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ARCHAEOLOGICAL AND PALEONTOLOGICAL SALVAGE AT BARBERS POINT, OAHU

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ARCHAEOLOGICAL AND PALEONTOLOGICAL SALVAGE AT BARBERS POINT, OAHU

by

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BERNICE P. BISHOP MUSEUM

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ABSTRACT

In 1965, a deep-draft commercial harbor at Barbers Point, Oahu Island was proposed by the U.S. Army Engineer District, Honolulu, in conjunction with the Department of Transportation, State of Hawaii. To mitigate the effect of construction on the cultural resources in the area, an archaeological and paleontological salvage project was conducted during July and August of 1977, by the Department of Anthropology, Bernice P. Bishop Museum, under Contract No. DACW84-77-C-0040 with the U.S. Army Engineer District, Honolulu.

The recommendations given in the report on the 1976 Cultural Resources Survey (A. Sinoto Ms.) were followed in the 1977 salvage project. Only those areas under federal jurisdiction were investigated, however, involving roughly 12% of the area previously surveyed.

The archaeological salvage examined five sites, four previously known and one newly located. Twenty-five portable artifacts (from six archaeological sites and one paleontological site) were recovered, and a set of hydration-rind dates, ranging in the 17th century, were obtained on basaltic glass from one site. Samples of midden, land snails, and soil were collected and analyzed.

The paleontological salvage covered thirteen unmodified sinkhole sites. A large inventory of fossil avifaunal remains was recovered. Especially notable was the discovery of nearly articulated skeletal remains of extinct species in the large, flooded sinkhole located in the limestone quarry. Analysis of birdbone material is still in process.

No evidence of any association between the fossil avifaunal assemblage of extinct birds and cultural remains was revealed.

Although some interpretations for individual sites have been made, based on data recovered during the salvage operations, the number of archaeological sites in the federal project area represented only a small portion (4%) of the total number of sites recorded for Barbers Point. Thus interpretation of these sites in the context of the larger sphere of settlement patterns at Barbers Point has not been attempted. Results of similar investigations, funded by the State of Hawaii for the remaining 88% of the sited area, may allow a more complete understanding of all salvaged sites, as well as of the prehistory of the Barbers Point area.

ACKNOWLEDGMENTS

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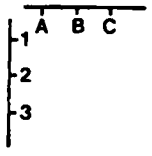
PLANS


Karstic Surface


Sinkhole

Grid System




Upright

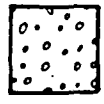

Facing

PROFILES

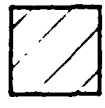

Karstic Substrate

O.B. - Overburden
I, II, III - Stratigraphic Layers


Cultural Layer


Birdbone Laden Layer


Birdbone Pocket


Unexcavated

INTRODUCTION

PRESENT ENVIRONMENT OF THE BARBERS POINT AREA

Located in the leeward coastal lowlands of southwestern Oahu, the Barbers Point project area is part of the Ewa Plain, a former coral-algae calcareous reef that emerged following the post-Pleistocene sea-level subsidence. The topography that usually results subsequent to such geophysical changes is termed karstic (Butzer 1971:204). The Ewa Plain stretches along the coast from Pearl Harbor through Waianae, some portions extending from sea level at the coastline to an elevation of 30 meters at about 5 to 8 km inland. The terrain rises along a gradual slope from sea level to an elevation of about 7 meters, approximately 1 km from the shoreline at the eastern terminus of the project area (Abbot & MacDonald 1970).

Agricultural, residential, and military development has altered much of the characteristic karstic topography of the region. Today, except in the vicinity of Barbers Point, only small, discontinuous stretches of such terrain are still apparent. The Barbers Point terrain is characteristically flat and pitted with sinkholes of various sizes and depths. The substrate is composed of hard, weathered, calcareous material with frequent inclusions of fossilized shell and coral structure, reminiscent of the original aquatic environment. Overlying the substrate are irregular rubble and rock masses resulting from erosion and other weathering action. Discontinuous pockets of alluvial and aeolian soils, which are transported from farther inland, also occur throughout the area (Stearns & Vaksvik 1935). The main soil types in the area are Vertisols and Mollisols (U. Haw. Press 1973). The paucity of basalt and other volcanics suggests that these resources are exotic to this specific area. A more comprehensive discussion of the geology of the Barbers Point area is provided in Appendix I.

The present climate in this zone is generally arid, characterized by abundant sunshine, moderate temperatures and humidity, and persistent tradewinds. The mean annual rainfall is about 20 inches, but there are long periods of drought, especially in summer months. The temperatures range seasonally from a mean maximum of 93° F to mean minimum of 64° F and the mean annual temperature is 73.5° F. The humidity is usually between 60 and 80%. The northeasterly tradewinds predominate, usually at about 4 to 12 mph, but occasionally rising above 25 mph (U. Haw Press 1973).

The dominant vegetation is characteristic of that found in dry, coastal zones (Neal 1965), dominated by hardy exotics, mainly *kiawe* (*Prosopis* sp.) and *koa-haole* (*Leucaena leucocephala*); some Java plum (*Eugenia cuminii*) and mango (*Mangifera indica*) occur in the lower areas. A notable endemic is *wiliwili* (*Erythrina sandwicensis*); other endemic species include *noni* (*Morinda citrifolia*) and ti (*Cordyline terminalis*). Many other shrubs and grasses occur throughout the project area. For a more comprehensive inventory of vegetation see: "Vegetative Survey of Barbers Point Harbor Area," by Dr. Derral Herbst (Appendix B-2 of *Final Environmental Statement, Proposed Barbers Point Harbor,* U.S. Army Engineer District, Honolulu, July 1976), and the Archaeological Research Center, Hawaii (ARCH) botanical survey by Marvin Miura (pending publication). Three endangered floral species are present in this area, as well as several other rare and uncommon plants.

No endangered species of fauna are recorded from the Barbers Point area. The terrestrial fauna present are feral dogs, feral cats, mongooses, mice, and rats. Avian fauna are more abundant, including boobies, egrets, barn owls, pheasants, and herons, as well as smaller common birds such as mynahs, sparrows, doves, and cardinals. (For a more comprehensive inventory of the fauna, see "Fish and Wildlife Agencies," Appendix C-4 in *Draft Environmental Impact Statement for Barbers Point Harbor,* U.S. Army Engineer District, Honolulu, April 1976). A small, red, endemic shrimp, *Halocaridinea rubra* (J. Maciolek, pers. comm.), which commonly inhabits the basal freshwater lens, was found during the salvage project in the flooded sinkhole site, B6-139. The rats and some species of birds may also be endemic.

At present, land usage is limited to industry and agriculture. Several of these activities already threaten the sited areas. The most apparent and adverse of these is Cyprus Hawaiian Cement Corporation's quarrying operation, which has already bulldozed and completely destroyed three sites recorded by Lewis (Sites B6-21, -26, and -27), and more recently damaged portions of Site B6-70 before salvage operations were commenced near Area D.

Kiawe is being cut, apparently for charcoal, in the perimeter of the project area, near some site clusters. Several trees were felled atop sites prior to and during salvage. Although most of the sited areas appear to be relatively

undisturbed, if current activities continue without supervision, more sites will undoubtedly be destroyed.

ARCHAEOLOGY AT BARBERS POINT: BACKGROUND

The first published archaeological record of the Barbers Point area was McAllister's *Archaeology of Oahu* (1933), in which the whole Ewa Plain was dismissed in one paragraph:

> Ewa coral plains, throughout which are the remains of many sites. The great extent of old stone walls, particularly near the Puuloa Salt Works, belongs to the ranching period of about 75 years ago. It is probable that the holes and pits in the coral were formerly used by the Hawaiians. Frequently the soil on the floor of the larger pits was used for cultivation and even today one comes upon bananas and Hawaiian sugarcane still growing in them [McAllister 1933:109].

Accordingly, for many years the area was assumed to be of marginal historic interest, if not devoid of ruins or sites, and was ignored except for infrequent examinations of individual sites that were uncovered by the increasing development of the area.

In 1970, Ernest Lewis, then a graduate student in the Department of Anthropology at the University of Hawaii, conducted a preliminary "on-the-ground" survey under the supervision of Dr. Yosihiko Sinoto, Department of Anthropology, B. P. Bishop Museum, for a graduate seminar paper (Lewis Ms.). Subsequent to this survey the potential archaeological value of this area became apparent.

In 1965 a proposal for a deep-draft harbor was authorized for Barbers Point, Oahu, by the 89th U.S. Congress. During its design phase, preparation for an E.I.S., and planning for cultural resources, the Department of Anthropology, B. P. Bishop Museum, was selected by the U.S. Army Engineer District, Honolulu, to perform contract archaeological investigations. This resulted in a series of integrated projects. The first, a reconnaissance survey, was conducted by Barrera in 1975 (Barrera Ms.), and this was followed by the Cultural Resources Survey, completed in 1976 (A. Sinoto Ms.). Based on the information provided by these surveys, the archaeological data to be recovered in the Barbers Point area was considered sufficiently unique and significant to Hawaiian prehistory that the entire reconnaissance survey area was declared eligible for the

National Register of Historic Places in June 1977, under National Register Criterion "d" (36 CFR Part 60.6), which states that a property "has yielded, or may be likely to yield, information important in prehistory or history." The 1977 salvage was designed to maximize retrieval of all such significant data (see p. 5).

In May 1977, Barbers Point documents were submitted to the Review Board by the State Historic Sites Section, Dept. of Land and Natural Resources, for consideration for the Hawaii State Register of Historic Places.

ARCHAEOLOGICAL AND PALEONTOLOGICAL SALVAGE AT BARBERS POINT

After the completion of the December 1976 survey, with more finalized plans for the harbor, the federal project boundary was specified to include only the immediate harbor dredging area, encompassing roughly 92 acres (Fig. 1). Thus, the 1977 salvage involved approximately 12% of the area surveyed previously and included only 4% of the recorded sites. Over 80% of the federal project area had already been altered extensively by bulldozing for limestone quarrying operations and for the existing barge harbor.

