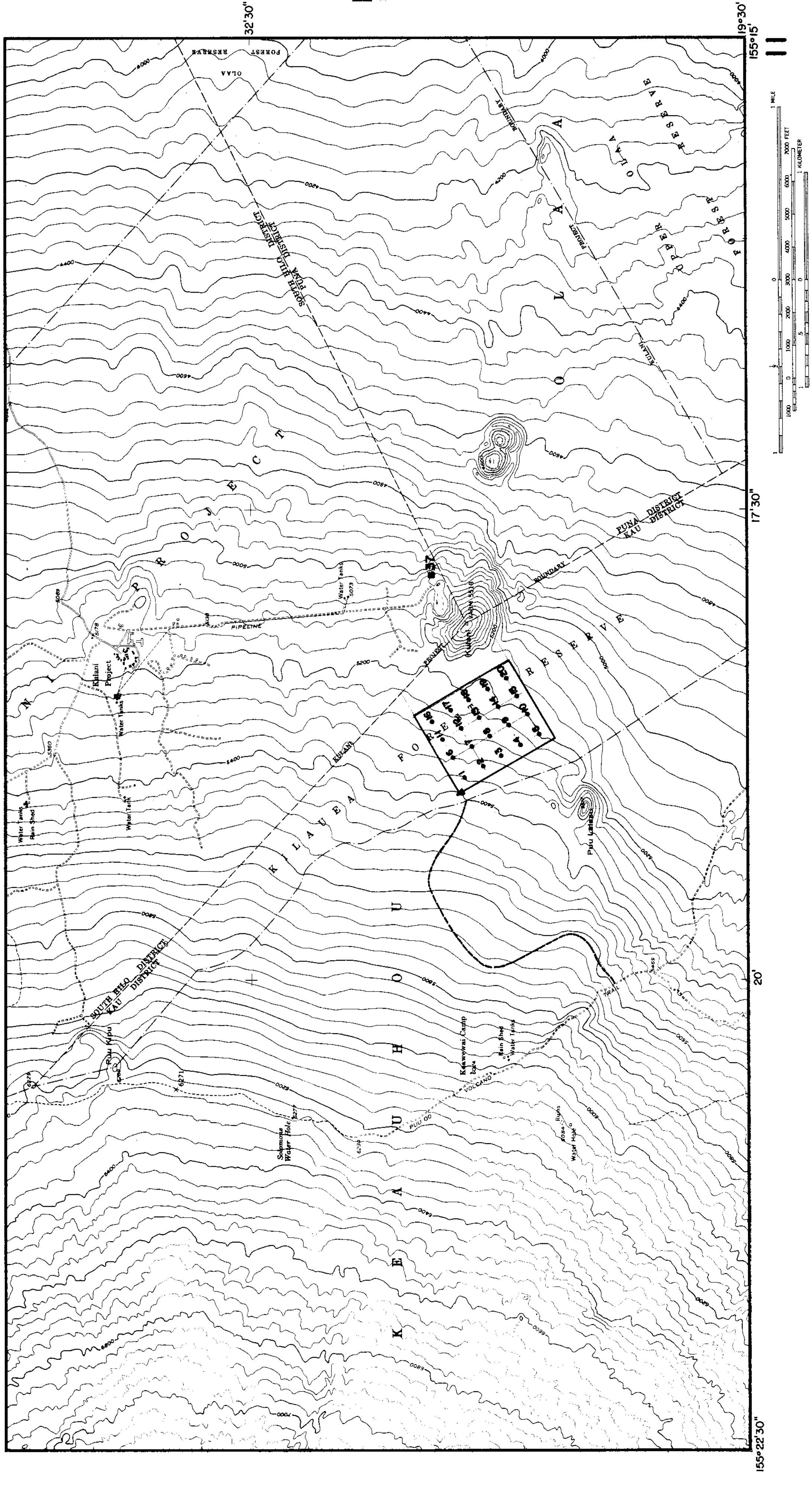

nsi(Mit)
l(it)-x
nsi(it)
lsi(An)
nsi
oM(An)
An(T-lsi)
An(i-M)
An(T-lsi)
lsi(it)
An(i-M)
UNMAPPED
H(T)
H(T-r)
r(E-H)
r(N-H)
An(M)
r(ns)
r-An(M)
ns(r)
oM(An)
An(ns-M)
r-An
H-r

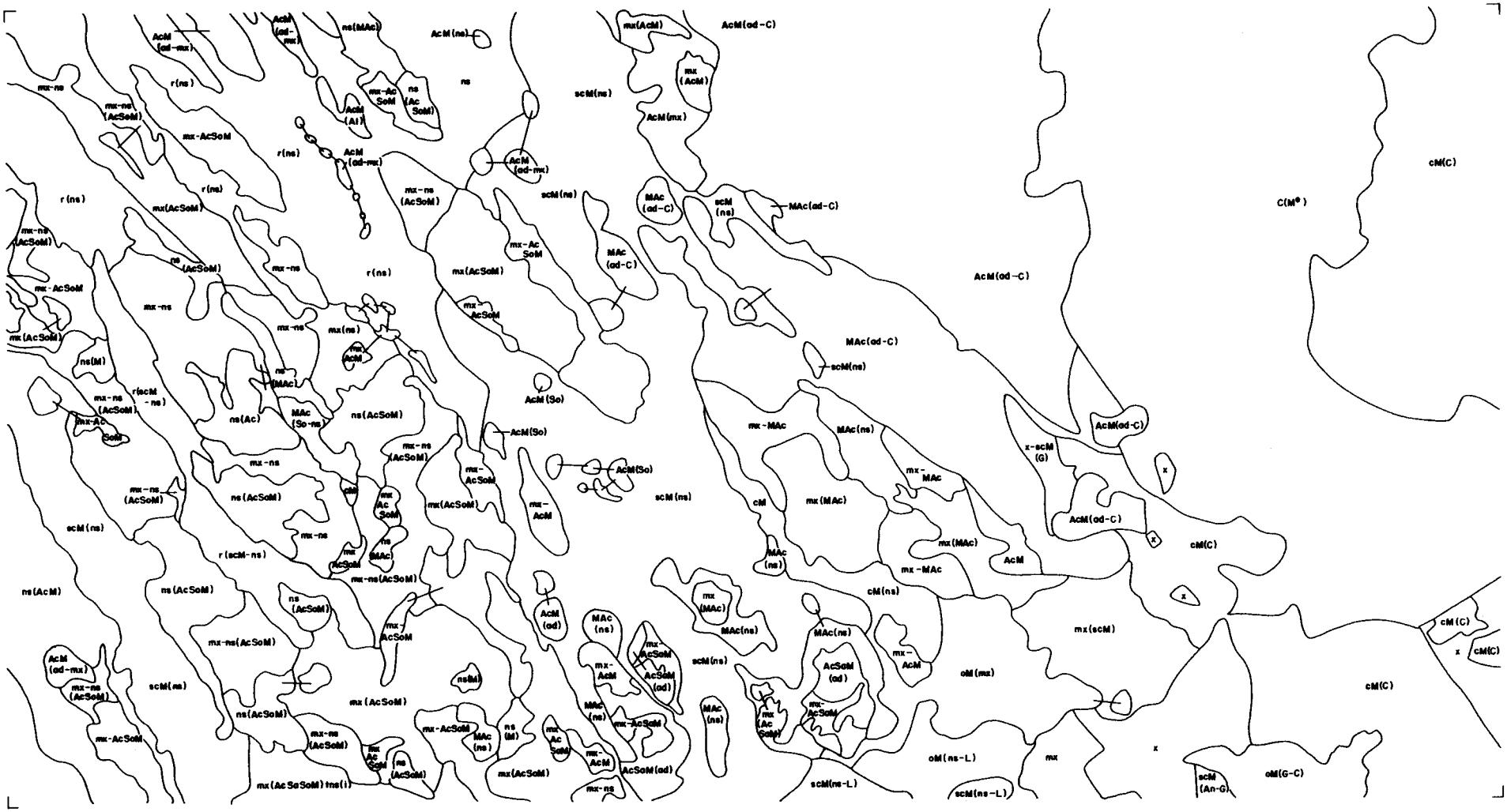

9
155° 22'30"
19°15'
12'30"
25'
27'30"
155°30'
HAWAII VOLCANOES NATIONAL PARK
Great Crack
Puu Nahaha
Kapaoo Point
Pahala
LAVA FLOW OF 1823
KEAIWA LAVA FLOW


155°15'
19°37'30"
35'
17'30"
20'
155°22'30"
UPPER WAIAKEA FOREST RESERVE
LAVA FLOW OF 1942
LAVA FLOW OF 1852
KULANI PROJECT BOUNDARY
FOREST RESERVE BOUNDARY
HIGHWAY
Water Holes
Mauna Loa Boys School (Abandoned)
Water Tank
Rain Shed
Water Hole
TRAIL
Waiakea Camp (Site)
BM 6112
SOUTH HILO DIST
NORTH HILO DIST
HUMUULA
MAUNA LOA FOREST AND GAME RESERVE

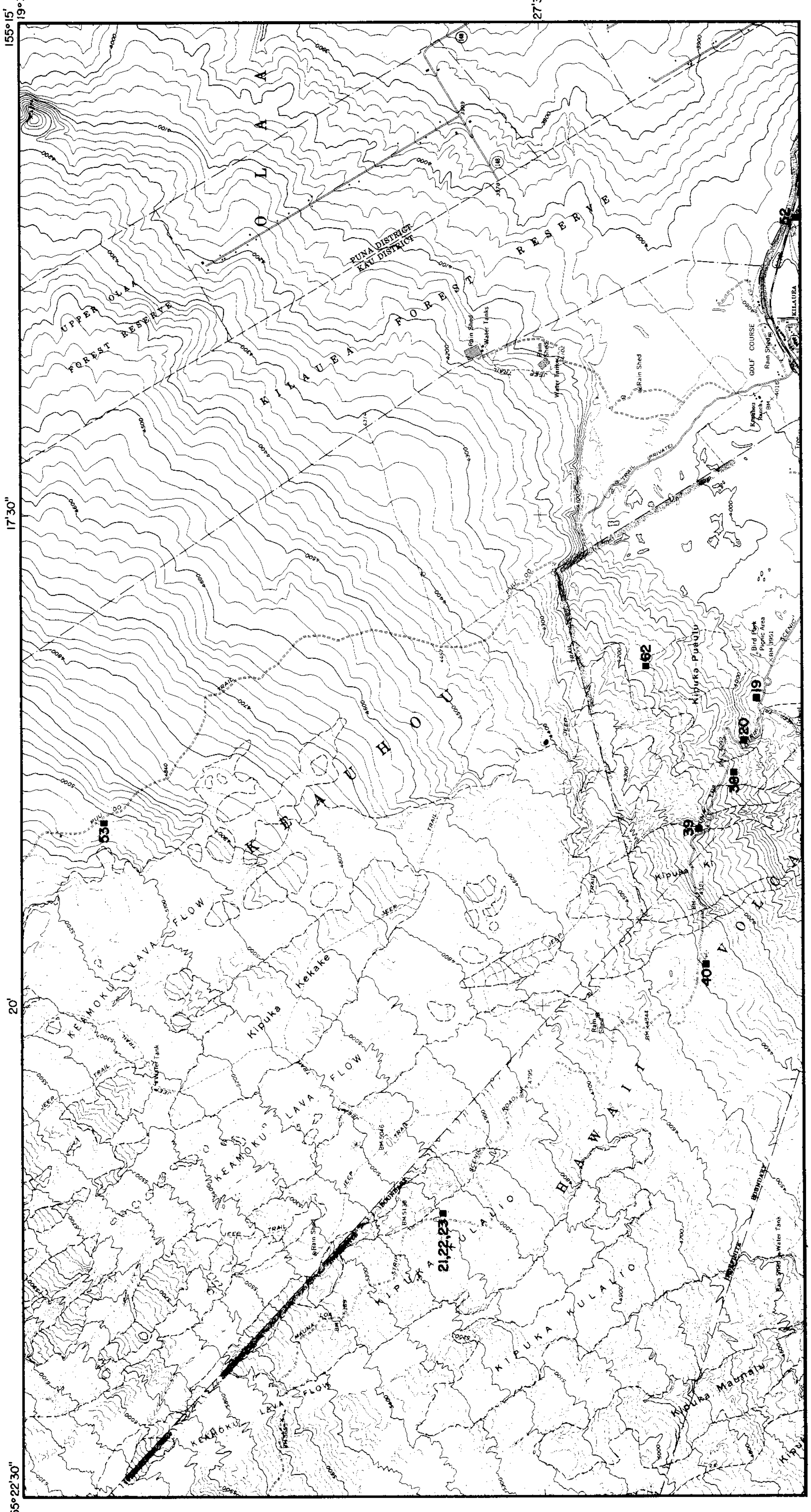
10

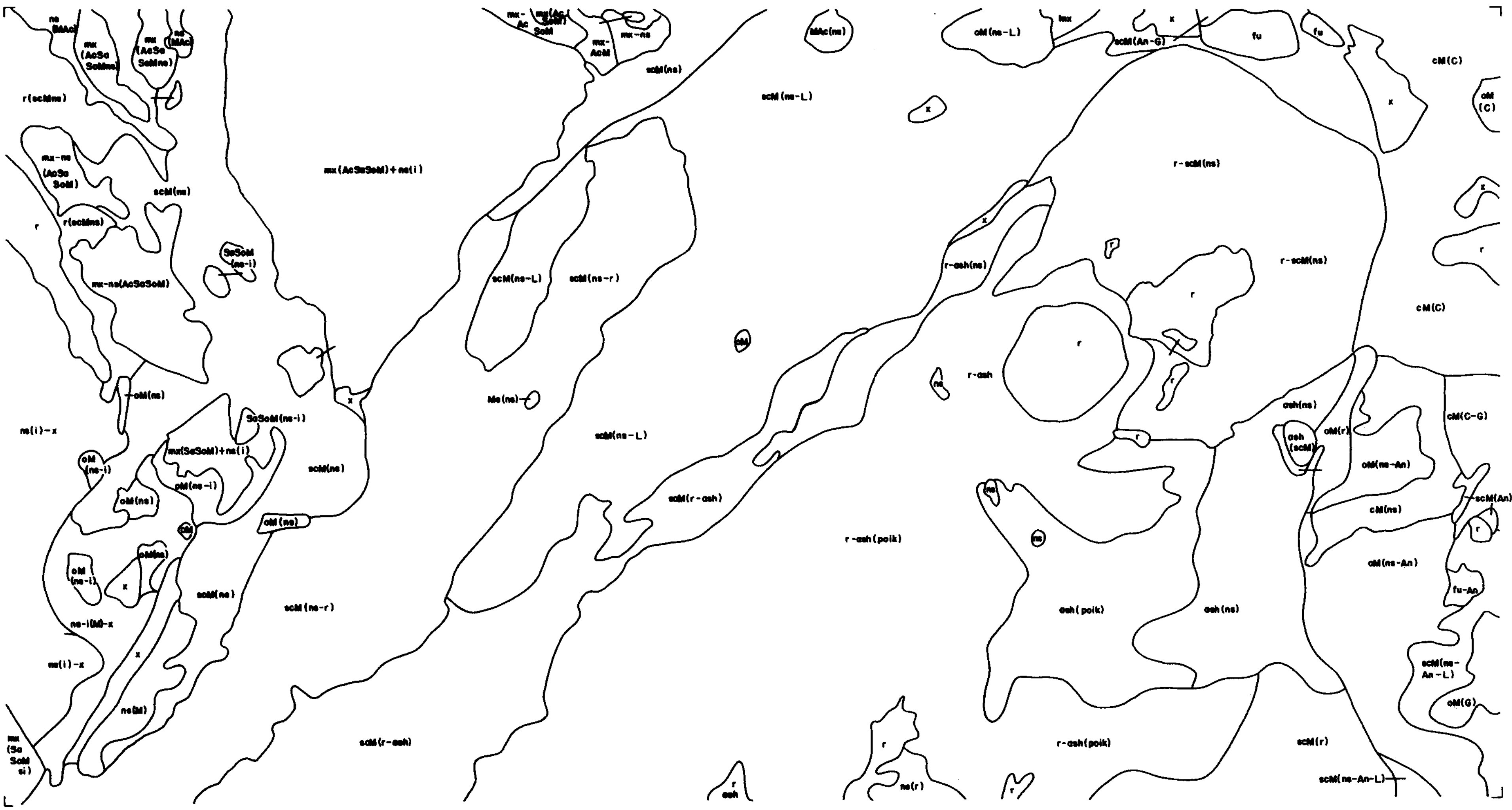

UNMAPPED
r(ns)
oM(So-ns)
oM(So-ns)
ns
ns(M)
AcM
ns(MSo)
AcM(od-mx)
AcM(od-C)
AcM(od-mx)
ns(MAc)
mx(AcM)
mx-AcM
mx(AcM)
mx(AcM)
ns
AcM(od-C)
ns(M)
AcM
(od-mx)
ns(M)
r(ns)
mx-ns(Ac-So)
AcM(od-mx)
AcM
(od-mx)
ns
mx-M
x
oM(C-od)
cM(C-od)
oM(C-od)
cM°(C)
oM(C-od)
MAc(od-C)
x
cM(C-od)
C(M°)
cM(C-od)
x
C(M°)
C(M°)
cM°(C)
C(M°)
AcM(od-C)


32'30"
19°30'
155°15'
17'30"
20'
155°22'30"
PUNA DISTRICT
KAU DISTRICT
SOUTH HILO DISTRICT
PIPELINE
Kulani Project
Water Tanks
Rain Shed
Keawewai Camp
Solomons Water Hole
Puu Lalaau
Puu Kipu

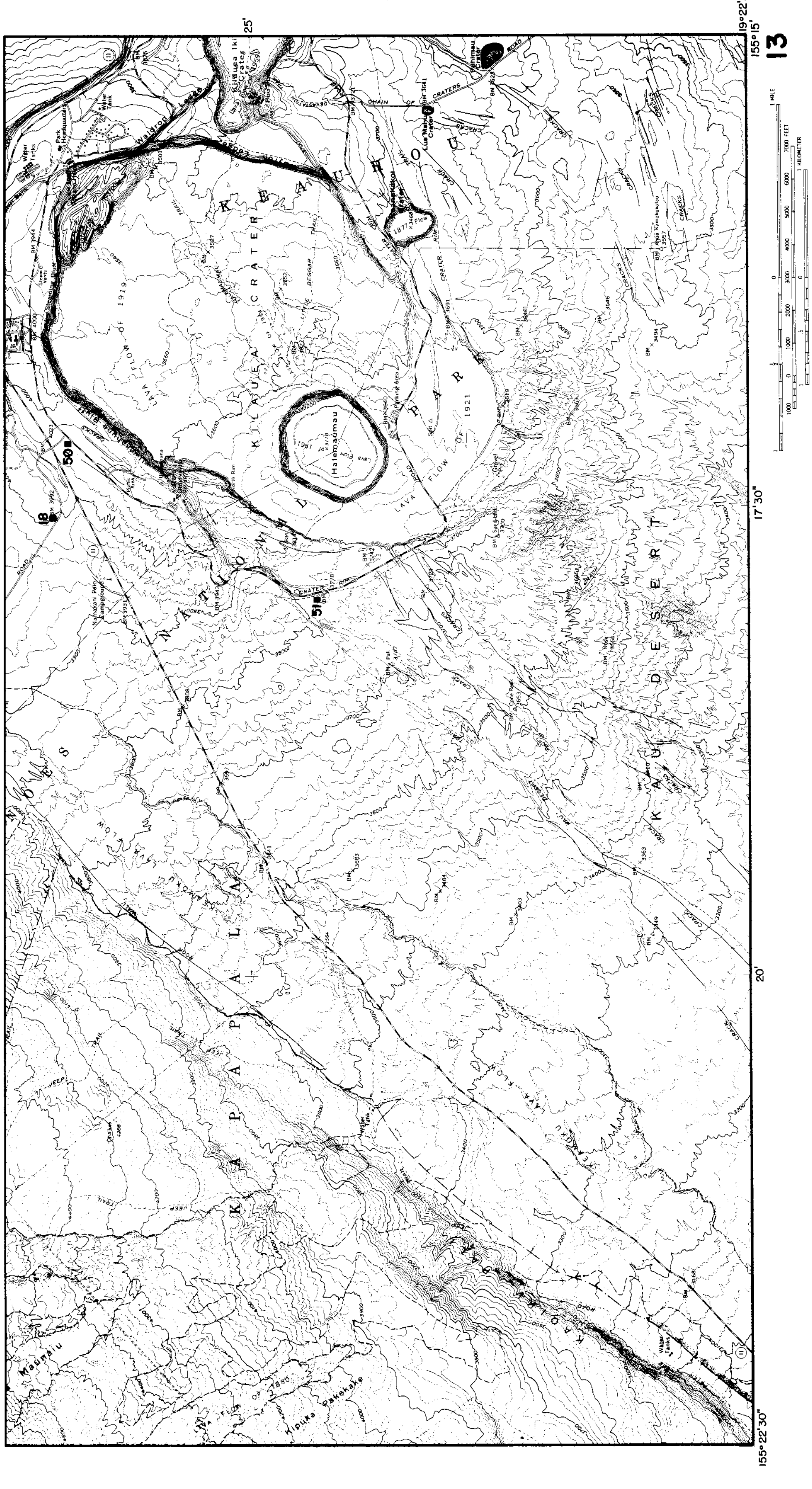

mx-ns
AcM (od-mx)
r(ns)
ns(MAc)
AcM(ns)
mx(AcM)
AcM(od-C)
mx (AcM)
mx-ns (AcSoM)
ns
scM(ns)
AcM(mx)
mx-AcSoM
AcM (Al)
mx-Ac SoM
ns (Ac SoM)
r(ns)
AcM (od-mx)
cM(C)
MAc (od-C)
scM (ns)
MAc(od-C)
C(M°)
mx(AcSoM)
mx-ns (AcSoM)
mx-Ac SoM
ns (AcSoM)
mx-ns
r(ns)
mx(AcSoM)
AcM(od-C)
mx-AcSoM
mx-ns
mx-ns
mx(ns)
mx (AcM)
mx (AcSoM)
ns(M)
ns (MAc)
MAc(od-C)
scM(ns)
AcM(So)
r(scM -ns)
mx-ns (AcSoM)
mx-Ac SoM
ns(Ac)
MAc (So-ns)
ns(AcSoM)
mx-MAc
MAc(ns)
x-scM (G)
AcM(od-C)
AcN(So)
mx-ns
mx-ns (AcSoM)
mx-AcSoM
AcM(So)
mx-ns (AcSoM)
ns(AcSoM)
cM
mx Ac SoM
mx(AcSoM)
mx-AcM
scM(ns)
cM
mx(MAc)
mx-MAc
x
scM(ns)
mx-ns
mx AcSoM
ns MAc
r(scM-ns)
mx-ns(AcSoM)
MAc (ns)
mx-MAc
AcM
mx(MAc)
cM(C)
x
ns(AcM)
ns(AcSoM)
ns (AcSoM)
AcM (od)
MAc (ns)
mx (MAc)
MAc(ns)
cM(ns)
mx(scM)
cM(C)
mx-ns(AcSoM)
mx-AcSoM
mx-AcM
mx-AcSoM (od)
scM(ns)
MAc(ns)
AcSoM (od)
mx-AcM
oM(mx)
cM(C)
AcM (od-mx)
mx-ns (AcSoM)
scM(ns)
nsM
mx-AcSoM (od)
mx-AcSoM
MAc (ns)
mx (Ac SoM)
mx(AcSoM)
ns(AcSoM)
mx-AcSoM
mx-ns (AcSoM)
mx-AcSoM
MAc (ns)
ns (M)
mx Ac SoM
mx-AcM
AcSoM(od)
oM(ns-L)
mx
x
scM (An-G)
oM(G-C)
mx(AcSoM)tns(i)
mx-ns
scM(ns-L)
scM(ns-L)

12

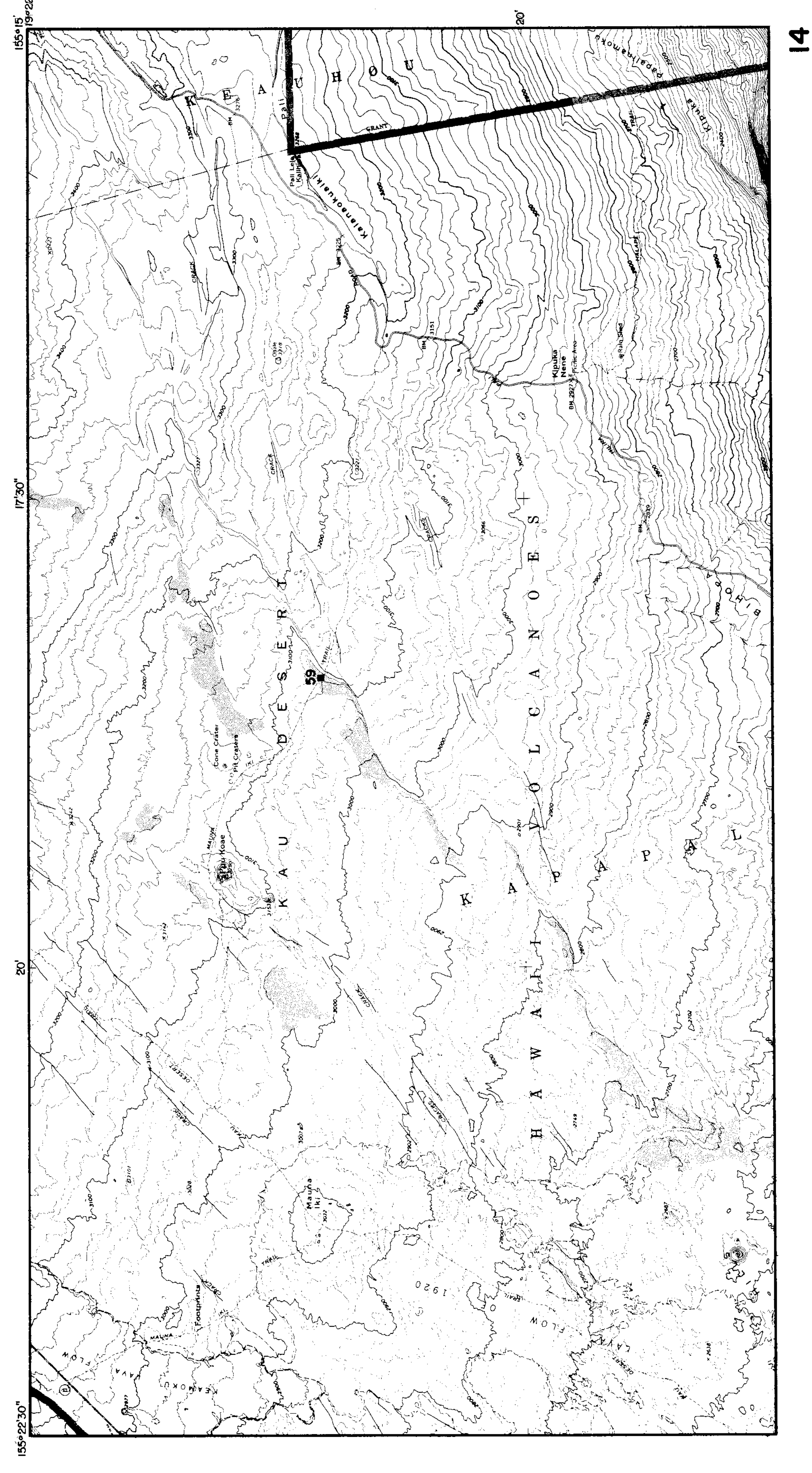

155°15'
19°30'
27'30"
17'30"
20'
155°22'30"
UPPER OLAA FOREST RESERVE
OLAA
PUNA DISTRICT
KAU DISTRICT
KILAUEA FOREST RESERVE
Rain Shed
Water Tanks
GOLF COURSE
KILAUEA
52
KEAUHOU
62
Kipuka Puaulu
Bird Park
Picnic Area
19
20
38
39
Kipuka Ki
40
53
VOLCANO
KEAMOKU LAVA FLOW
Kipuka Kekake
HAWAII
21,22,23
KIPUKA KULALIO
KIPUKA KULALIO
Kipuka Mauna Iu
TRAIL
JEEP
Water Tank