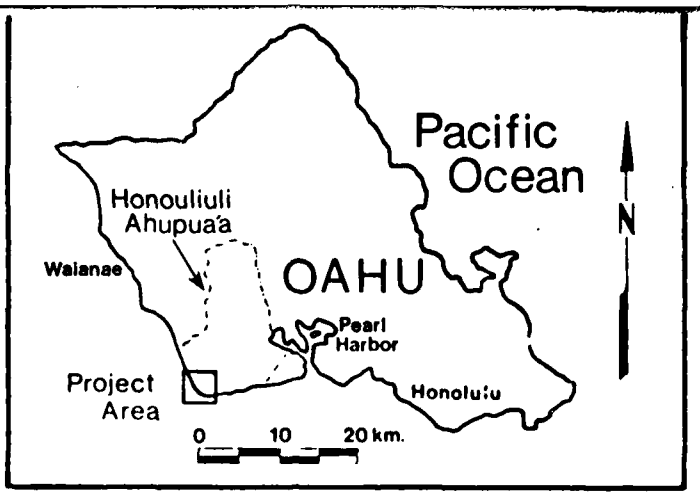
The 1977 project, in compliance with federal law and regulations,* was undertaken following recommendations made in the previous surveys to mitigate the direct impact of land modification activities, specifically bulldozing, blasting, and dredging, on sites located within the harbor dredging boundaries. The purpose of salvage archaeology, where other alternatives are precluded, is to achieve, through scientific methods, maximum recovery and preservation of information about sites. The Research Design for this project was reviewed and concurred with by the State Historic Preservation Office and the U.S. Advisory Council on Historic Preservation.

FOCUS OF RESEARCH

At the completion of Barrera's Cultural Resources Reconnaissance of 1975, 12 new sites had been located (Barrera Ms.); together with those recorded by Lewis (Ms.), a total of 30 sites were known and recorded within the survey area (see Fig. 1). Barrera's reconnaissance provided data necessary to assess the general nature of the cultural resources present and facilitated formulation of recommendations for a more intensive Cultural Resources Survey. This Cultural Resources Survey, completed in December 1976 (Sinoto Ms.), located 68 new sites and revealed that the area had extensive research potential for two major reasons:

*See *Identification and Administration of Cultural Resources* (Draft), ER 1105-2-XX, 9 January 1975; Advisory Council on Historic Preservation, *Procedures for Compliance, Section 106* of *The National Historic Preservation Act of 1966*, Federal Register, Vol. 39, No. 34, Part II, 19 February 1974; National Park Service, (36 CFR Part 66), *Recovery of Scientific, Prehistoric, Historic and Archaeological Data: Methods, Standards and Reporting Requirements, Federal Register*, Vol. 42, No. 19, 28 January 1977 [Proposed]; Vivian et al. 1975; Lipe & Lindsay 1974; McGimsey & Davis 1977.

Fig. 1



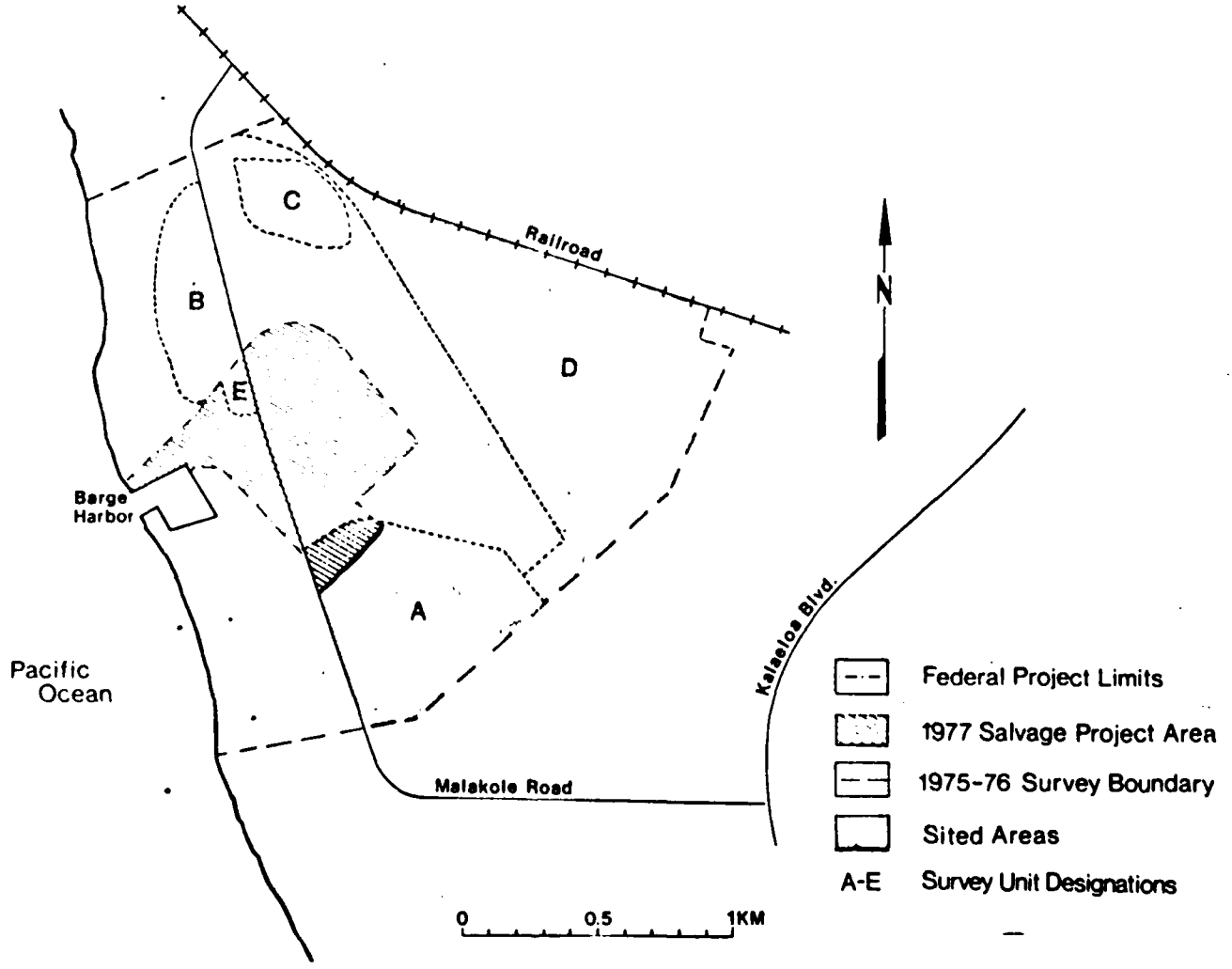


FIG. 1. **BARBERS POINT SURVEY AREA HONOULIULI, OAHU**

1. The presence of sites in a "marginal" area, about which little is known, affords an opportunity to extract data regarding prehistoric adaptation to the unique karstic environment, including prehistoric utilization of resources and land in the area.

2. The presence of fossil birdbone is significant not only paleontologically, but also provokes intriguing questions regarding possible association with prehistoric man.

ARCHAEOLOGICAL SALVAGE

Objectives

For the 1977 salvage project, the following research questions were posed to address the problem of prehistoric adaptation at Barbers Point:

1. What was the prehistoric environment like? Was it really a "marginal" adaptation?
2. What was the subsistence based on? Agriculture, marine resources, both?
3. What sort of population inhabited the area? Permanent, transient, or seasonal transients?
4. What are the dates associated with the sites?

Methodology

The fieldwork was conducted between July 8 and September 6, 1977, in four phases:

1. Reconnaissance, focusing on previously bulldozed areas (quarry and barge harbor)
2. Clearing of sites
3. Mapping
4. Excavation of all cultural sites.

Recording

Site numbers are permanent Bishop Museum numbers; except for B6-138, a new site, all were assigned at the time of the extensive survey (1976). Since the Cultural Resources Report, however, two specific changes have been made:

1. Some site classifications have been revised (i.e., C-shape to U-shape).
2. To accomodate unrecorded but previously tallied sites, numbers formerly assigned to single-unit sites now refer to clusters of spatially proximal features, designated by letters after site numbers (e.g., B6-100A to -100E).

Individual sites have not yet been assigned State Historic Preservation Office numbers.

Mapping

Due to heavy vegetation cover on surface structures and debris deposited in sinkholes, approximately three days were necessary to clear and prepare sites for mapping and excavation. Transit lines were also cleared for mapping purposes.

All location and detailed mapping was done with a Nikon E6 tilting level and a Gurley telescopic plane-table alidade. All measurements were recorded in metric units and orientations were based on magnetic north, using Wilkie prismatic compasses. All elevations were based on Pt. 0+00 (from U.S. Army Corps of Engineers Survey Map, 1976) on Malakole Road, with conversion to metric readings. Survey unit designations were again utilized to define discontinuous sited areas with the current addition of Unit E to the previously established Units A through D. A baseline established along Malakole Road in 1976 was utilized to tie in separate survey units.

Federal Project Limit brass boundary markers set into the ground by U.S. Army Corps of Engineer Surveyors (FPB 1-4, see Fig. 2, folded map at end of report), facilitated accurate boundary determinations.

Excavations

The use of a grid system was found to be only applicable and practical for some sites; thus grids were established at sites with surface structural remains and at some site clusters with spatially proximal features. Grid axes were oriented to the alignment of the site rather than by compass direction. Each grid unit measured one meter square and was assigned an alphabet/number reference designation. The irregularly sided sinkholes were excavated as single units without grids, primarily due to their small floor areas, which made gridding impractical. However, excavation was conducted in quadrants or other sub-units to permit closer controls.

Walls, cairns, and other surface features were systematically dismantled to permit investigation of interior contents, substratum, and construction techniques.

All excavated material was double-sieved in 1/4" mesh screens and then in 1/8" mesh screens, except soil samples, which were recovered and bagged without screening. All bone and sample material was retained and matrix material was discarded.

Survey Results

Only one previously unrecorded archaeological site was located, B6-138, a wall and sinkhole in Survey Unit E, in the thickly vegetated area south of Malakole Road, opposite the former Military Installation compound. Only one site, B6-139, was in the quarry area.

Figure 2 (folded map at end of report) shows locations of all recorded sites in the federal project area. Table 1 shows the distribution of sites and features by type, and Figures 3 and 4 are plan maps of sites in Survey Unit E and in a portion of Survey Unit A.

Table 1. DISTRIBUTION OF FEATURE TYPES IN ARCHAEOLOGICAL AND PALEONTOLOGICAL SITES AT BARBERS POINT (Federal Project Area).