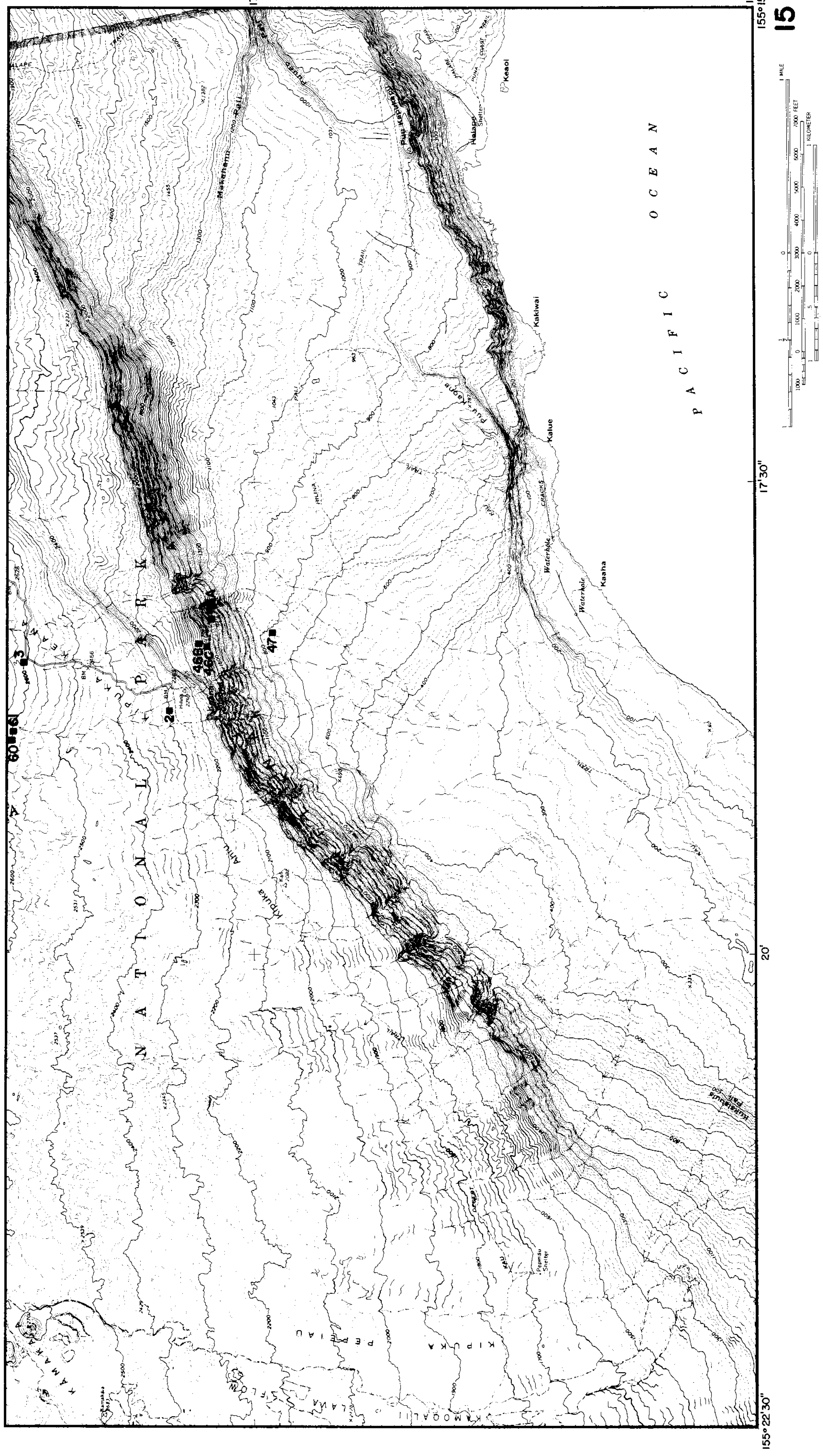
mx(AcSaSoM)+ns(i)
scM(ns)
scM(ns-L)
scM(ns-r)
scM(r-csh)
r-csh(poik)
csh(poik)
csh(ns)
r-scM(ns)
r-csh(ns)
r-csh
scM(r)
scM(ns-An-L)
cM(C)
cM(C-G)
cM(ns-An)
cM(ns)
cM(G)
cM(ns-L)
scM(An-G)
fu
fu-An
MAc(ns)
Me(ns)
mx-ns(AcSaSoM)
SaSoM(ns-i)
mx(SaSoM)+ns(i)
ns(i)-x
r(scMns)


13
19°22'30"
155°15'
25'
17'30"
20'
155°22'30"
KILAUEA CRATER
Halemaumau
LAVA FLOW OF 1919
LAVA FLOW OF 1921
HAWAII NATIONAL PARK
KAU DESERT
Kilauea Iki Crater
CHAIN OF CRATERS
CRATER RIM
Kipuka Pakekake
Mauna Iki
1 MILE
1 KILOMETER

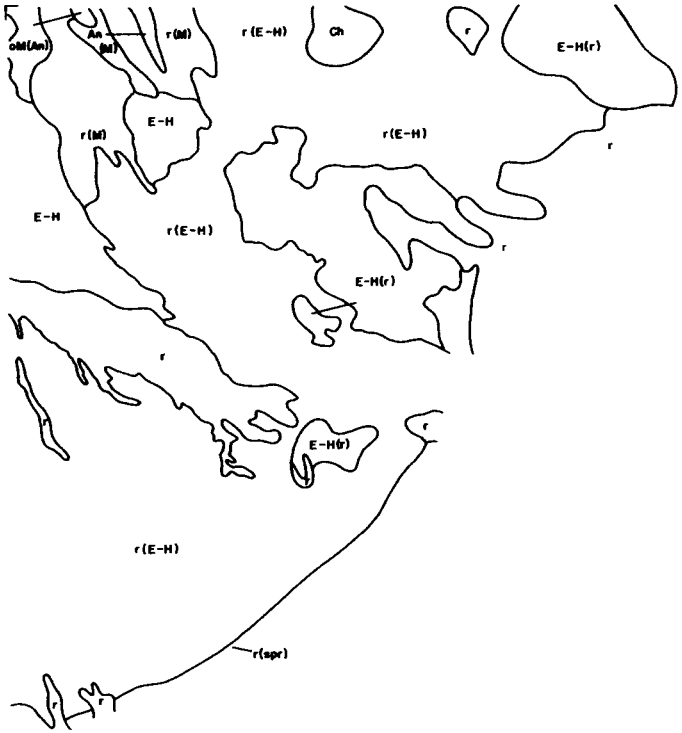

sctM(ns-r)
sctM(r-osh)
r-osh(poik)
sctM(ns-An)
sctM(ns-r)
r
osh
r-osh
ns(r)
sctM(r)
sctM(ns-An-L)
ctM(An-ns)
ctM-An
An(ns-M)
An(Mo)
An(ns-I-Mo)

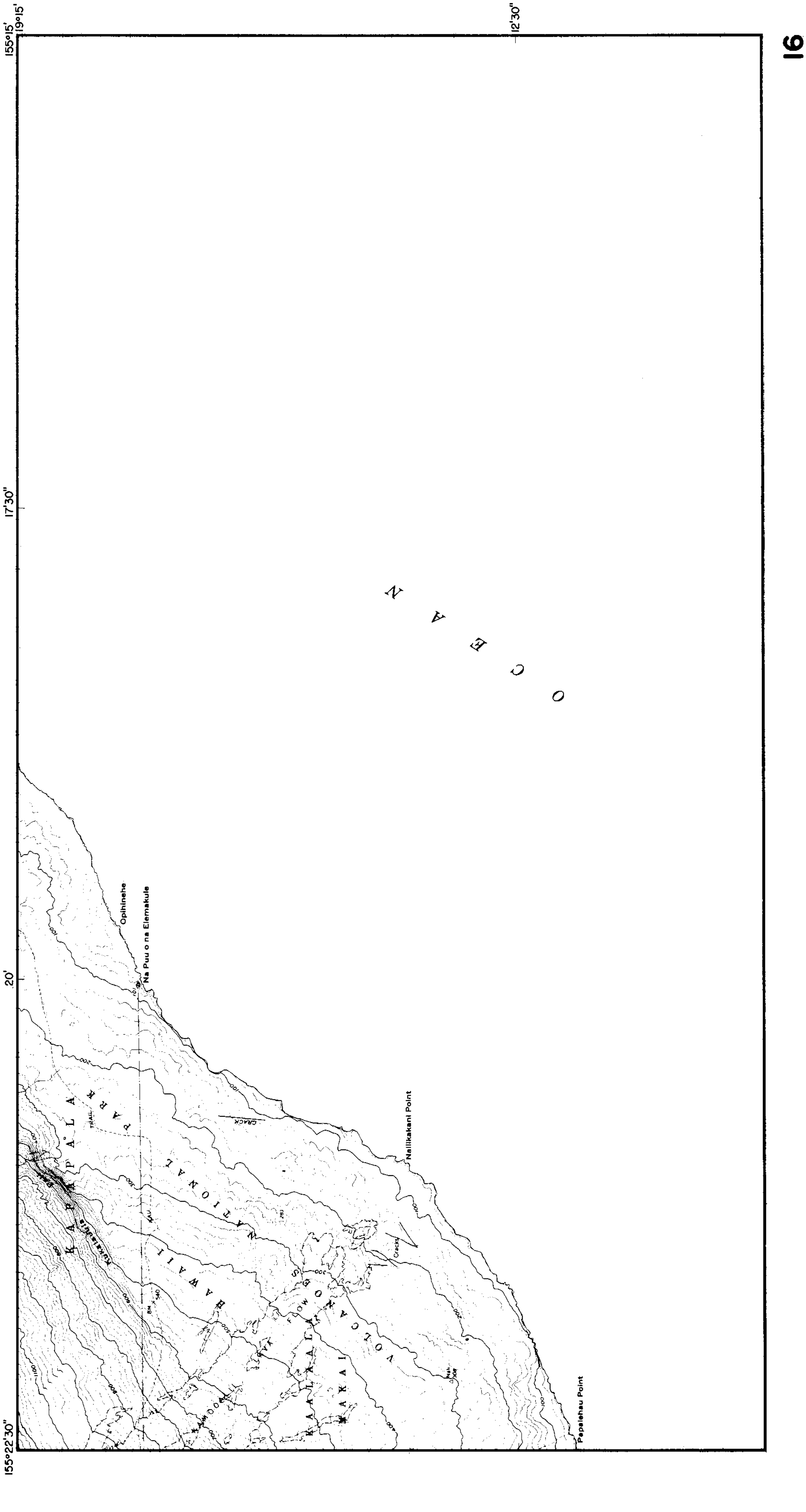

155°15'
19°22'30"
20'
17'30"
155°22'30"
14
K E A U H O U
Pali Lei
K A U D E S E R T
H A W A I I V O L C A N O E S
K A P A P A L A
Kipuka Nene
Picnic Area
Cone Crater
Pit Craters
59
Mauna Iki
Footprints
1920
FLOW
LAVA
TRAIL
CRACK
GRANT


r-osh(polk)
r-osh
scM(r)
r(scM)
oM(An)
r(ns)
oM
(ns)
r(scM)
An(Me)
An
(Me)
oM(An)
MD(r)
r
r(E-H)
r(M)
oM(An)
An(M)
MD
r(E)
E(r)
MD(r)
cM-An
An(ns-M)
An(ns-i-Me)
E-r(M)
r(M)
MD(r)
cM(An-ns)
An(ns-M)
MD(An-r)
An(ns-
i-M)
Ch
E
lsi(E-H)
r(E)
H
spr(olf)



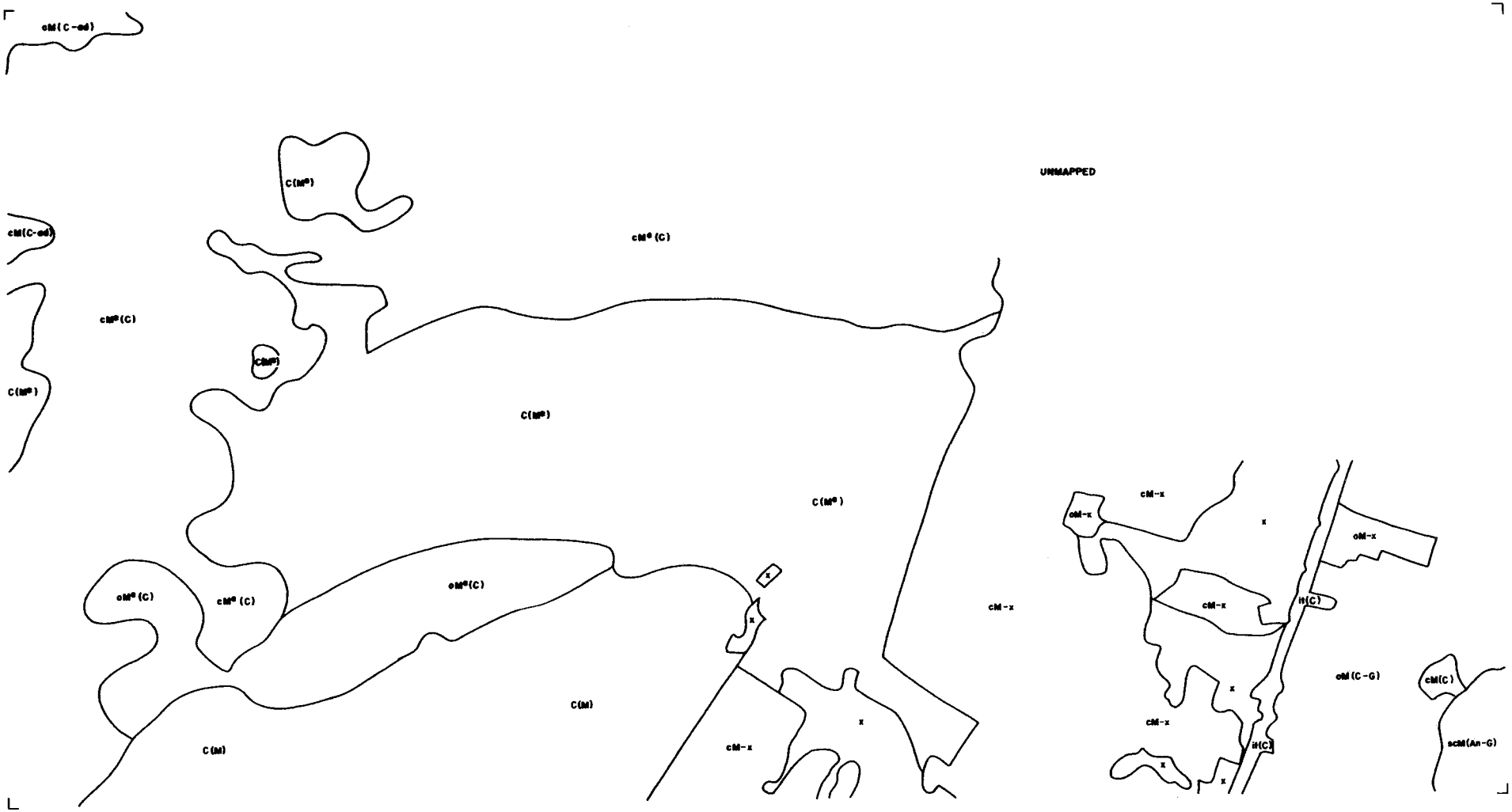
15
19°15'
155°15'
17'30"
20'
155°22'30"
PACIFIC OCEAN
NATIONAL PARK
Keaoi
Halape
Kakiwai
Kalue
Waterhole
Kaaha
Kipuka