Feature Type	Site No. 50-OA-B6- 70	78	100	119	138	139	140	141	142	143	144	145	146	147	148	Totals
Cairn	3		1													4
Enclosure (Rectangular)				1												1
Sinkhole (Unmodified)			3				1	1	1	2	1	1	1	1	1	13
Sinkhole (Modified)		1														1
Filled Sinkhole	1				1											2
Water-filled Sinkhole						1										1
U-shaped Structure	1															1
Wall			1		1											2
Totals	5	1	5	1	2	1	1	1	1	2	1	1	1	1	1	25

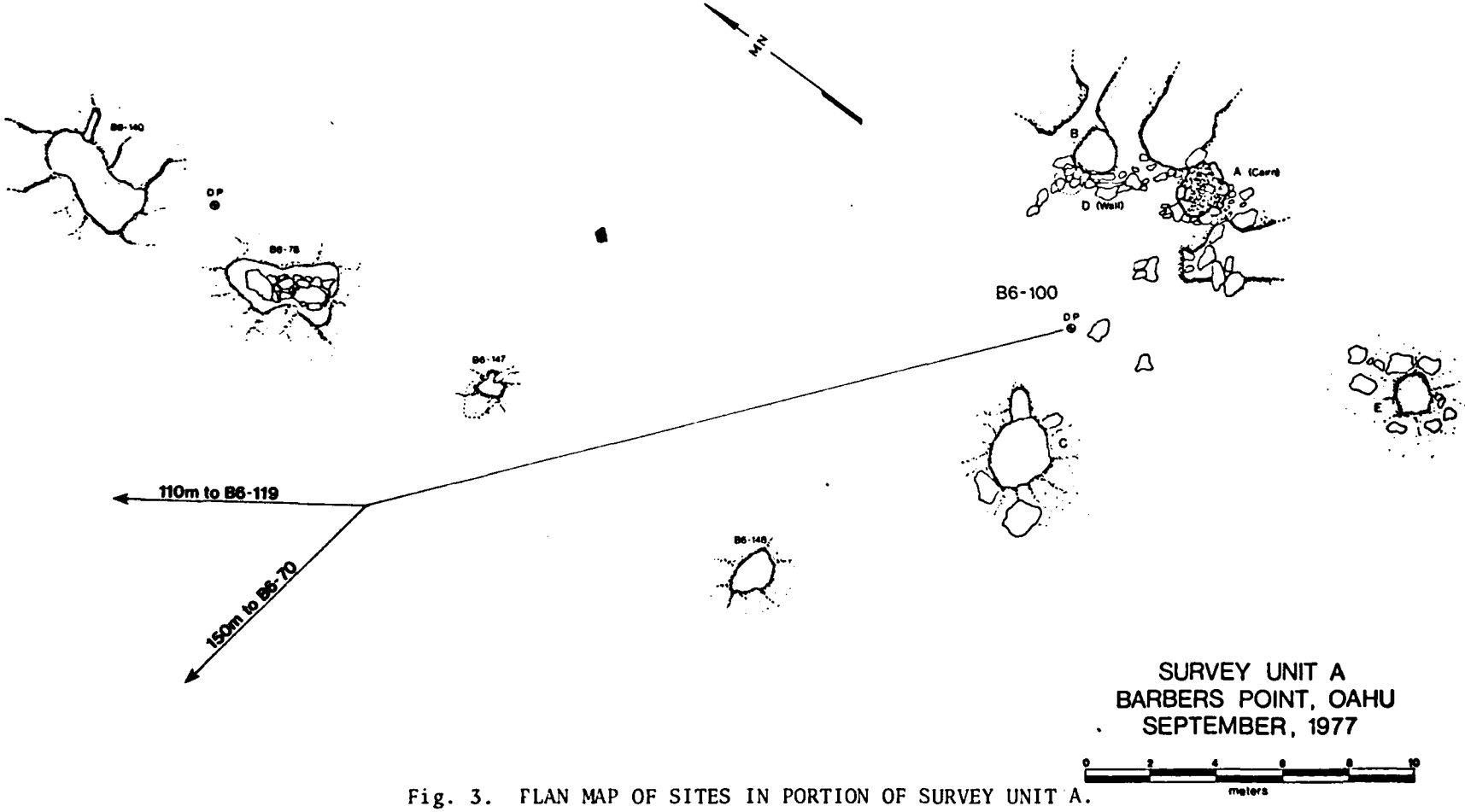


Fig. 3. PLAN MAP OF SITES IN PORTION OF SURVEY UNIT A.

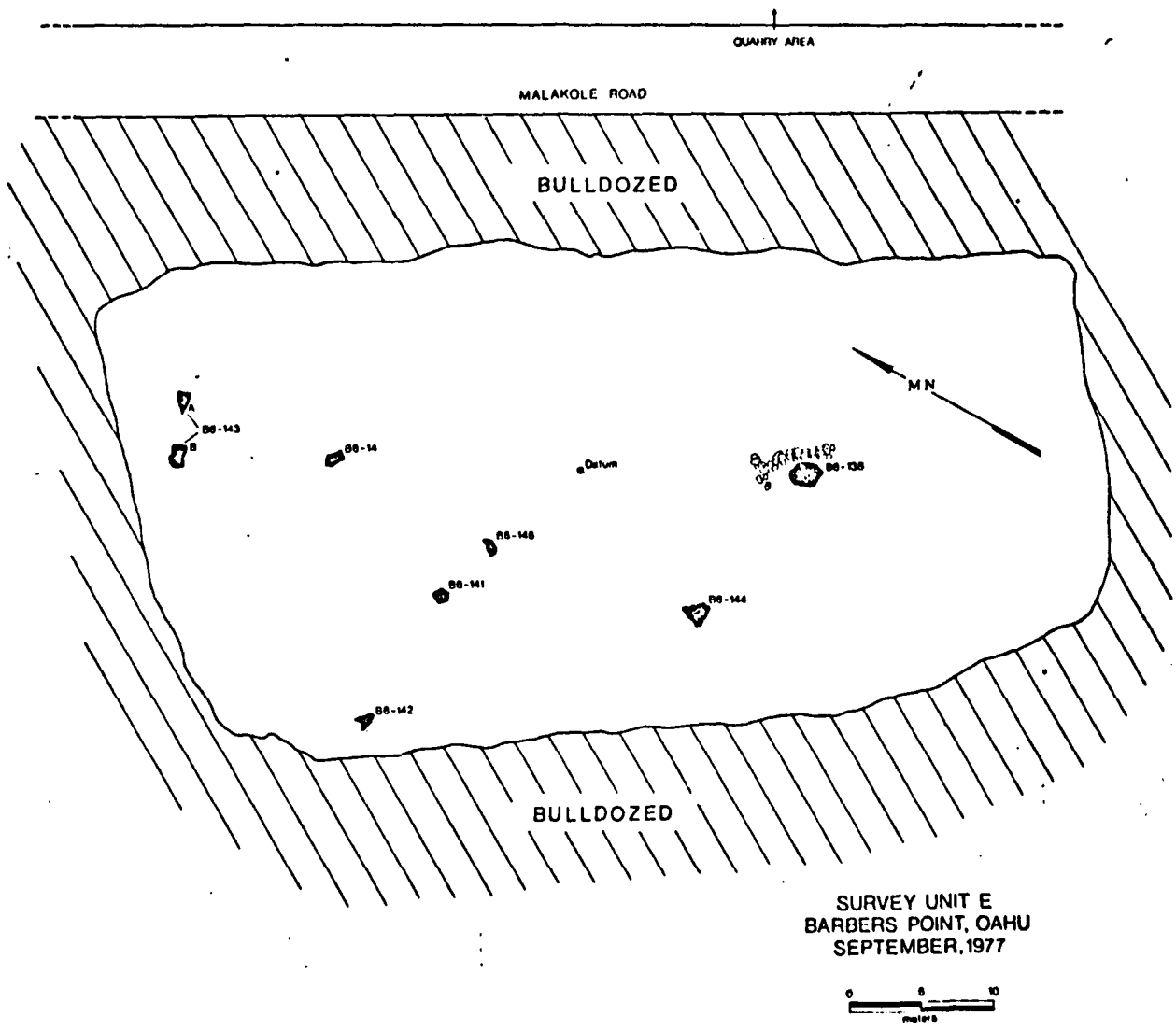


Fig. 4. PLAN MAP OF SITES IN SURVEY UNIT E.

Excavation Results

A total of five archaeological sites, comprising twelve individual features (Table 2) were salvaged. Four of the sites--B6-70, -78, -100, and -119--were previously recorded in Survey Unit A (Figs. 2 and 3). The fifth, B6-138, was recorded in Survey Unit E during the current project (Figs. 2 and 4).

Table 2. CULTURAL SITES AND NUMBER OF FEATURES SALVAGED

Site No.	Survey Unit	No. of Features Salvaged	Area Excavated
50-OA-B6- 70	A	5	14.8 m^2
- 78	A	1	7
-100	A	3	24.1
-119	A	1	19.3
-138	E	2	9.7
	TOTAL	12	74.9 m^2

Results of salvage excavations for individual sites are presented below.

Site 50-OA-B6-70 (Figs. 5 and 6)

Survey Unit: A
Site Type: Five-feature cluster

Description. This cluster, located at the eastern edge of the quarry, consisted of a U-shaped structure, a filled sinkhole, and three cairns. Only the U-shaped structure had been recorded previously. Recent bulldozing of the quarry destroyed a portion of the W wall of the U-shape and pushed rubble and

debris into the site. The U-shape, constructed of stacked and upright limestone slabs, measured 3 m long, 4 m wide, and averaged .60 m in height. The double-faced walls were .8 m thick and the axis was oriented NE by SW, with the opening to the SW. Remnants of irregular slab paving were evident on the surface at the northern interior section of the structure floor. Moderate interior deposit was exhibited prior to salvage excavation. A filled sinkhole, measuring 2.5 by 1.5 m at ground surface, was located 1.5 m NW of the NW wall of the U-shape. A cluster of three crude cairns, located 4 m SE of the SE wall of the U-shape, measured 2.5 m in diameter by .6 m high, 2 m by .6 m,and 1.8 m by .24 m, respectively.

Fig. 5. SITE B6-70, U-SHAPED STRUCTURE, BEFORE CLEARING. View from SW.