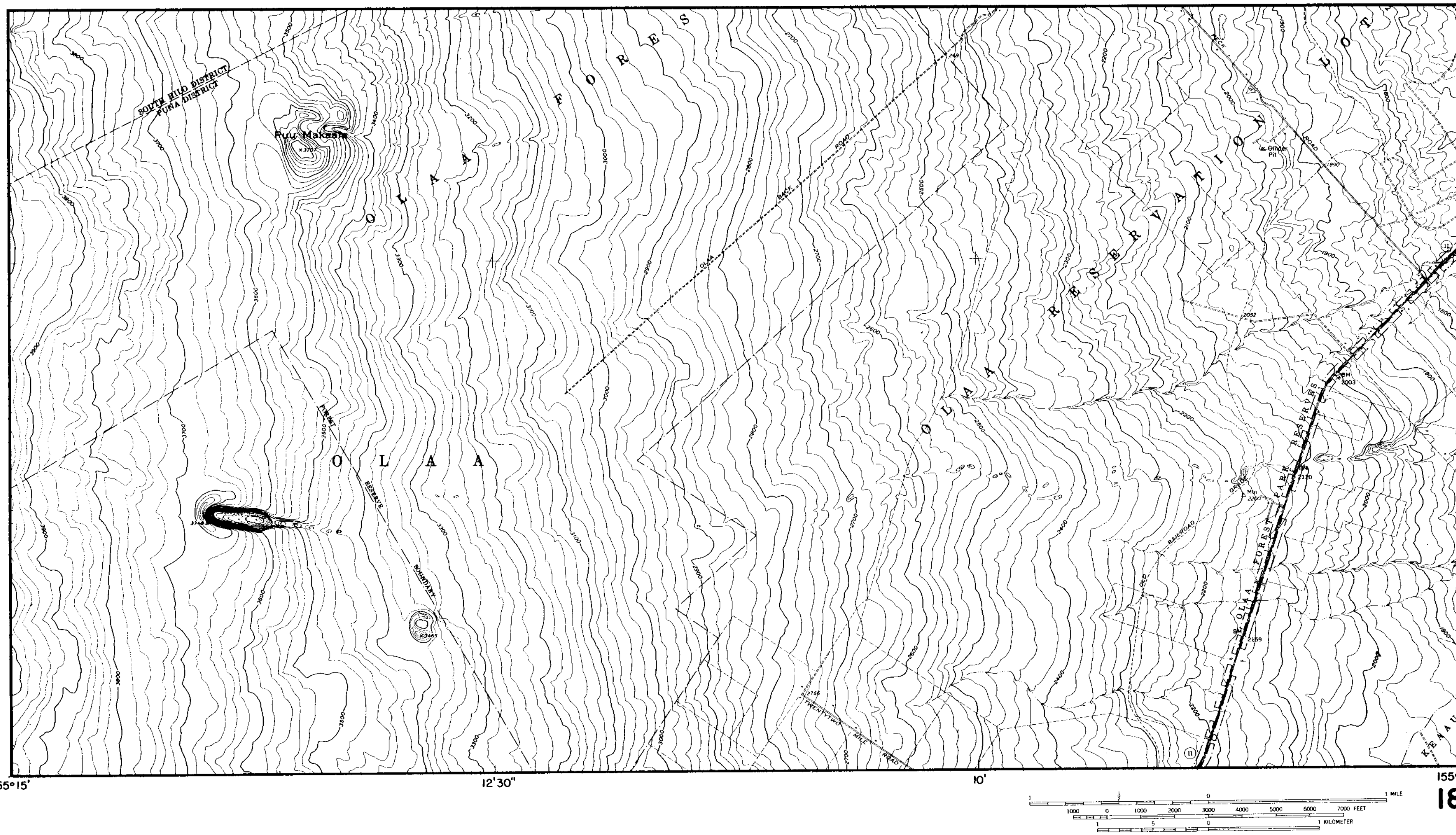

r(E-H)
Ch
r
E-H(r)
r(M)
E-H
r(E-H)
r
E-H
r(E-H)
r
E-H(r)
r
E-H(r)
r
r(E-H)
r(spr)

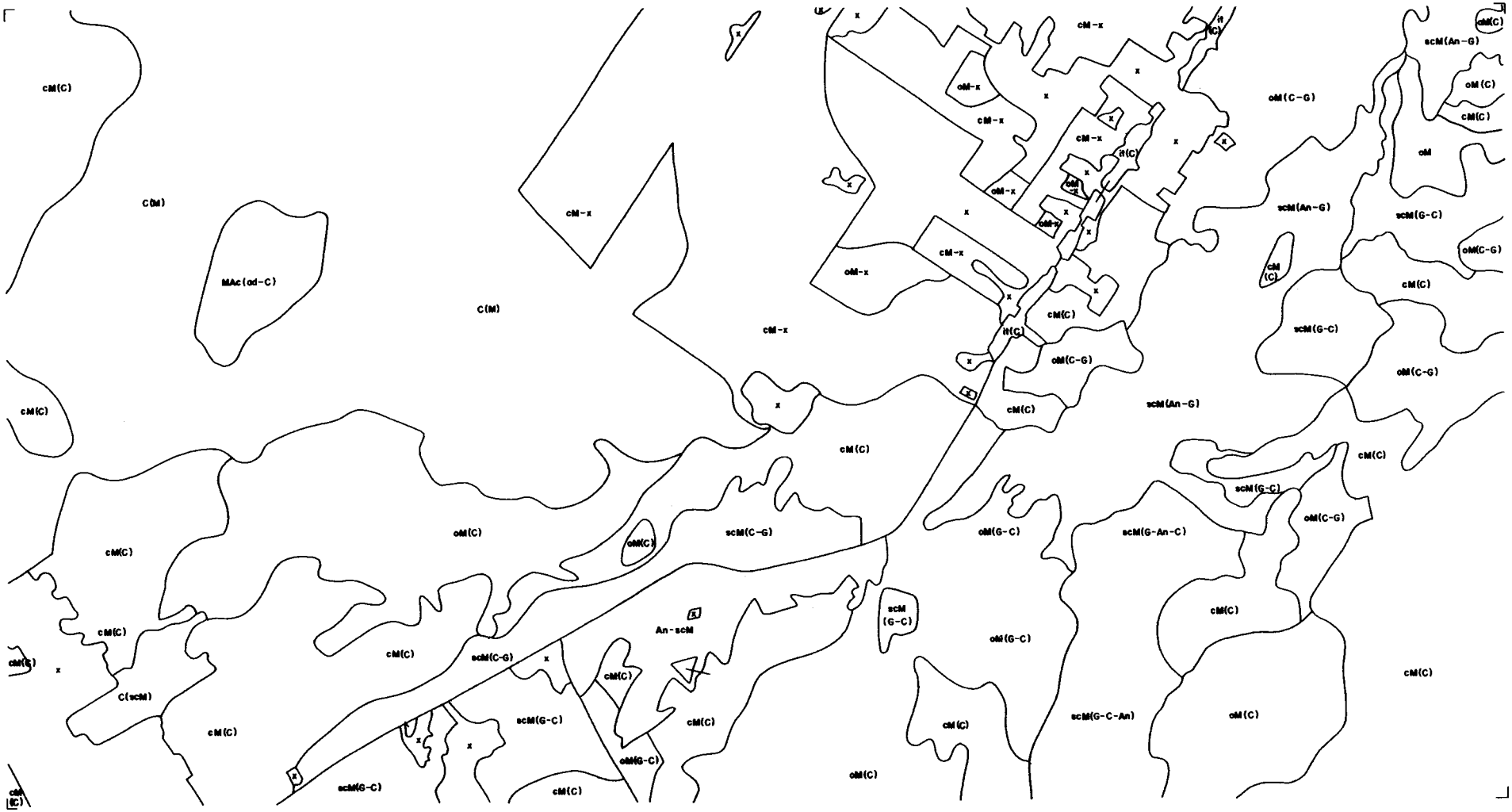

16
155°15'
19°15'
12'30"
17'30"
20'
155°22'30"
O C E A N
Opihinehe
Na Puu o na Elemakule
Nalikakani Point
HAWAII NATIONAL PARK
VOLCANOES
CRACK
TRAIL

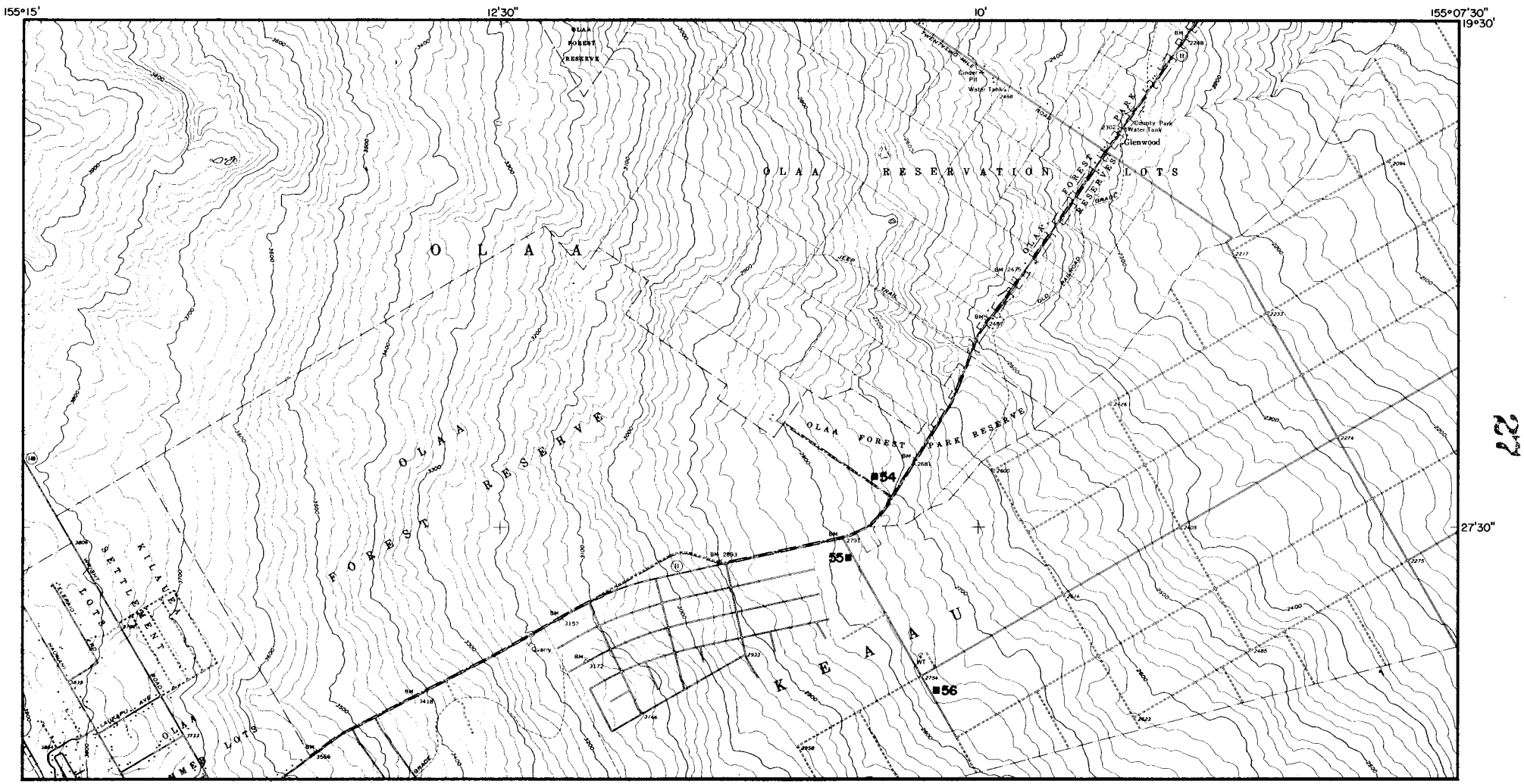
155°15'
12'30"
10'
155°07'30"
19°37'30"
35'
UPPER WAIAKEA FOREST RESERVE
WAIAKEA RESERVE
MAKAHA FOREST RESERVE
41
42
36
BOUNDARY
STREAM
ROAD
TRAIL
SOUTH HILO DISTRICT
PUNA DISTRICT

17

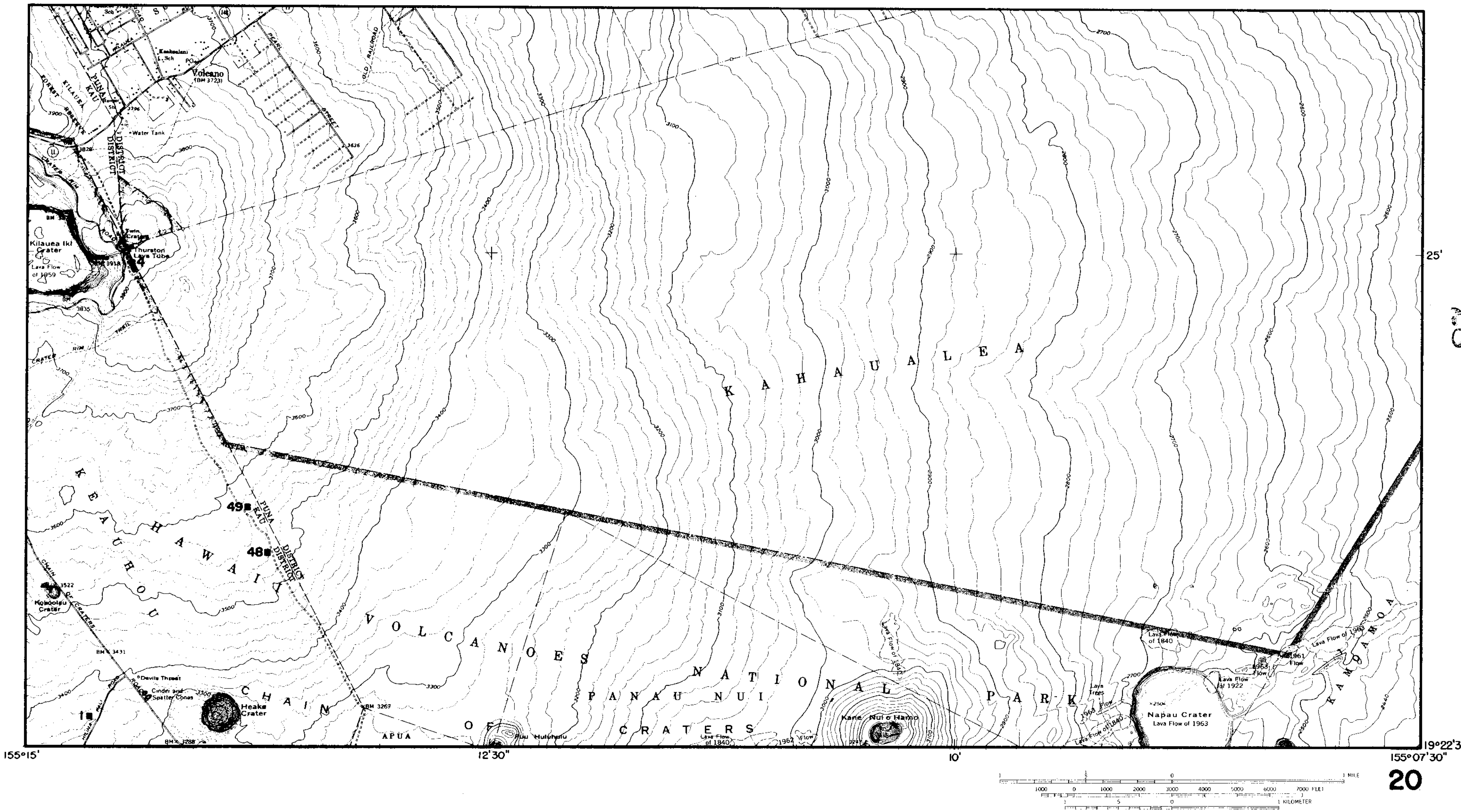

UNMAPPED
cM(C-ed)
C(M°)
cM°(C)
cM(C-ed)
cM°(C)
C(M°)
C(M°)
C(M°)
cM°(C)
cM°(C)
cM°(C)
C(M)
C(M)
cM-x
cM-x
cM-x
cM-x
cM-x
cM-x
M(C)
M(C)
oM(C-G)
cM(C)
scM(An-G)