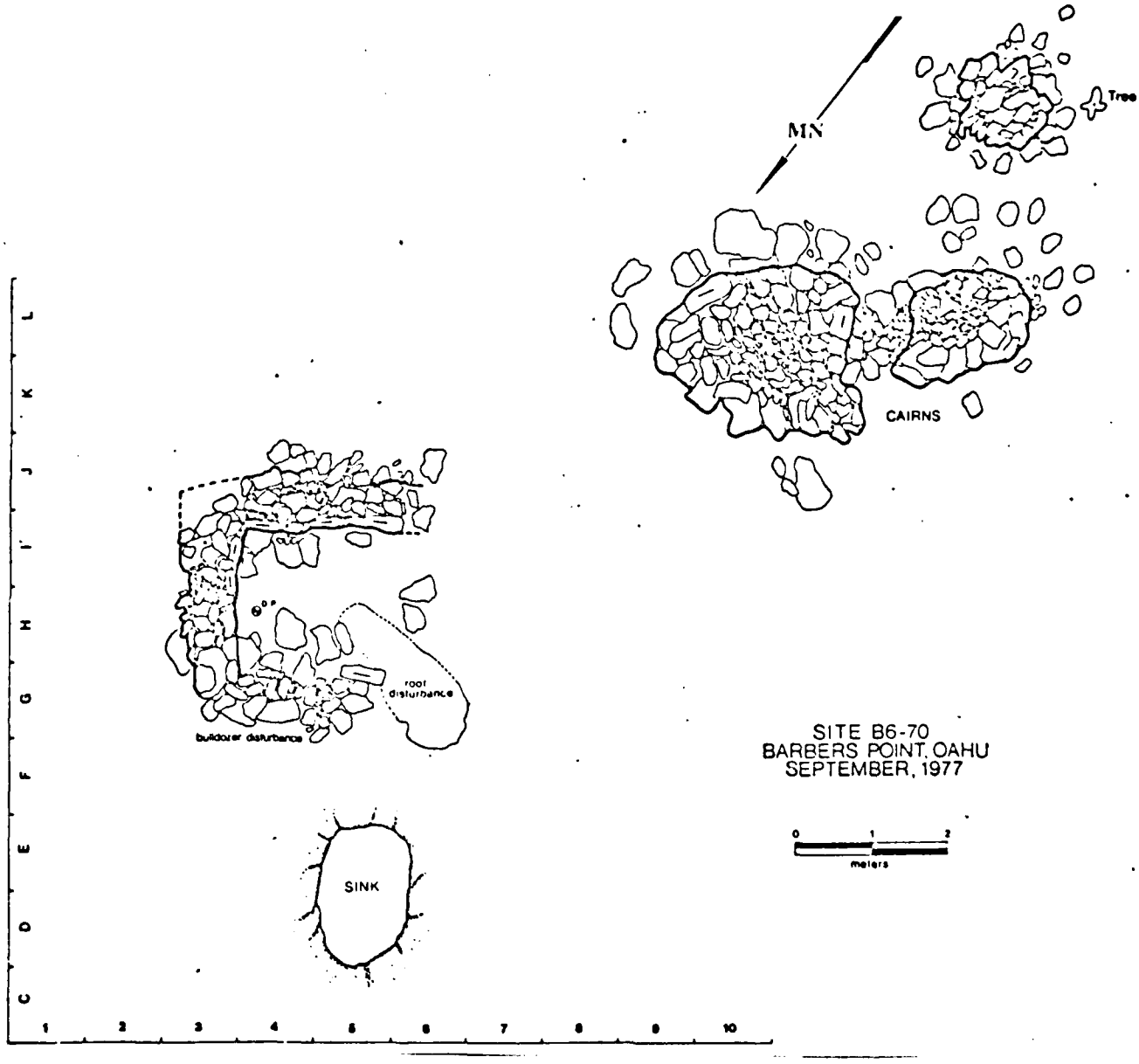


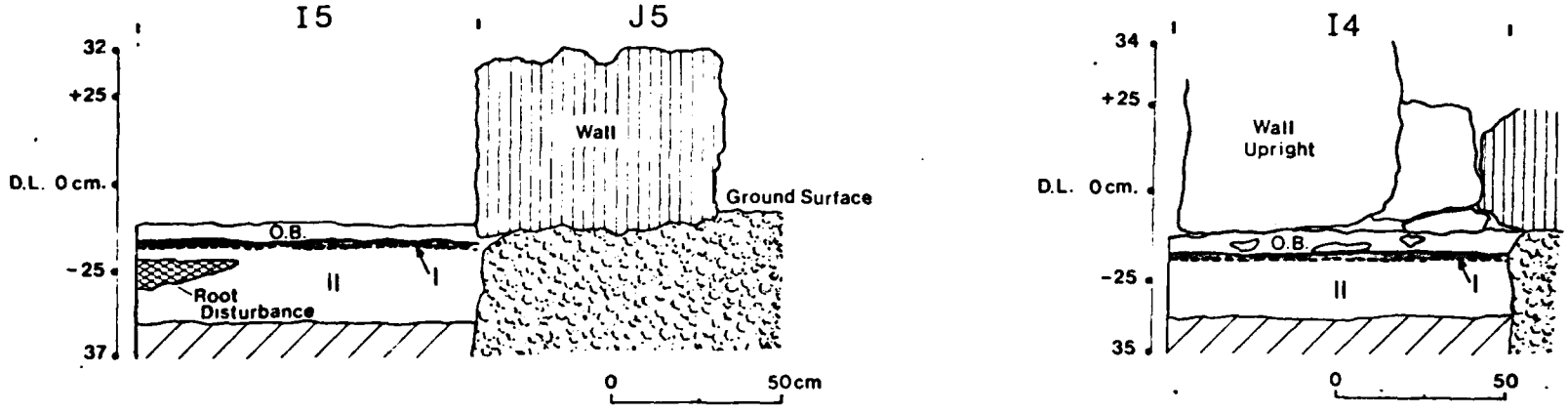
Fig. 6. PLAN MAP OF SITE B6-70, FIVE-FEATURE CLUSTER.

Previous Excavation Results. Test excavation was conducted in the interior of the U-shaped structure during the 1976 intensive survey. A 1-by-.5-m trench was tested, but yielded no artifacts or midden.

Salvage Excavation Results. The three cairns were dismantled and yielded negative results. No internal structures or features were uncovered and all three were built directly atop the solid limestone substratum with no significant soil or organic deposition underlying the structures, except for some recent vegetable material. The presence of this material can be directly attributed to mice and natural filtration downward through the many interstices between the structural fill. Thus, further analysis was judged unnecessary.

Excavation of the entire interior floor of the U-shaped structure showed a shallow deposit averaging 10 cm thick above a sterile horizon in direct contact with the solid limestone substrate (Fig. 7; Table 3). A probable cultural deposit, c. 3 cm thick (Layer I), defined by scattered ash and some midden, was exhibited directly below the overburden and overlying the sterile layer. The occurrence of scattered ash and midden appeared localized near and beyond the opening at the SE portion of the structure. The structure yielded one artifact, a basaltic-glass flake (50-OA-B6-70-H7-1) from Layer I, about 1 m outside and SW of the opening.

After removal of the rubble fill the sinkhole was excavated and revealed an overburden and three layers (Fig. 8; Table 3). The overburden was composed of humus and recent vegetable deposit. Layer I was laden with midden materials, apparently a secondary deposition, and five artifacts were recovered (see p. 18). Layer II included large amounts of birdbone in the top 25 cm and became sterile below. Final identification of the birdbone is still in process; however, several extinct species have been tentatively identified. Although the interface between Layers I and II appeared disturbed and poorly defined, the coloration and matrix material differences, as well as inclusions, defined the layer changes. Below Layer II, a sterile, weathered soil layer (III) overlying solid substratum was encountered.



SITE B6-70, Structure
Profile, North Face

Fig. 7. PROFILES OF NORTH FACE OF U-SHAPED STRUCTURE, SITE B6-70.

Table 3. STRATIGRAPHIC DATA FOR SITE B6-70

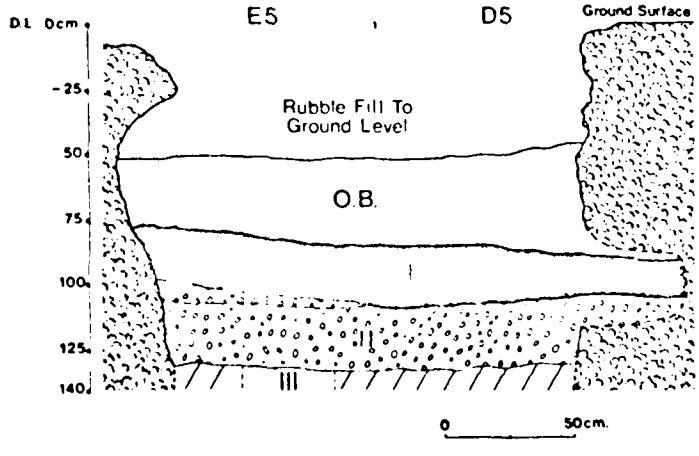
U-shape

Layer	Munsell	Thickness	Soil Type	Content
O.B.	10YR 2/1 black	5 cm	Organic matter	
I	7.5YR 4/2 brown/ dark-brown	3 cm	Aeolian/alluvial	Cultural
II	10YR 7/3 very pale brown	25 cm	Silty leached limestone	Infrequent birdbone

Sink

O.B.	10YR 2/1 black	25-40 cm	Organic matter	Cultural
I	7.5YR 4/2 brown/ dark-brown	25 cm	Aeolian/alluvial	Cultural, esp. midden
II	7.5YR 5/6 strong brown (matrix)	25-30 cm	Aeolian/alluvial	Predom. birdbone
III	7.5YR 5/6 strong brown (matrix)	15 cm	Aeolian/alluvial/ leached silt	Sporadic birdbone

All contacts are relatively well-defined.



SITE B6-70, Sinkhole
Profile, West Face

Fig. 8. PROFILE OF WEST FACE OF SINKHOLE, SITE B6-70.

Artifacts: Six artifacts were recovered from this site. One originated from the U-shaped structure and the rest from Layer I in the sinkhole deposit. All are prehistoric in type, and hydration-rind dates of basaltic glass from this site (see dating section) indicate late-prehistoric origin.