SOUTH HILO DISTRICT
PUNA DISTRICT
Puu Makaala
OLAA FOREST RESERVATION LOT
OLAA
OLAA FOREST PARK RESERVES
FOREST RESERVE BOUNDARY
OLAA BACK ROAD
TWENTYTWO MILE ROAD
RAILROAD
Cinder Pit
KEAAU
155°15'
12'30"
10'
155°07'30"
19°30'
32'30"
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER
18

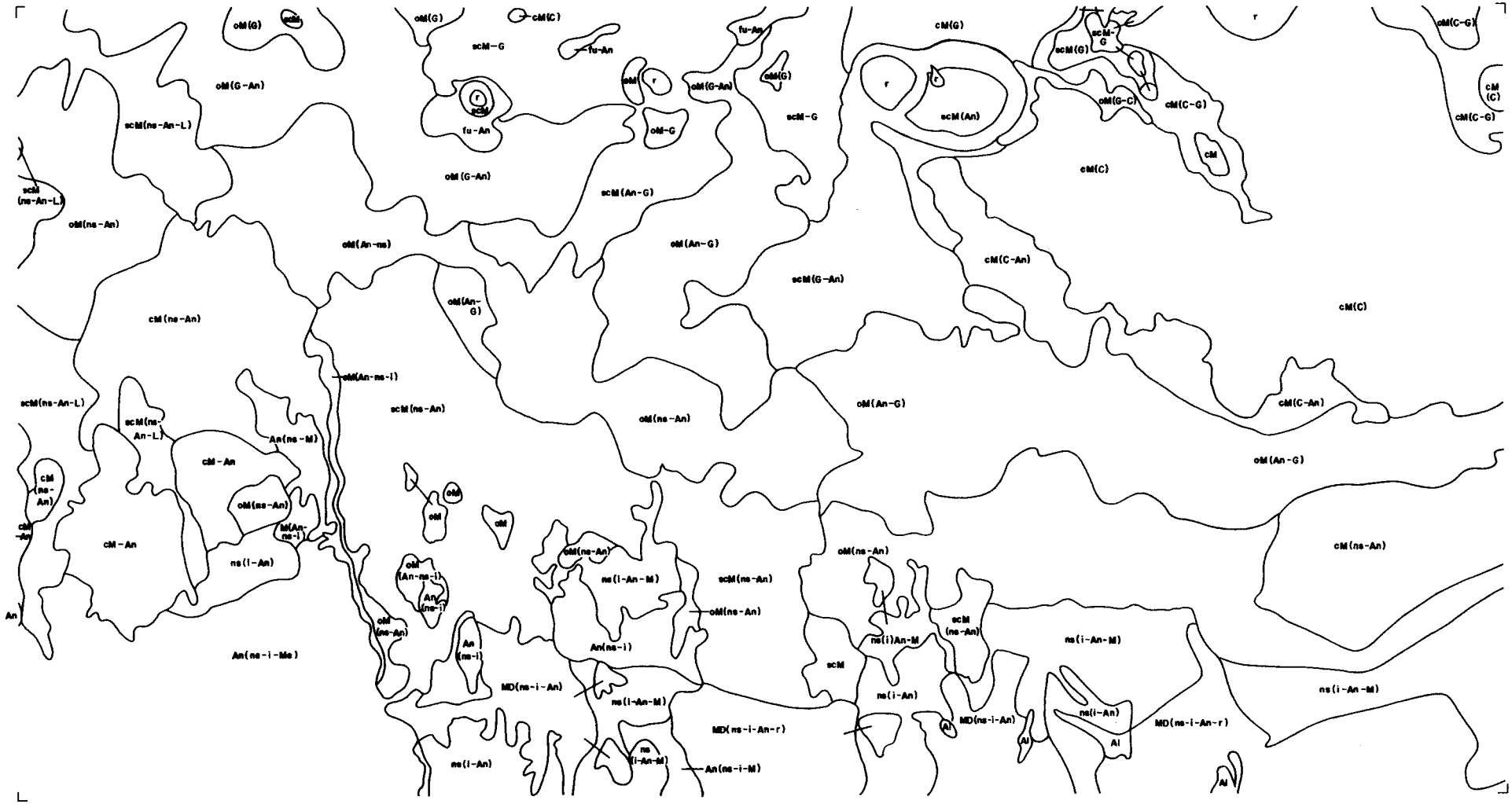

cM(C)
C(M)
MAc(od-C)
cM-x
oM-x
oM(C)
scM(C-G)
scM(G-C)
C(scM)
An-scM
oM(G-C)
scM(G-An-C)
scM(G-C-An)
oM(C-G)
scM(An-G)
oM
oM(C-G)
scM(G-C)
scM(An-G)

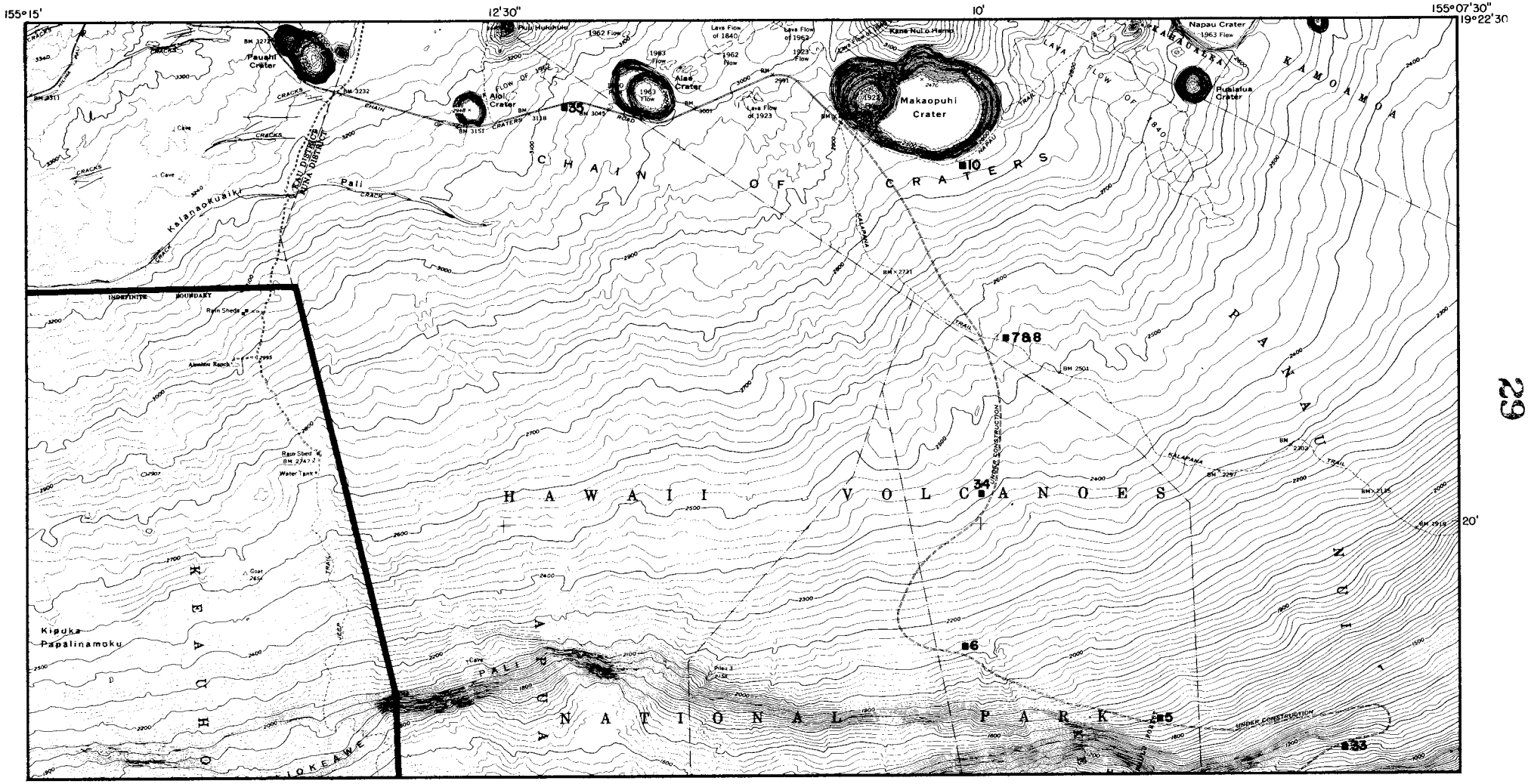

155°15'
12'30"
10'
155°07'30"
19°30'
27'30"
OLAA
FOREST
RESERVE
OLAA RESERVATION LOTS
OLAA FOREST RESERVE ROAD
OLAA FOREST PARK RESERVE
Cinder Pit
Water Tank
County Park
Water Tank
Glenwood
Quarry
KILAUEA
SETTLEMENT
LOTS
KEAAU
54
55
56
19
42

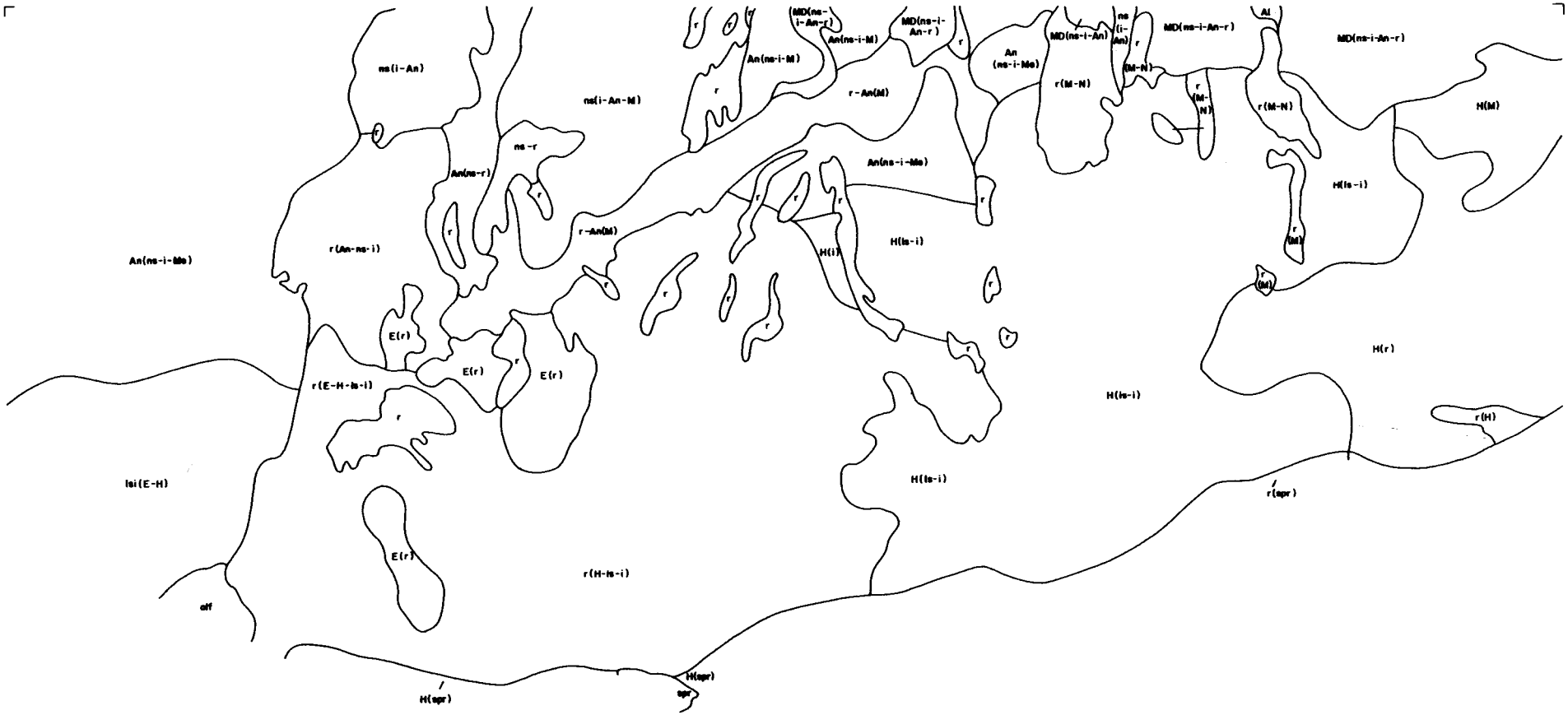

cM(C)
scM(G-C)
oM(C)
cM(C)
cM(C)
cM(C)
oM(C)
scM(G-C-An)
cM(C)
oM(C)
cM(C)
cM(C-G)
cM(C)
oM(G)
cM(C-G)
scM(G-C-An)
cM(C)
scM(ns-An-L)
oM(G)
oM(C-G)
cM(C)
scM-G
oM(G)
scM(ns-An-L)
scM-G(An)
scM-G(An)
fu-An
scM-G
scM(ns-An-L)
scM(G-An)
scM
scM(G)
oM(G-An)
cM(C)
cM(C)
scM(G)
scM-G
cM(C)
cM(C-G)
scM-G
cM(C)
cM(C-G)
scM(G)
scM(G)
oM(C-G)