A drilled birdbone fragment from the sinkhole (50-Oa-B6-70-E5-1) holds potential significance. If the bone is identified as an extinct species, it would be the sole indication found of prehistoric associations between cultural activities and the now-extinct avifaunal assemblage.

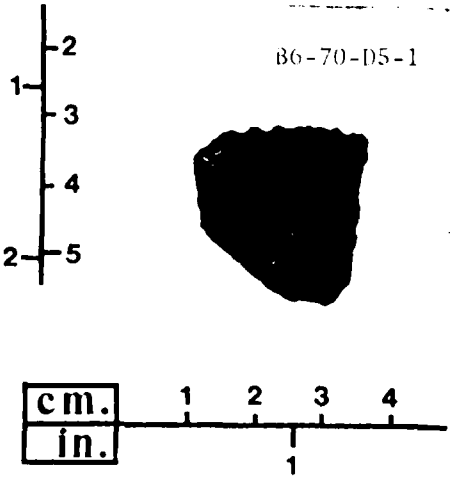
Summary of Artifacts from Site B6-70

U-Shaped Structure

Artifact #: 50-OA-B6-70-H7-1*
Artifact: flake
Material: basaltic glass
Dimensions: *l:* 1.5 cm; *w:* 1.0 cm; *th:* .5 cm
Provenience: 18 cm b.d.** / Layer I / Square H7
Storage location: sent to HMR, Inc. for dating analysis.

Sinkhole

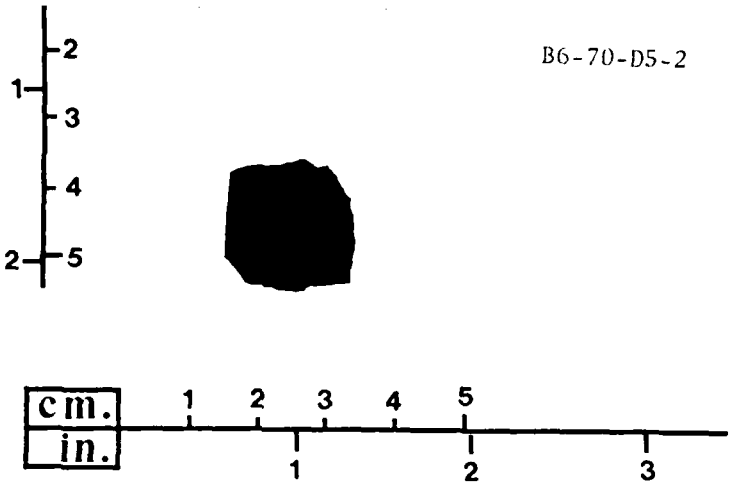
Artifact #: B6-70-D5-1
Artifact: polished chip
Material: hematite
Dimensions: *l:* 2.6 cm; *w:* 2.6 cm; *th:* .85 cm
Provenience: 110 cm b.d. / Layer I / Square D5
Storage location: BPBM, Dept. Anthropology.



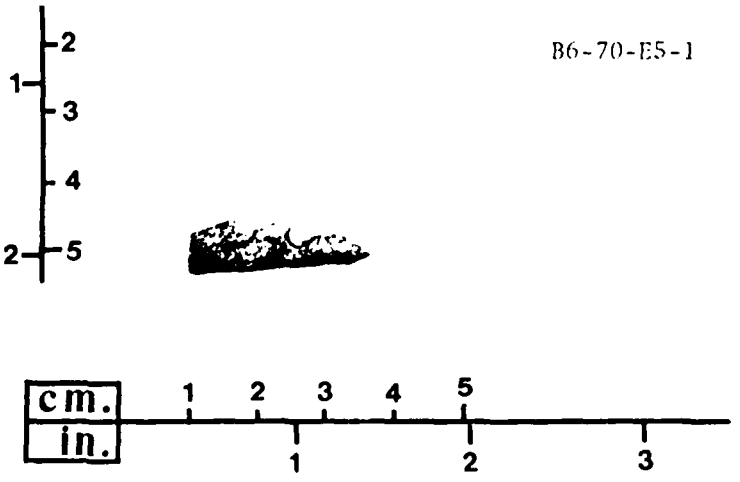
* B.P.B.M. artifact numbers are assigned by adding the provenience and individual artifact number to the site number.
**Below datum.

Artifact #: B6-70-D5-2
Artifact: flake
Material: Basaltic glass
Dimensions: *l:* 1 cm; *w:* .6 cm; *th:* .3 cm
Provenience: 93 cm b.d. / Layer I / Square D5
Storage location: Sent to HMR, Inc. for dating analysis.

Artifact #: B6-70-D5-3
Artifact: adz chip
Material: Basalt
Dimensions: *l:* 19.5 mm; *w:* 19 mm; *th:* 4 mm
Provenience: 93 cm b.d. / Layer I / square D5
Storage location: BPBM, Dept. Anthropology.



Artifact #: B6-70-E5-1
Artifact: drilled bone fragment
Material: Ulna of large bird
Dimensions: *l:* 2.7 cm *w:* 1.0 cm; *th:* .7 cm
Provenience: 114 cm b.d. / Layer I / Square E5
Storage location: BPBM, Dept. Anthropology.



Artifact #: B6-70-E5-2
Artifact: flake
Material: basaltic glass
Dimensions: *l:* 1.2 cm; *w:* .9 cm; *th:* .4 cm
Provenience: 109 cm b.d. / Layer I / Square 5
Storage location: Sent to HMR, Inc., for dating analysis.

Interpretations. The salvage excavations at Site 50-Oa-B6-70 provided data to formulate the following interpretations.

1. The U-shaped structure was probably utilized for habitation, primarily as a sleeping shelter.
   a. Solid-wall construction and orientation against prevailing tradewinds indicates function as human shelter or habitation site.
   b. The occurrence of ash and fire-stained areas suggests small open fires in the structure, but the absence of a stone-lined fireplace or pit infers that cooking and eating was primarily done elsewhere.
   c. The thinness of the cultural deposit indicates a low frequency of activity within the structure.

2. The sinkhole was probably associated with the structure as a refuse pit.
   a. Its size and proximity to the site are conducive to this function.
   b. The nature of the Layer I sinkhole deposit, with substantial amounts of midden largely occurring in homogeneous concentrations that appeared undisturbed after initial deposition, suggests refuse dumping.
   c. Some of the identified constituents of the midden are the same as those from the structure, in smaller quantities (see Tables 11 and 12), especially the bivalve, *Brachidontes cerebristriatus*.
   d. The paucity of midden within the structure and the disturbed condition of the cultural deposit, with scatterings occurring beyond the structure opening, suggests that refuse was swept out of the habitation and probably discarded into the pit.

3. The site was probably not for long-term habitation.
   a. There was a lack of interior features, such as a fireplace.
   b. Amounts and type of midden do not indicate permanent occupation. Pieces and fragments of artifacts were recovered, but no indication of manufacture was evident.

The function of the three cairns is still undetermined and there is no evidence to associate these with the U-shaped structure.

4. The sinkhole was filled with rubble in recent historic times.
   a. Substantial overburden deposition below rubble fill indicates hiatus.
   b. Stratigraphic evidence from other sites (1976 test excavations and 1977 salvage) in the study area exhibits overburden deposition only after the early-historic period.

Site 50-OA-B6-78 (Figs. 9 and 10)

Survey Unit: A
Site Type: Modified sinkhole
Previously recorded.

Description. This site, located 18 m N of B6-100, was a large sinkhole with an opening measuring 2.5 by 1.5 m at ground surface, and the surface of the floor deposit measured 1.9 m deep from ground surface. A crude limestone wall was centrally constructed along the length (NW-SE) of the sinkhole floor, dividing the area into two compartments. This wall measured .5 m high and .8 m

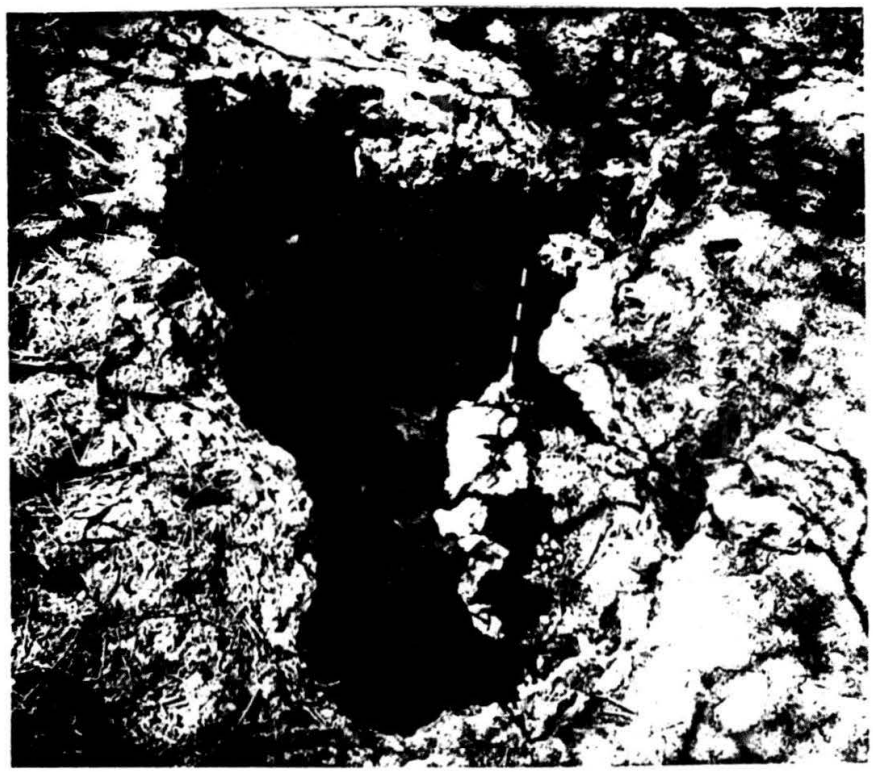


Fig. 9. SITE B6-78, SINK WITH WALLED FLOOR.
View from N.

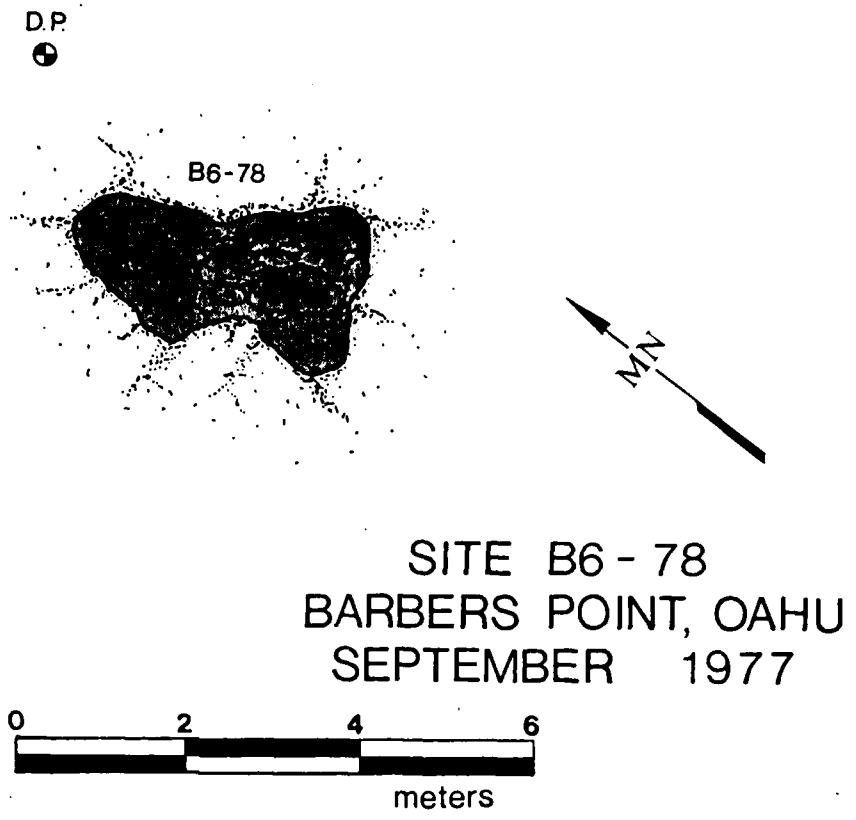


Fig. 10. PLAN OF SITE B6-78, MODIFIED SINKHOLE.

wide, and was constructed of crudely piled limestone slabs and boulders ranging in size from .15 by .2 by .1 to .7 by .5 by .5 m.

Previous excavation results. During the 1976 survey, a test excavation was conducted, adjacent to the slab wall at the southeastern quadrant of the sinkhole floor. No subsurface indication of cultural activities was encountered in the 1-by-.5-m trench. However, a large number of birdbones, with a good representation of extinct species, was recovered from the second layer excavated.

Salvage excavation results. Dismantling of the crude slab wall revealed that it was a superficial structure with no subsurface components. The basal slabs were placed on top of the overburden. None of the slabs were set in or embedded into the soil below. Excavation revealed a heavy deposition and the absence of any artifacts or other cultural elements below the surface of the pit floor. An overburden and six layers were exhibited (Fig. 11; Table 4). Layer I contained large quantities of birdbone; several pieces were tentatively identified in the field as skeletal parts of extinct species. Small pockets of loose, organic material, land snails (see Appendix III), and bird and rat bones were exposed at the interface of Layers I and II. The sporadic occurrence of smaller amounts of birdbone, often in a solitary state, from subsequent layers (below Layer II) seems to indicate secondary deposition from downward filtration from Layer II.

Layers V and VI were sterile layers laden with breccia and weathered, decomposed limestone silt. A freshwater lens appeared at a depth of 4.34 meters below datum, underlying these layers. This lens was found to fluctuate with tidal sea-level changes.

Interpretation. The presence of the crude wall had indicated some cultural activities at this site, but the negative results of excavation, yielding no cultural layer, no artifacts, and no midden, limits cultural associations to the construction of the wall at the surface of the sinkhole floor.

The function of the wall is yet undetermined, though the placement of basal slabs superficially on the overburden strongly suggests recent historical origins. Also, the stratigraphic sequence obtained from other sites in the vicinity (B6-100 and B6-70) indicates that both prehistoric and early-historic cultural activities took place before the deposition of overburden. In 1976, from some of the historic sites tested in Survey Unit B, historical artifacts such as buttons, nails, and others were recovered from layers well below the overburden.

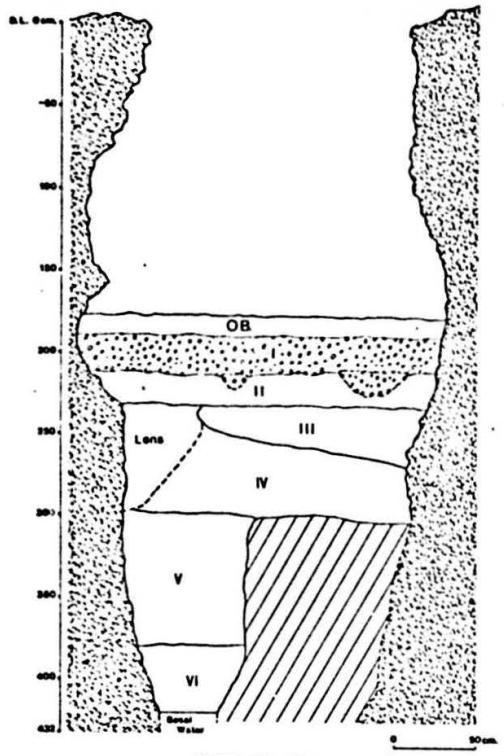


Fig. 11. PROFILE OF NORTH FACE OF SINKHOLE, SITE B6-78.

Table 4. STRATIGRAPHIC DATA FOR SITE B6-78

Layer	Munsell	Thickness	Soil Type
O.B.	10YR 2/1 black	≈ 15 cm	
I	7.5YR 5/4 brown	≈ 25 cm	Aeolian silt/alluvial sediment
II	7.5YR 5/4 brown	≈20-25 cm	Aeolian silt/predominant birdbone
III	5YR 6/6 reddish yellow	≈15-35 cm	Aeolian silt
Lens	7.5YR 4/4 brown/dark-brown		
IV	5YR 5/6 reddish yellow	≈35-50 cm	Aeolian/alluvial and
V		90 cm	Collapsed limestone
VI	10YR 7/3 very pale brown	40 cm	Silty sand, leached limestone

Contacts II-III are somewhat vague due to pockets; others well-defined.
No cultural elements.

Site 50-OA-B6-100 (Figs. 12, 13, 14)

Survey Unit: A
Site Type: Five-feature cluster
Previously recorded as a four-feature cluster.

Description. This site, located 18 m S of B6-78, consisted of three sinkholes, features B, C, and E, with respective diameters of 1.2, 2, and 1 m at ground surface; a low-lying crude wall (D), 4 m long, .5 m wide and .3 m high; and a crude cairn (A) 1.8 m in diameter and .7 m high, located at the southern terminus of the wall.

Fig. 12. B6-100, WALL (D) AND CAIRN (A). View from SW.

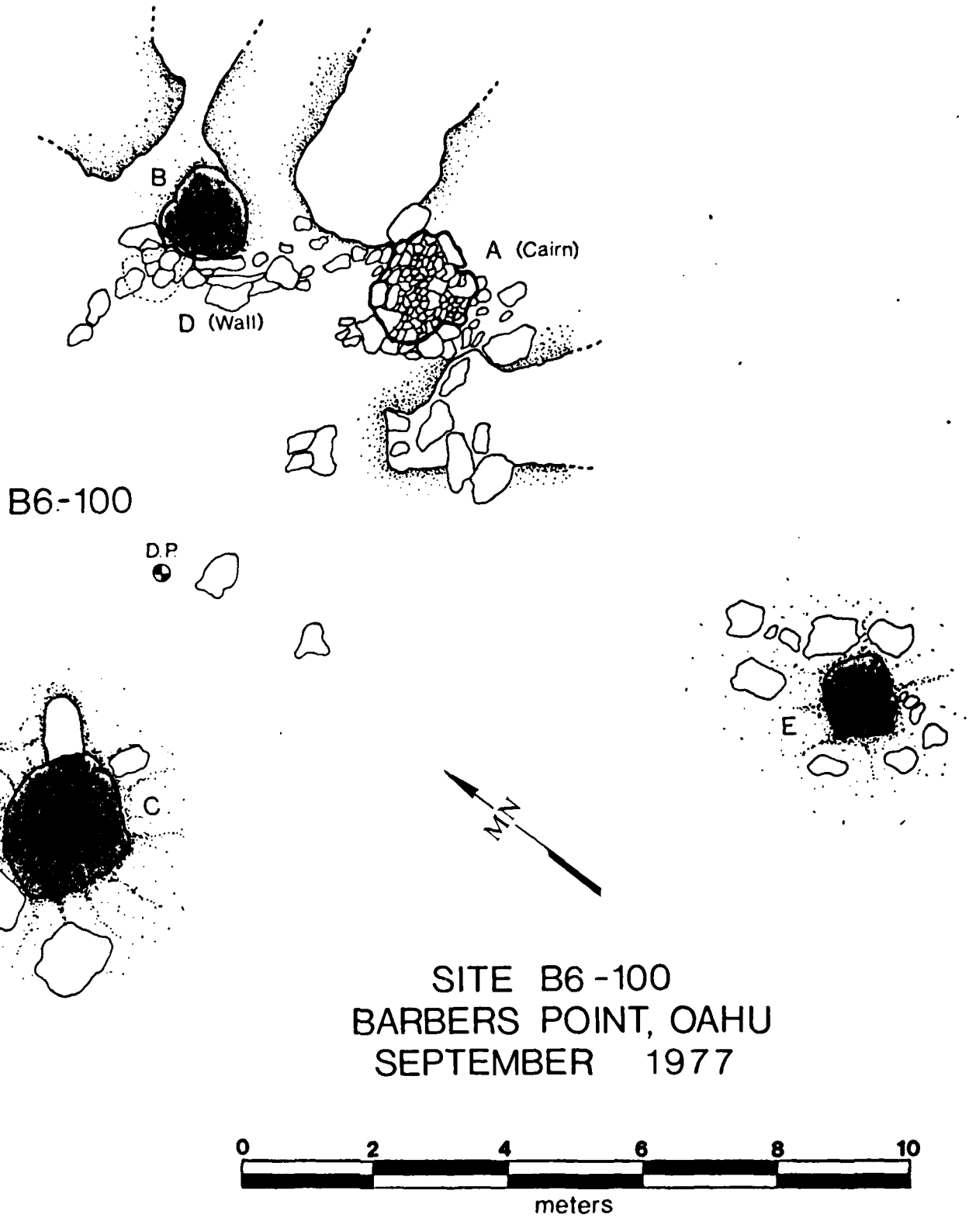


Fig. 13. PLAN MAP OF SITE B6-100, FIVE-FEATURE CLUSTER.