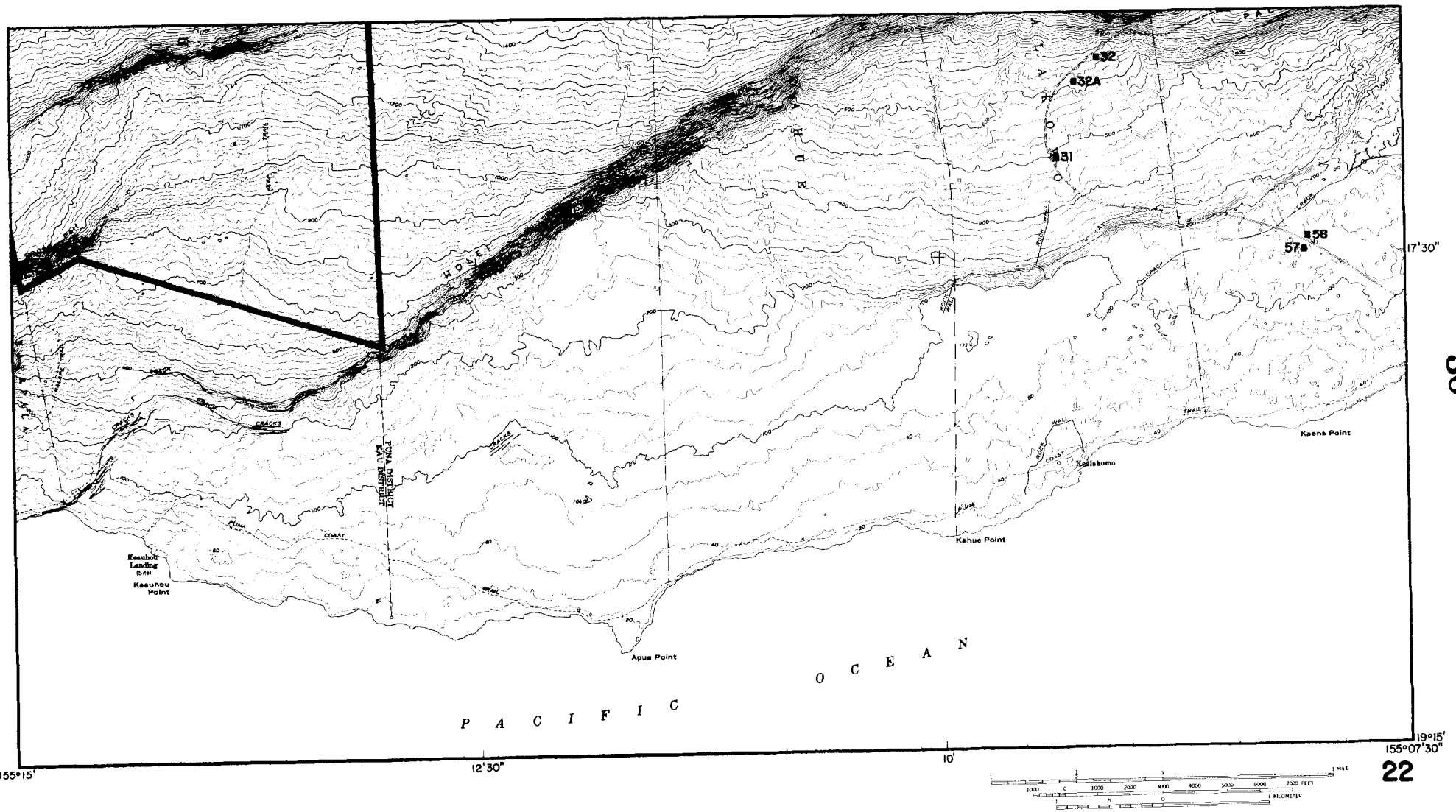

K A H A U A L E A
V O L C A N O E S N A T I O N A L P A R K
P A N A U N U I
C H A I N O F C R A T E R S
K E A U H O U
H A W A I I
K A M O A M O A
A P U A
Volcano (BM 3723)
Kilauea Iki Crater
Lava Flow of 1959
Twin Craters
Thurston Lava Tube
Water Tank
PUNA DISTRICT
KAU DISTRICT
Koko'olau Crater
Devils Throat
Cinder and Spatter Cones
Heake Crater
Puu Huluhulu
Kane Nui o Hamo
Napau Crater
Lava Flow of 1963
Lava Flow of 1922
Lava Flow of 1840
Lava Trees
1962 Flow
1963 Flow
1961 Flow
OLD RAILROAD
PEARL
STREET
49
48
4
1
155°15'
12'30"
10'
155°07'30"
19°22'30"
25'
1 MILE
7000 FEET
1 KILOMETER

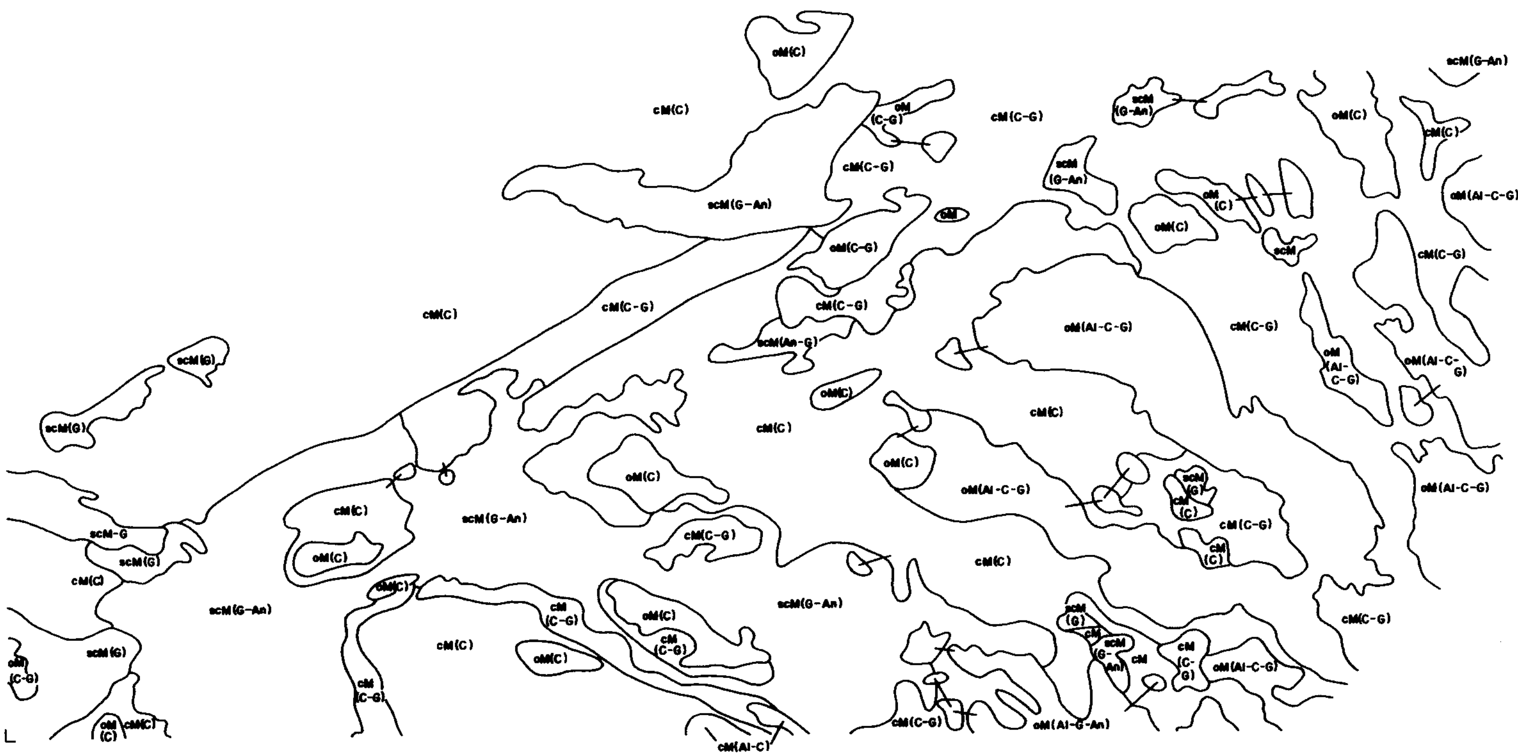
20

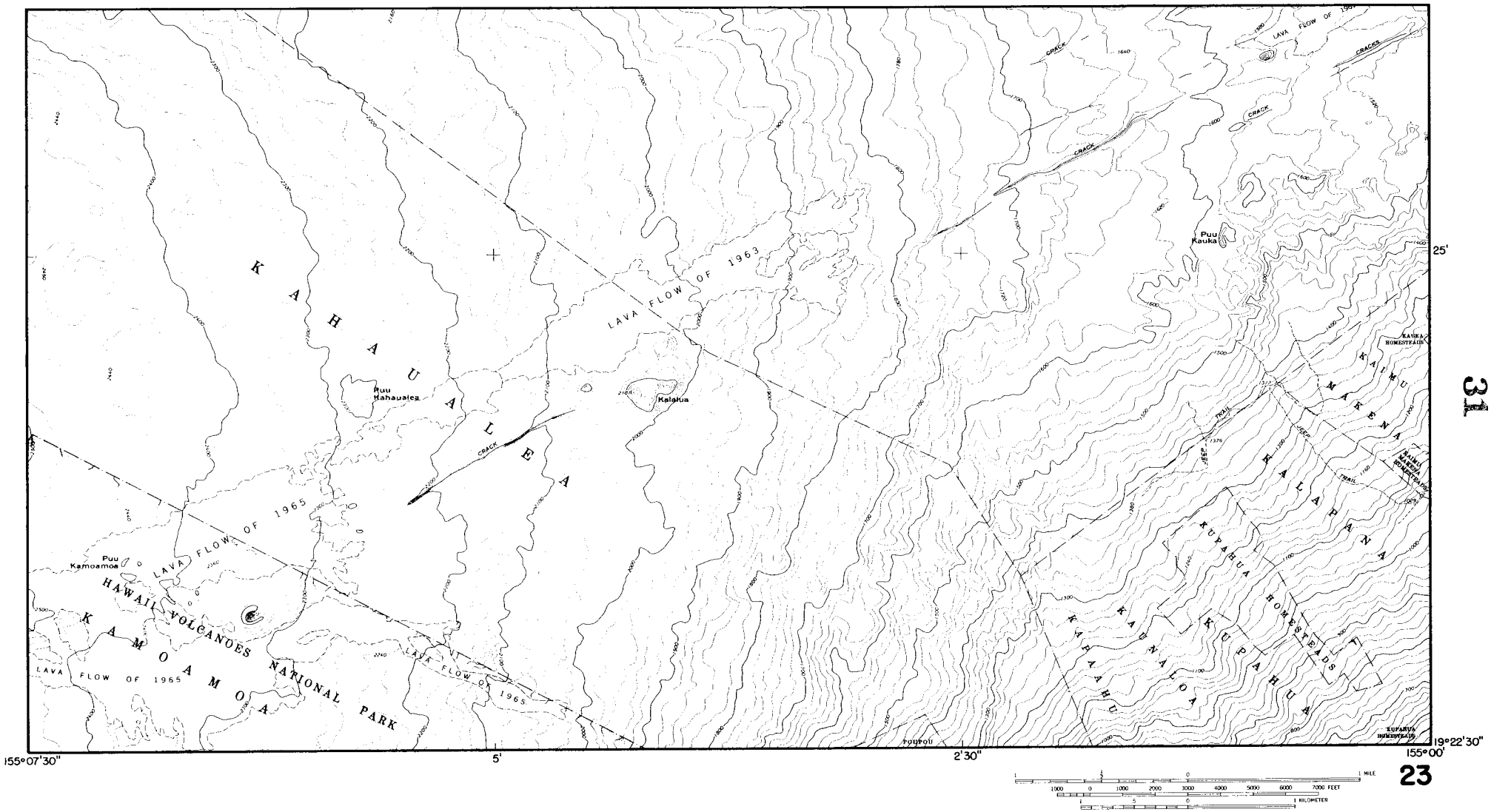

oM(G)
scM
oM(G)
cM(C)
scM-G
fu-An
fu-An
cM(G)
scM-G
oM(G-An)
r
scM
fu-An
oM
r
oM(G-An)
oM(G)
oM-G
scM-G
scM(An)
oM(G-C)
cM(C-G)
cM
cM(C)
cM(C-G)
scM(ns-An-L)
oM(G-An)
scM(An-G)
cM(C)
scM(ns-An-L)
oM(ns-An)
oM(An-ns)
oM(An-G)
cM(C-An)
scM(G-An)
oM(An-G)
cM(ns-An)
cM(C)
oM(An-ns-i)
scM(ns-An)
oM(ns-An)
oM(An-G)
cM(C-An)
scM(ns-An-L)
scM(ns-An-L)
An(ns-M)
cM-An
oM(ns-An)
cM(ns-An)
oM(An-G)
oM
oM
oM
oM(ns-An)
oM(ns-An)
cM-An
ns(i-An)
oM(An-ns-i)
An(ns-i)
ns(i-An-M)
scM(ns-An)
oM(ns-An)
cM(ns-An)
An
oM(ns-An)
An(ns-i)
oM(ns-An)
ns(i)An-M
scM(ns-An)
ns(i-An-M)
An(ns-i-Me)
An(ns-i)
scM
MD(ns-i-An)
ns(i-An-M)
ns(i-An)
MD(ns-i-An)
ns(i-An)
MD(ns-i-An-r)
ns(i-An-M)
MD(ns-i-An-r)
ns(i-An)
ns(i-An-M)
An(ns-i-M)
Al
Al
Al
Al


155°15'
12'30"
10'
155°07'30"
19°22'30
20'
Pauahi Crater
Alae Crater
Makaopuhi Crater
Napau Crater
1963 Flow
Pualaiua Crater
CHAIN OF CRATERS
KAMOAMOA
HAWAII VOLCANOES
NATIONAL PARK
Pali
Kalanaokuaiki
INDEFINITE BOUNDARY
Kipuka Papalinamoku
Rain Shed
Water Tank
Cave
CRACKS
TRAIL
JEEP
UNDER CONSTRUCTION
Napau Crater
1963 Flow
Pualaiua Crater
Makaopuhi Crater
Alae Crater
Pauahi Crater
CHAIN OF CRATERS
KAMOAMOA
HAWAII VOLCANOES
NATIONAL PARK
Pali
Kalanaokuaiki
INDEFINITE BOUNDARY
Kipuka Papalinamoku
Rain Shed
Water Tank
Cave
CRACKS
TRAIL
JEEP
UNDER CONSTRUCTION


ns(i-An)
ns(i-An-M)
ns-r
An(ns-r)
r(An-ns-i)
An(ns-i-Mo)
r-An(M)
E(r)
r(E-H-ls-i)
lsi(E-H)
elf
r(H-ls-i)
H(spr)
spr
MD(ns-i-An-r)
An(ns-i-M)
r-An(M)
An
(ns-i-Mo)
MD(ns-i-An)
r(M-N)
ns
(i-
An)
(M-N)
Al
H(M)
H(ls-i)
H(i)
H(r)
r(H)
r(spr)

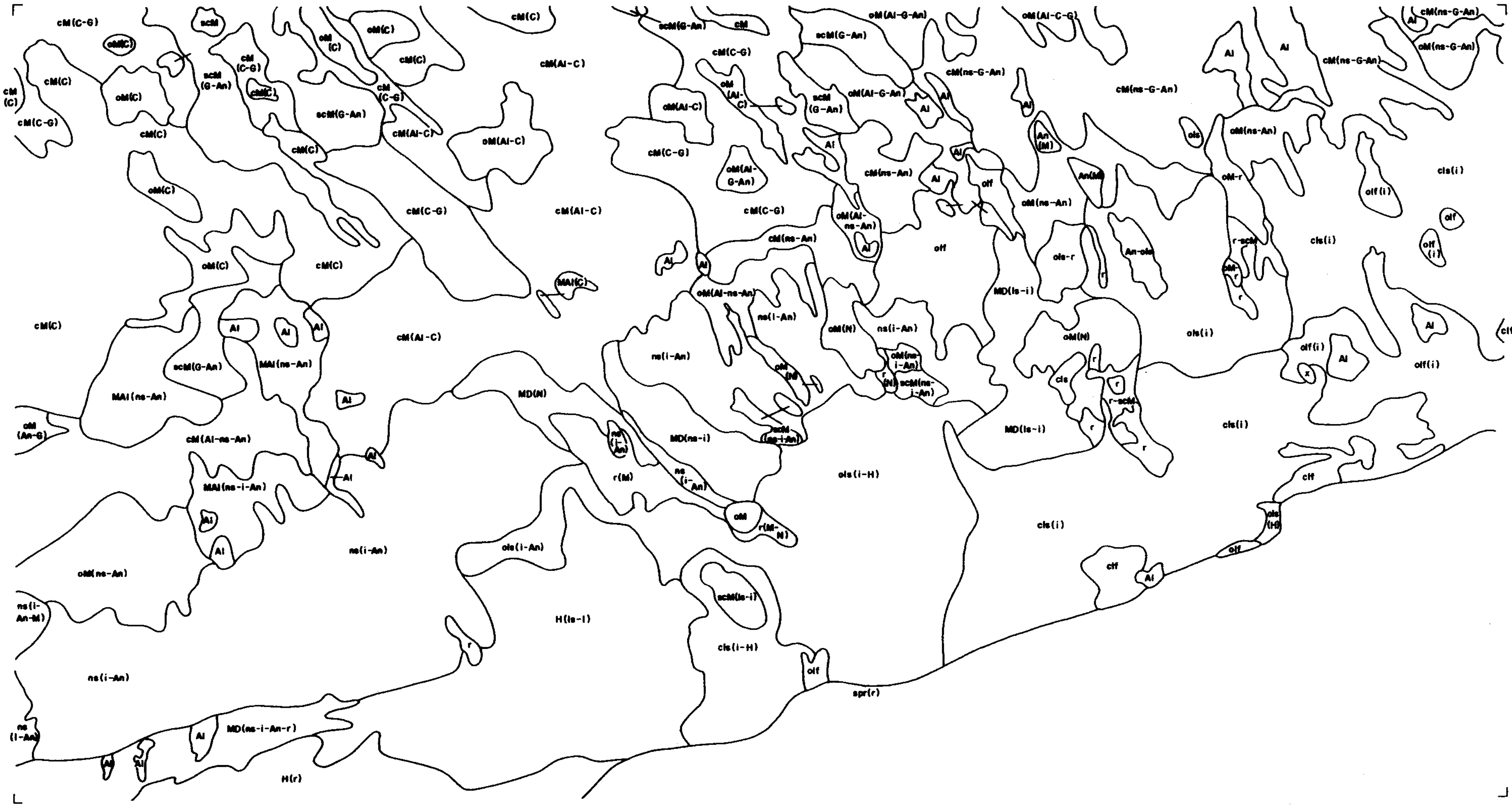

H O L E
H O L E
32
32A
31
58
57a
17'30"
Kaena Point
Kealakomo
Kahue Point
Keauhou Landing (Site)
Keauhou Point
Apua Point
PUNA DISTRICT
KAU DISTRICT
P A C I F I C O C E A N
155°15'
12'30"
10'
19°15'
155°07'30"
22