Fig. 14. B6-100C, SINKHOLE.
View from E rim.

Previous excavation results. No subsurface testing was conducted at this site during the 1976 survey.

Salvage excavation results. Features A and D: The cairn (A) and wall (D) were dismantled with negative results. The stacked-slab wall was constructed atop a solid limestone outcrop and exhibited no internal structures or underlying deposit. Dismantling of the cairn revealed rubble-filled construction with

larger slabs at the base and around the exterior surfaces of the structure. No upright slabs were utilized in the construction. The cairn was also built directly over the solid outcrop, with no indication of any soil or other deposits at the base. Further investigation was deemed unnecessary for these features.

Features B and E

Sinkholes B and E exhibited no cultural elements, but faunal remains, including those of a juvenile bovid (identified by Dr. A. Ziegler as most probably a calf) from E, and several extinct avifaunal species from B, were recovered. Formal identification of these species is still pending.

Feature C

Excavation of the floor deposit of this large sinkhole exposed three layers below the overburden (Fig. 15; Table 5), and yielded 13 artifacts, all prehistoric in type. Layer I, c. 10 cm in thickness, was a cultural deposit with small quantities of midden (see Table 13), scatterings of ash, and fire-cracked volcanic rocks (vesicular basalt). Several fire-stained areas were exposed in the upper 3 cm of the cultural layer. A circular fireplace, 30 cm in diameter, centrally located and highly disturbed, was exposed at the top of Layer I. Three firecracked volcanic rocks (vesicular basalt) were left intact surrounding a thin ash deposit. Layer I was only partially intact, however, and the central portions of the site floor appeared to be churned. Action attributable to flood water or animals resulted in much mixing with the overburden. Below Layer I was a deposit heavily laden with birdbone in the upper 20 cm but with decreasing amounts in the lower portions. A probe pit, .5 by .5 m, was dug into the sterile layer (III) underlying Layer II and reached coral rubble at 3.4 meters below datum.

Table 5. STRATIGRAPHIC DATA FOR SITE B6-100C

Layer	Munsell	Thickness	Soil Type
O.B.	10YR 3/2 dark yellow-brown	≈ 10 cm	
I	10YR 4/3 brown/dark brown	≈ 10-12 cm	
II	7.5YR 4/4 brown/dark brown	≈ 30-50 cm	
III	7.5YR 5/6 strong brown	≈ 50 cm	

I - II contact disturbed.

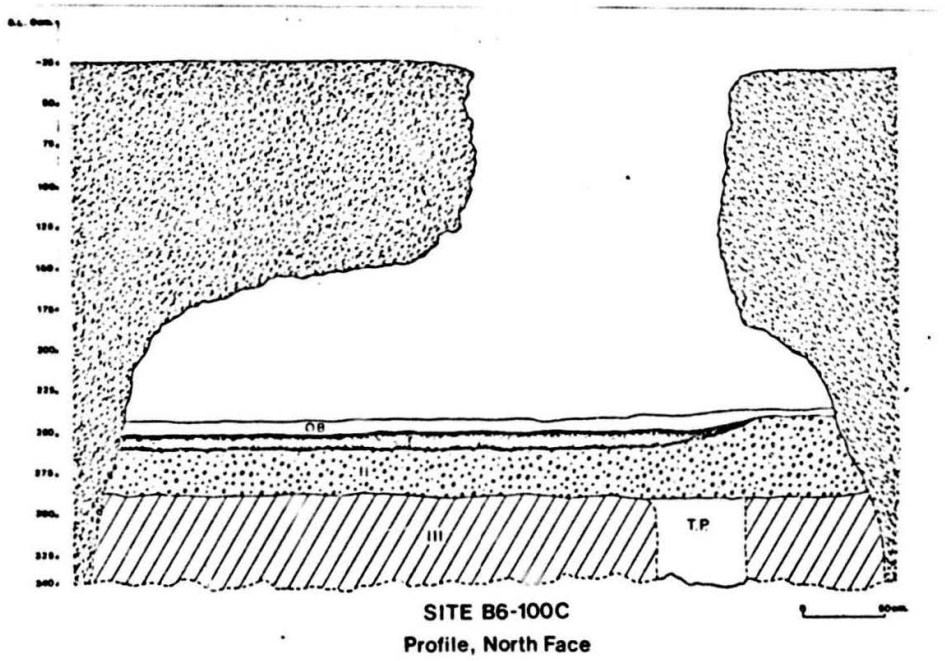


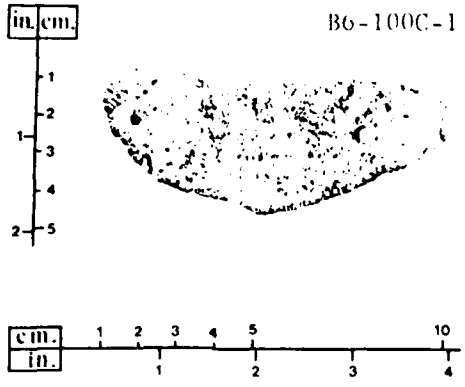
Fig. 15. PROFILE OF NORTH FACE OF SINKHOLE, SITE B6-100C.

Summary of Artifacts from Site B6-100C

Thirteen artifacts, all prehistoric in type, were recovered from this sinkhole, nine from Layer I and four from the surface of deposit, mixed with the overburden in the disturbed zone. Seven were basaltic-glass flakes; these were not datable, however (see p. 61). The unmodified, firecracked basalt rocks were included as artifacts because their presence implies importation from outside of the karstic area.

The five artifacts recovered from the disturbed area were found as a secondary deposit; however, their probable origin in Layer I is indicated by the presence of this single cultural layer in the site.

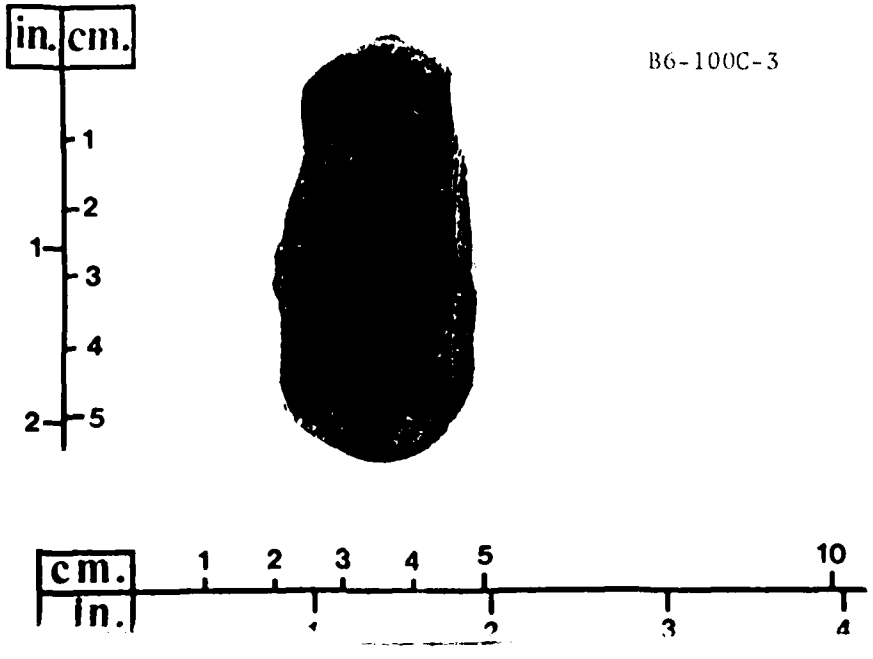
Artifact #: 50-OA-B6-100C-1
Artifact: file
Material: coral (*Porites*)
Dimensions: *l:* 9.1 cm; *w:* 4.1 cm; *th:* 1.7 cm
Provenience: 247 cm b.d. / Layer I
Storage location: BPBM, Dept. Anthropology



B6-100C-1

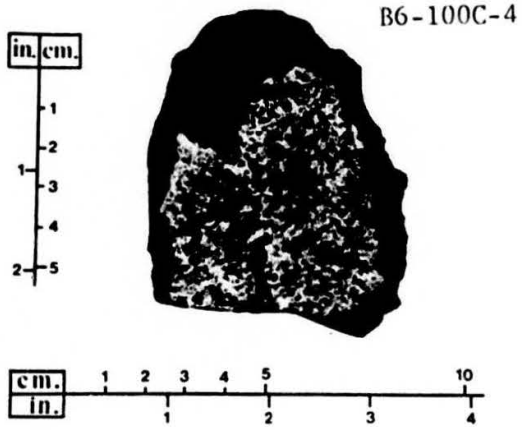
Artifact #: B6-100C-2
Artifact: flake
Material: basaltic glass
Dimensions: *l:* 1.3 cm; *w:* 1.1 cm; *th:* .3 cm
Provenience: 247 cm b.d. / Layer I
Storage location: sent to HMR, Inc.

Artifact#: B6-100C-3
Artifact: modified adz fragment
Material: basalt
Dimensions: *l:* 6 cm; *w:* 2.8 cm; *th:* 1.8 cm
Provenience:
Notes: Appears to have been utilized as pecker; has battered ends.