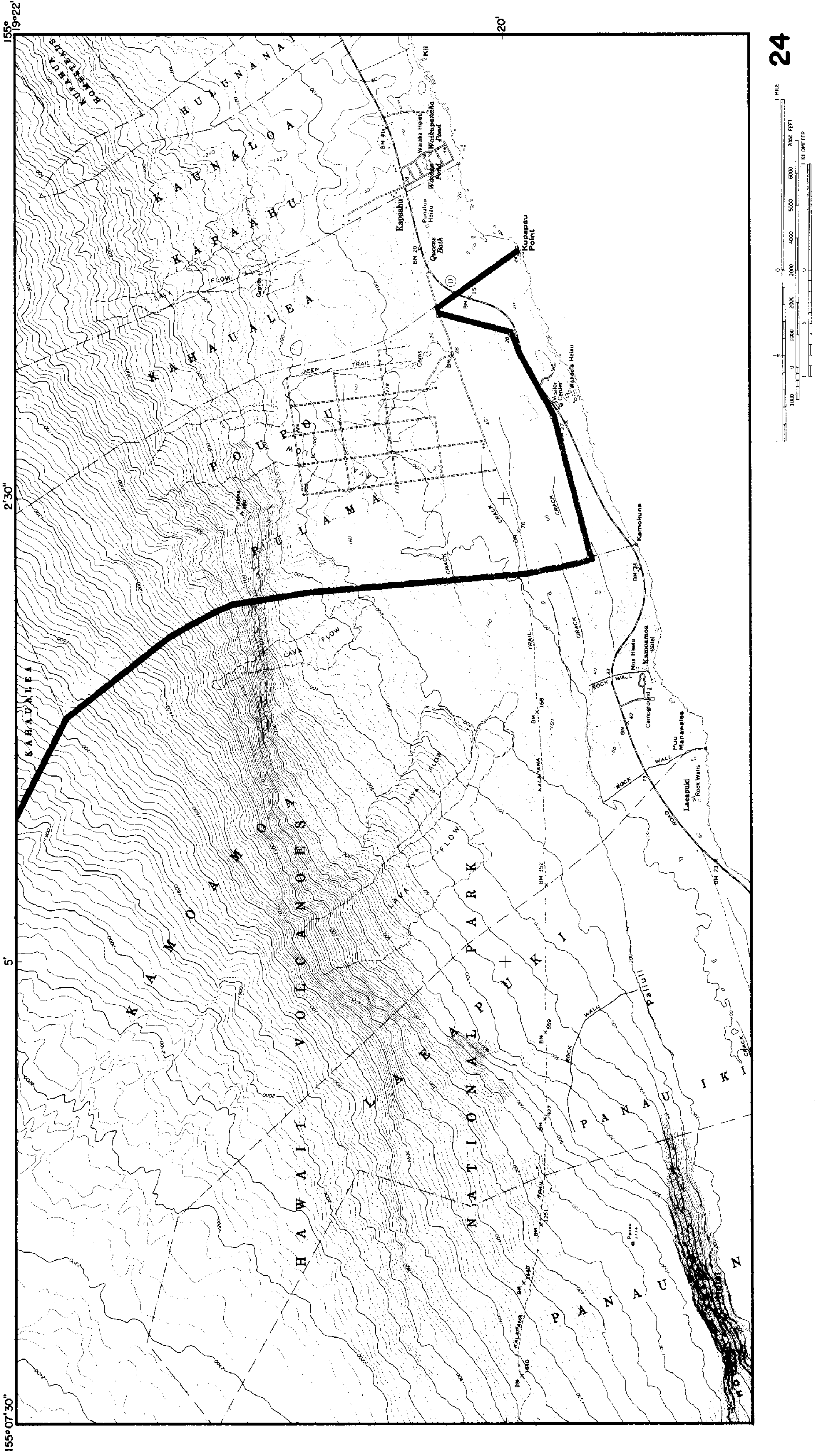

oM(C)
scM(G-An)
cM(C)
oM
(C-G)
cM(C-G)
scM
(G-An)
scM
(G-An)
oM(C)
cM(C-G)
oM(Al-C-G)
scM(G-An)
oM
(C)
oM
oM(C)
scM
cM(C-G)
oM(C-G)
cM(C-G)
cM(C)
cM(C-G)
oM(Al-C-G)
cM(C-G)
scM(An-G)
scM(G)
oM(C)
oM
(Al-
C-G)
oM(Al-C-
G)
scM(G)
cM(C)
cM(C)
oM(C)
oM(C)
oM(Al-C-G)
oM(Al-C-G)
cM(C)
scM(G-An)
scM
(G)
cM
(C)
cM(C-G)
cM(C-G)
scM-G
scM(G)
oM(C)
cM
(C)
cM(C)
oM(C)
cM(C)
scM(G-An)
cM
(C-G)
oM(C)
scM(G-An)
cM(C-G)
cM(C)
scM
(G)
cM
scM
(G-
An)
cM
cM
(C-
G)
oM(Al-C-G)
oM
(C-G)
scM(G)
cM
(C-G)
oM(C)
cM
(C-G)
cM(C-G)
oM(Al-G-An)
oM
(C)
cM(C)
cM(Al-C)

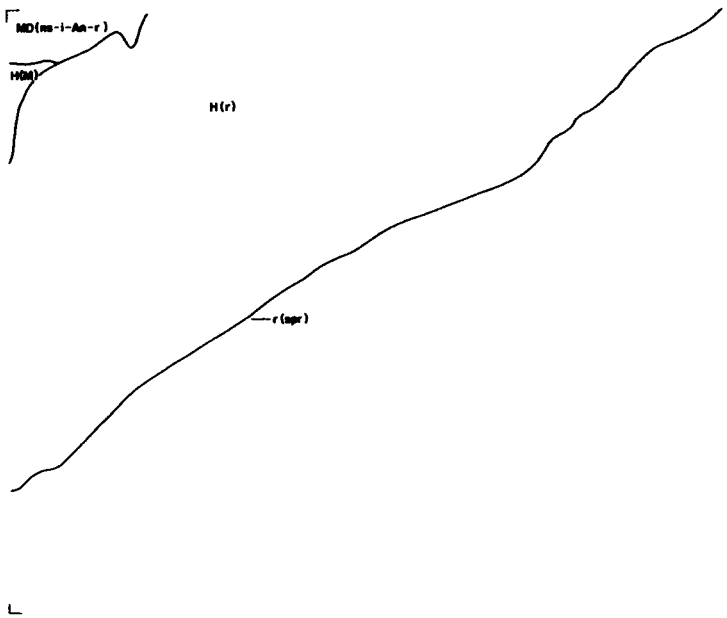

KAHAUALEA
LAVA FLOW OF 1963
Puu Kahaualea
Kalalua
Puu Kauka
CRACK
CRACKS
LAVA FLOW OF 1965
Puu Kamoamoa
HAWAII VOLCANOES NATIONAL PARK
KAMOAMOA
KAUKA HOMESTEADS
KAIMU
MAKENA
HALAPANA
KUPAHUA HOMESTEADS
KUPAHUA
KAUNAOA
KAPAAHU
TRAIL
JEEP
155°07'30"
5'
2'30"
155°00'
19°22'30"
25'
MILE
FEET
KILOMETER

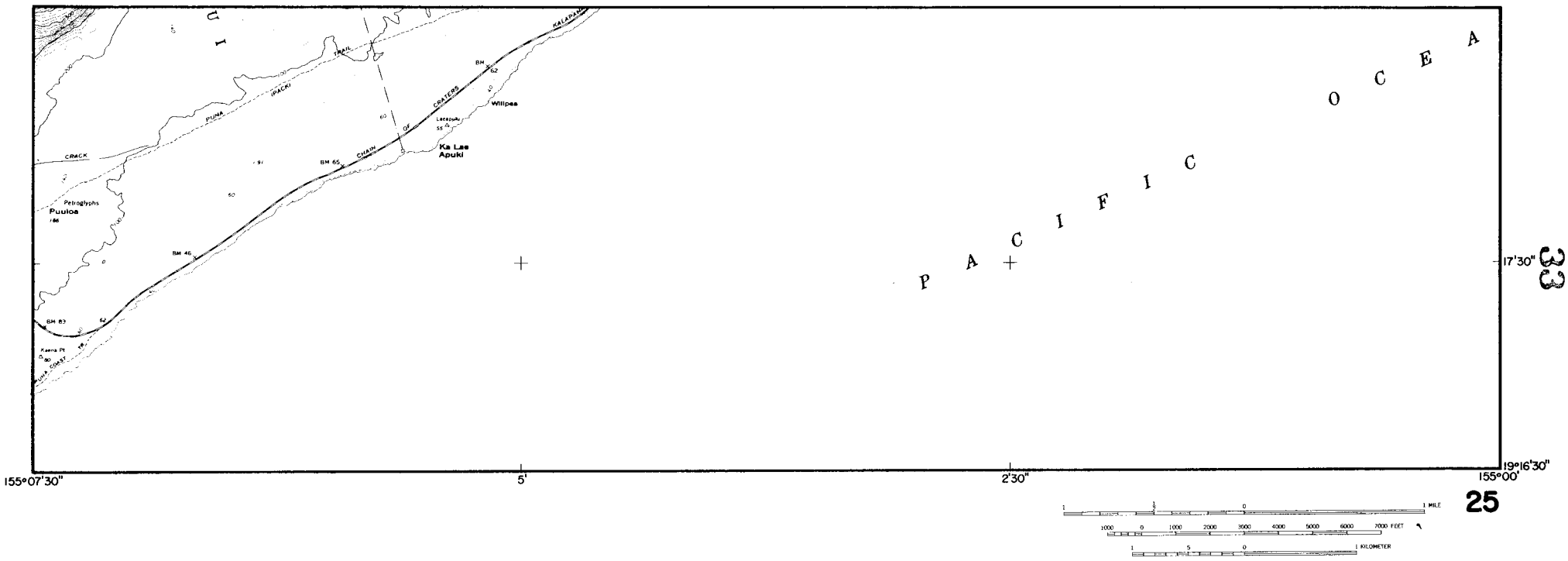
31

23




24
155°
19°22'30"
20'
2'30"
5'
155°07'30"
HAWAII VOLCANOES NATIONAL PARK
KAMOAMOA
LAEAPUKI
PANAUIKI
KAHAUALEA
POUPOU
PULAMA
KAPAAHU
KAUNALOA
Kupapau Point
Queens Bath
Waikupanaha Pond
Visitor Center
Wahaula Heiau
Kamokuna
Kamoamoa (Site)
Moa Heiau
Campground
Puu Manawalea
Laeapuki
Rock Walls
LAVA FLOW
ROCK WALL
CRACK
JEEP TRAIL
KALAPANA TRAIL
1 MILE
1 KILOMETER


MD(ms-i-As-r)
H(r)
r(spr)


PACIFIC OCEAN
Petroglyphs
Puuloa
Ka Lae
Apuki
Willipes
CRACK
TRAIL
PUNA
(BACK)
CRATERS
CHAIN
OF
KALAPANA
BM 65
BM 46
BM 83
BM 62
Kaena Pt
155°07'30"
5'
2'30"
155°00'
19°16'30"
17'30"
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER

THE MAP SYMBOLS

The symbols used (TABLE 1) on the vegetation maps prepared as overlays of the aerial photographs are derived from the names of genera or other predominant surface cover. They are usually in two parts, a front symbol of letters indicating the more obvious stand or surface features and an attribute symbol added in parentheses after the front symbol. The attribute symbol denotes a finer variation. More systematically, a front symbol indicates a major cover type, an attribute symbol, a variation within the cover type, commonly recognized by a change in the subdominant species. For example, oM(C) stands for open Metrosideros forest with Cibotium, and oM(G) stands for open Metrosideros forest with Gleichenia, the false staghorn fern. There are 28 front symbols and 28 attribute symbols. Symbols denoting species are capitalized abbreviations of the generic names. Symbols denoting other vegetational or surface features are also similar simple abbreviations, but in lower case. Examples of lower case symbols are, ns native shrubs, it introduced trees, or r rockland (i.e., lava flows with little or no vegetation).

There are situations with no obvious dominance of the above named floristic structural or surface criteria at the map scale used. Such situations are denoted by hyphening of front symbols. For example, mx-ns represents mixed grass cover with native shrub communities, or cM-An implies closed Metrosideros groves interspersed with Andropogon grassland. Hyphens between attribute symbols (appearing in parentheses) are inserted merely for better readability.

Vegetation boundaries are not always clearly indicated in the field or on aerial photographs. The drawing of vegetation boundaries across a larger terrain requires constant decisions. In a few instances, a boundary decision could not be made because the spatial vegetation changes were only very gradual or continuous. Such continua were recognized by overprinting of the symbol combination in the place that seemed to most

TABLE 1. Symbols used in the vegetation map for Hawaii Volcanoes National Park. The symbols are largely abbreviations of the generic names of species. For example, a front symbol "oM," indicating open Metrosideros forest might be combined with an attribute symbol, such as "(Sa)" indicating a scattering of Sapindus occurred with the Metrosideros. Often more than one front or attribute symbol is combined. In use and in the following alphabetic list the attribute symbols are enclosed in parentheses. These symbols were recorded on the transparent overlays made to correspond to the aerial photographs.

(Ac)-	Scattered Acacia koa
AcSaM-	Mixed Acacia koa-Sapindus-Metrosideros forest
(ad)-	Admixed trees in lower story (Myrsine lessertiana, Myoporum, Coprosma rhynchocarpa, Cheirodendron, Pelea, etc.) and arborescent shrubs (Pipturus, etc.)
Al-	Forest dominated by Aleurites moluccana
(Al)-	Scattered Aleurites
An-	Andropogon grassland (includes A. virginicus and A. glomeratus)
(An)-	Andropogon
ash-	Ash deposits with little or no vegetation
(ash)-	Much barren ash
C-	Cibotium tree fern forest
(C)-	Cibotium
Ch-	Dense Chrysopogon-Cynodon grassland on loess-like, yellow ash (Puu Kaone, map sheet 15).
clf-	Closed mixed lowland forest, mostly fragmented by urbanization and strongly modified and variable from tree planting (Mangifera, Samanea, Aleurites, Cocos, Pandanus, Psidium guajava, Thespesia, Schinus, etc.)
cls-	Closed lowland scrub, mostly low-growing
cM-	Closed Metrosideros forest
E-	Eragrostis tenella grassland
(E)-	Abundant annuals, Eragrostis tenella and Bulbostylis capillaris

TABLE 1. (continued)

(e)-	Abundant epiphytes or lianas (*Astelia*, *Freycinetia*, *Cheirodendron*, mosses and liverworts). Symbol appears in exponential position, i.e., M^e = *Metrosideros* with epiphytes.
fu-	Fumarole areas with dwarf shrubs, *Andropogon virginicus*, *Nephrolepis*, *Gleichenia*, and barren ground
(G)-	*Gleichenia*
H-	*Heteropogon contortus* grassland
(H)-	*Heteropogon contortus*
(i)-	Introduced shrubs (*Psidium guajava*, *Stachytarpheta jamaicensis*, *Lantana*, *Cassia* spp., *Solanum* spp., etc.)
it-	Stand composed of introduced trees
(it)-	Introduced trees (*Eucalyptus*, *Jacaranda*, etc.)
(L)-	Lichens (*Cladonia* spp., *Stereocaulon*, etc.)
(ls)-	Sprawling or short lowland scrub (*Waltheria*, *Osteomeles*, *Cassia leschenaultiana*, *Indigofera*, *Cassia*, etc.)
lsi-	Mixed lowland scrub composed largely of introduced species
(M)-	Scattered, old *Metrosideros*
MAc-	Mixed *Metrosideros*-*Acacia koa* forest
MAl-	Mixed *Metrosideros*-*Aleurites* forest (the latter scattered) with other mesophytic forest tree species (*Myrsine lessertiana*, *Santalum*, etc.)
MD-	Mixed *Metrosideros*-*Diospyros* forest, almost always open, with other dryland forest species (*Antidesma*, *Canthium*, etc.)
(Me)-	Abundant *Melinis* patches
mx-	Mixed grassland (mxg = grazed)
(mx)-	Mixed grass (above 4000 feet elevation)

TABLE 1. (continued)

(N)-	Nephrolepis patch communities on a'a lava
ns-	Native shrubs (includes Styphelia, Vaccinium, Dodonaea, Dubautia, Coprosma ernodeoides, Metrosideros, Myoporum, Wikstroemia, Sophora, etc.)
(ns)-	Native shrub (Styphelia, Dodonaea, etc.)
o-	Open (only used in combinations)
olf-	Open mixed lowland forest, mostly fragmented by urbanization and strongly modified and variable from tree planting (Mangifera, Samanea, Aleurites, Cocos, Pandanus, Psidium guajava, Thespesia, Schinus, etc.)
ols-	Open lowland scrub, mostly low-growing
oM-	Open Metrosideros forest
P-	Prosopis forest
(poik)-	Poikilophydrous (i.e., xerophytic) plants (Kau Desert; map sheets 13-15)
r-	Lava flows with little or no vegetation (r for rockland)
(R)-	Scattered Rhacomitrium moss
(r)-	Much barren lava
(Sa)-	Scattered Sapindus
scM-	Metrosideros scrub
(scM)-	Metrosideros scrub, scattered
(So)-	Scattered Sophora
spr-	Salt-spray and other shore communities
(spr)-	Salt-spray and other shore communities
(T)-	Tricholaena rosea grass patches
x-	Cleared, cultivated or strongly modified areas that have not been left for long enough to establish recognizable vegetation types
(x)-	Much modified by man

adequately characterize the variation. This resulted in the oddity in a few cases that a vegetation segment (designated by a boundary) may show more than one different symbol. For example, a sparsely vegetated lava flow on Mauna Loa (near 11,000 ft elevation) may grade from r (meaning rockland with almost no plant life) to r-r(R) (meaning rockland with very sparsely scattered moss colonies of Rhacomitrium lanuginosum) within the same map segment. Wherever different symbols occur within the same boundary, the symbols denote only minor spatial variations or vegetation changes.

SUMMARY OF MAJOR VEGETATION TYPES

The mapped vegetation units may be called "dominance-types" (sensu Whittaker 1962) since they were identified by the more obvious structural and floristic criteria. The map units were further interpreted by five topographic vegetation profiles (for a full description see Mueller-Dombois 1966:396-441; for a brief overview of the profiles see Mueller-Dombois 1972:22 ff.).

For the purpose of this report it seems adequate to provide a summary of the quantitatively and qualitatively more important cover types in the Park. These are here referred to as major vegetation types. The map sheets show many additional units, which may be interpreted as variations of the major vegetation types. The symbol combinations indicate their similarity to the major cover types. The approximate height limit used to separate "scrub" from "forest" was 5 m. The distinction between "open" and "closed" forest was made at approximately 60% crown cover.

In the following tabulation 31 major vegetation types are summarized under six environmental sections with differing macroclimates. The vegetation types are further indexed by map symbol and map sheet number.

I. ALPINE ENVIRONMENT: Dry, cool climate (500-750 mm rainfall/yr; 6°-9.5°C mean air temperature) with daily night-frost at surface. Vegetation types on upper east

slope of Mauna Loa above 8,500 feet (2590 m) elevation.

Vegetation type	Map symbol	Map sheet
1. Rhacomitrium moss desert (i.e., old lava flows [rockland] with scattered moss colonies)	r(R)	1-5
2. Vaccinium--Styphelia lowscrub desert (i.e., old lava flows with scattered low-growing native shrubs)	r(ns)	2-5
II. SUBALPINE ENVIRONMENT: Summer-dry climate (± 1000 mm rainfall/yr; 9.5°-12°C mean air temperature) with frequent clouds near ground. Vegetation types on east slope of Mauna Loa between 8,500 - 6,700 feet (2590 - 2042 m) elevation.		
3. Open to closed globose scrub. Often several shrub species (Vaccinium, Styphelia, Dodonaea) aggregated into clumps	ns	3-6
4. Globose scrub with scattered Metrosideros trees (i.e., treeline ecosystem)	ns(M)	3-5
5. Open Metrosideros scrub-forest with scattered Sophora trees	oM(So-ns)	4-5
III. MONTANE SEASONAL ENVIRONMENT: Summer-dry climate (1100 - 1600 mm rainfall/yr; 12°-17°C mean air temperature) with frequent clouds near ground. Vegetation types from end of Mauna Loa Strip Road to Halemaumau area from 6,700 -3,800 ft elevation.		
6. Mixed grassland with native shrubs (dominated by Styphelia tameiameiae) and scattered or grouped trees of Acacia koa, Sophora chrysophylla and Metrosideros collina(i.e. mountain parkland ecosystem)	mx-ns(AcSOM)	4-5, 12-13

Vegetation type	Map symbol	Map sheet
7. Savanna of mixed tall-grass with scattered trees Acacia, Sapindus and Metrosideros /(no Styphelia shrub communities)	mx-AcSaM	12
8. Mixed Acacia-Sapindus-Metrosideros forest with lower-story trees and arborescent shrubs (Kipuka Ki and Puaulu forests)	AcSaM(ad)	12
9. Open Metrosideros-lichen forest with native low shrubs (i.e., mostly low-stature Metrosideros forest on pahoehoe lava with ash)	oM(ns-L)	12-13
10. Metrosideros scrub-forest with native shrubs (i.e., lichens not dominant; often on a'a lava in this climate)	scM(ns)	12-13
IV. MONTANE RAIN FOREST ENVIRONMENT: Humid climate without pronounced dry seasons (1800-3000 mm and more rainfall/yr; 12-20°C mean air temperature). Vegetation types from Kilauea and Olaa Forest Reserves to Napau Crater area, from 5,500 to 1,500 ft (1676 - 457 m) elevation.		
11. Mixed Acacia koa-Metrosideros forest with arborescent shrubs and Cibotium tree ferns	AcM(ad-C)	11-12
12. Closed Metrosideros-Cibotium forest	cM(C)	12-13,19-21, 23-24
13. Open Metrosideros-Gleichenia forest	oM(G)	20-21
14. Open Metrosideros-Cibotium-Gleichenia forest	oM(C-G)	20-21
15. Open Metrosideros-Cibotium forest	oM(C)	13, 19-20,23
16. Cibotium tree fern forest with scattered old Metrosideros trees that are covered with epiphytes	C(M^e)	11-12, 18

Vegetation type	Map symbol	Map sheet
17. Disturbed Metrosideros scrub-forest with Gleichenia fern and Andropogon grass patches	scM(G-An)	19-21, 23
18. Open Metrosideros-Gleichenia-Andropogon forest with scattered Aleurites moluccana trees. Occurs in submontane humid to summer-dry transition climate in eastern part of Park (from 1500-2000 feet elevation; 457-610 m)	oM(Al-G-An)	23-24
V. SUBMONTANE SEASONAL ENVIRONMENT:		
A. Summer-dry climate of lower altitudes (from 1000-3000 feet elevation; 305-914 m) on the south slope of Kilauea. Annual rainfall from 1400 to 2200 mm.		
19. Open Metrosideros-Andropogon forest with native shrubs	oM(ns-An)	13-14, 20-21, 24
20. Andropogon savannah	An(ns-M) and An(ns-i)	14-15, 21-22
21. Native scrub with introduced shrubs, Andropogon grass and scattered old Metrosideros trees	ns(i-An-M)	21-22, 24
22. Open Metrosideros-Diospyros forest with native and introduced shrubs Andropogon grass and rock-outcrop	MD(ns-i-An-r)	21-22, 24-25
23. Very open Metrosideros-Diospyros forest, mostly on barren a'a lava	MD(r)	15
B. Summer-drought climate with strong winds in west-central part of Park; Kau Desert (from 1500 - 3700 feet elevation; 457 - 1128 m). Annual rainfall from 800-1400 mm.		

Vegetation type	Map symbol	Map sheet
24. Extremely sparse xerophytic vegetation (including poikilohydrous ferns) on lava rock-outcrop and shifting ash dunes	r-ash(poik)	13-15
VI. COASTAL LOWLAND: Warm-tropical climate, mean air temperature 23°C, from summer-drought (west) to subhumid (east). Mean annual west-east rainfall gradient from approximately 700 to 1700 mm.		
25. Eragrostis tenella grassland*	E(r) and r(E)	9, 15-16, 22
26. Heteropogon contortus grassland	H, H(r) and r(H)	9, 22, 24-25
27. Heteropogon grassland with low shrubs, mostly introduced (Indigofera, Waltheria, Cassia leschenaultiana)	H(ls-i)	22, 24
28. Widely scattered old Metrosideros trees on nearly barren lava, mostly on a'a	r(M)	15-16, 22
29. Mixed lowland scrub (with native species: Canthium odoratum, Wikstroemia phillyraefolia and Diospyros ferrea and introduced shrubs: Schinus terebinthifolius, Eugenia cumini, Psidium guajava, Pluchea odorata)	ls(i), lsi(E-H)	15, 22, 24
30. Open mixed lowland forest (Mangifera indica, Samanea saman, Aleurites moluccana, Cocos nucifera, Pandanus, Thespesia)	olf(i)	24

* This sparsely covered annual grassland has changed in recent years in many places to a perennial Tricholaena rosea (symbol T see map sheet 9) grassland, and the cover is constantly changing due to stepped up goat control measures.

Vegetation type	Map symbol	Map sheet
31. Salt spray and other strand communities	r(spr) and spr	15-16, 22, 24-25

ACKNOWLEDGEMENTS

A major effort was the transfer of the vegetation boundaries from the original transparent air photo overlays to the new transparent topographic map overlays. This work was done by Mr. Tomatsu Nakata, whose skillful art work is herewith gratefully acknowledged. Thanks is also given to Mr. N. Balakrishnan, who helped substantially in the proofreading of the new map sheets.

LITERATURE CITED

Baker, J. K. and D. W. Reeser. 1972. Goat management problems, Hawaii Volcanoes National Park. U.S. Dept. of Interior, National Park Service, Natural Resources Reports, No. 2. 63 p.

Doty, M. S. 1966. The aerial photographs, pp. 11-21. In Atlas for Bioecology Studies in Hawaii Volcanoes National Park. Hawaii Botanical Science Paper No. 2, 507 p.

_____ and D. Mueller-Dombois. 1966. Atlas for Bioecology Studies in Hawaii Volcanoes National Park. Hawaii Botanical Science Paper No. 2. 507 p. (Reprinted as College of Trop. Agric., Hawaii Agric. Expt. Sta. Miscell. Public. 89.)

Mueller-Dombois, D. 1966. The vegetation map and vegetation profiles, pp. 391-441. In Atlas for Bioecology Studies in Hawaii Volcanoes National Park. Hawaii Botanical Science Paper No. 2. 507 p.

_____. 1970. First progress report, Hawaii Terrestrial Biology Subprogram. Hawaii IBP Tech. Rept. No. 1. 144 p.

_____. 1972. Second progress report, Island Ecosystems Stability and Evolution Subprogram. Hawaii IBP Tech. Rept. No. 2. 290 p.

_____ and G. Spatz. 1972. The influence of feral goats on the lowland vegetation in Hawaii Volcanoes National Park. Island Ecosystems IRP/U.S. IBP Tech. Rept. No. 13. 46 p.

NPS. 1973. Draft environmental statement, Natural Resources Management Plan, Hawaii Volcanoes National Park, Hawaii. 69 p. (Final environmental statement, 1974, 67 p. + appendices.)

Newell, C. L. 1968. A phytosociological study of the major vegetation types in Hawaii Volcanoes National Park, Hawaii. M.S. Thesis, Dept. of Botany, University of Hawaii. 191 p.

Rajput, M. A. 1968. Tree stand analysis and soil characteristics of the major vegetation cover types in Hawaii Volcanoes National Park, Hawaii. M.S. Thesis, Dept. of Botany, University of Hawaii. 236 p.

Smathers, G. S. 1972. Invasion, early succession and recovery of vegetation on the 1959 Kilauea Volcanic surfaces, Hawaii Volcanoes National Park, Hawaii. Ph.D. Dissertation, Dept. of Botany, University of Hawaii. 326 p.

_____.and D. Mueller-Dombois. 1972. Invasion and recovery of vegetation after a volcanic eruption in Hawaii. Island Ecosystems IRP/U.S. IBP Tech. Rept. No. 10. 172 p.