B6-100C-3

Artifact #: B6-100C-4
Artifact: retouched flake
Material: basalt
Dimensions: *l:* 8.7 cm; *w:* 6.5 cm; *th:* 1.8 cm
Provenience: 242 cm b.d. / overburden
Storage location: BPBM, Dept. Anthropology

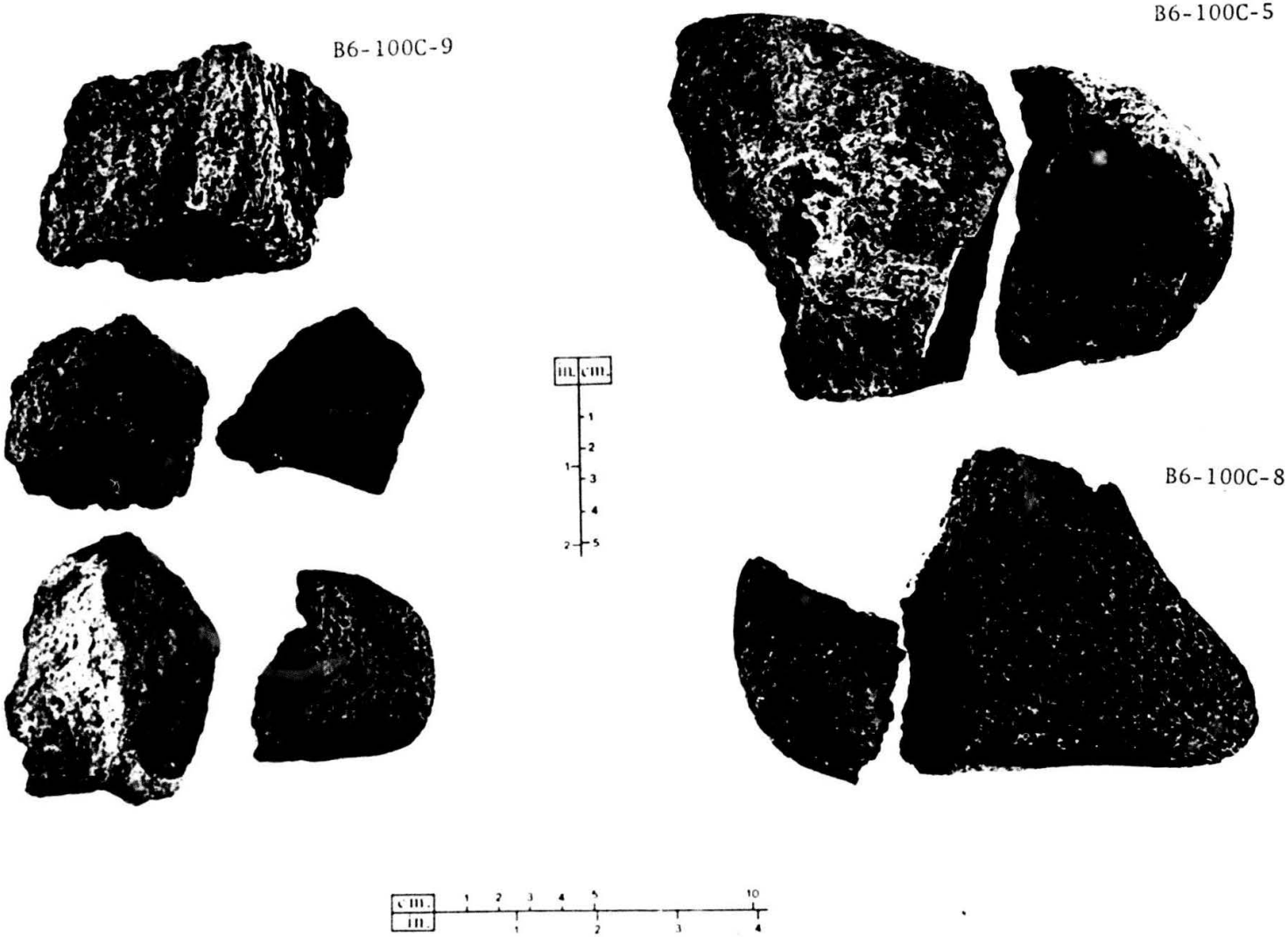


Artifact #: B6-100C-5 (see photo, p. 32)
Artifact: firecracked rock
Material: basalt, vesicular
Dimensions: *l:* 15 cm; *w:* 11 cm; *th:* 8 cm
Provenience: 242 cm b.d. / overburden
Storage location: BPBM, Dept. Anthropology

Artifact #: B6-100C-6
Artifact: flake
Material: basaltic glass
Dimensions: *l:* 1.4 cm; *w:* .9 cm; *th:* .2 cm
Provenience: 247 cm b.d. / Layer I
Storage location: HMR, Inc.

Artifact #: B6-100C-7
Artifact: flake
Material: basaltic glass
Dimensions: *l:* .9 cm; *w:* .7 cm; *th:* .2 cm
Provenience: 246 cm b.d. / Layer I
Storage location: HMR, Inc.

Artifact #: B6-100C-8 (see photo, p. 32)
Artifact: firecracked rock
Material: basalt, vesicular
Dimensions: *l:* 16 cm; *w:* 9 cm; *th:* 6 cm
Provenience: 247 cm b.c. / overburden
Storage location: BPBM, Dept. Anthropology



(See artifact descriptions, pp. 31 and 33)

Artifact #: B6-100C-9 (see photo, p. 32)
Artifact: firecracked rock
Material: basalt, vesicular
Dimensions: various; five pieces
Provenience: 244 cm b.d. / Layer I
Storage location: BPBM, Dept. Anthropology

Artifact #: B6-100C-10
Artifact: flake
Material: basaltic glass
Dimensions: *l:* 1.5 cm; *w:* .5 cm; *th:* .3 cm
Provenience: 248 cm b.d. / Layer I
Storage location: HMR, Inc.

Artifact #: B6-100C-11
Artifact: flake
Material: basaltic glass
Dimensions: *l:* 1.3 cm; *w:* 1 cm; *th:* .5 cm
Provenience: 247 cm b.d. / Layer I
Storage location: HMR, Inc.

Artifact #: B6-100C-12
Artifact: flake
Material: basaltic glass
Dimensions: *l:* 1.1 cm; *w:* .4 cm; *th:* .3 cm
Provenience: 244 cm b.d. / Layer I

Artifact#: B6-100C-13
Artifact: flake
Material: basaltic glass
Dimensions: *l:* 1.0 cm; *w:* .7 cm; *th:* .3 cm
Provenience: 247 cm b.d. / Layer I
Storage location: HMR, Inc.

Interpretations. No cultural elements were present in the two sinkhole features B and E, eliminating direct association with any of the other features including a refuse pit function. Thus, although they are features included in this site cluster due to their proximity to the other cultural features, they will be considered paleontological sites in context and in content.

Surface cultural features A and D, cairn and wall, were dismantled with negative results. No determination of function or association with feature C, the large sinkhole, can be made.

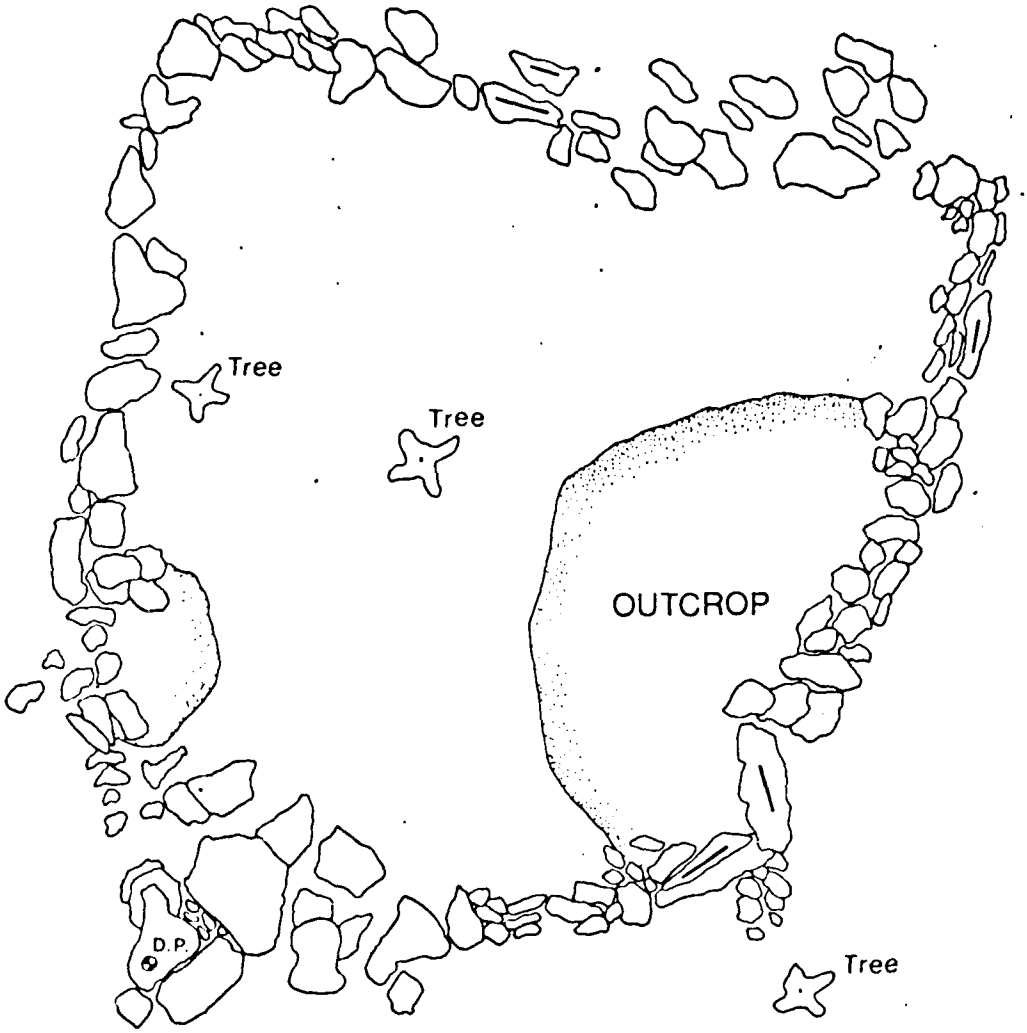
Feature C, the large sinkhole, was probably utilized as a habitation site. The presence of a fireplace ringed with imported basalt, some midden, and artifacts suggests more than just temporary usage. The small amount of midden may be the result of eating and cooking activities occurring outside the sinkhole or refuse removal outside of the site, as exhibited at Site B6-70. This site, like the B6-70 U-shaped structure, may have functioned primarily as a sleeping shelter.

Site 50-OA-B6-119 (Figs. 16 & 17)

Survey Unit: A
Site Type: Rectangular enclosure
Previously Recorded

Description. This enclosure is located 10 m S of the eastern edge of the quarry area, and consists of a low, soil-filled area enclosed on four sides by a crude wall of stacked and upright limestone slabs, constructed on the surrounding outcropping. The structure measured 4.5 by 4 m, and the walls stood .5 m high and .5 m wide.

Fig. 16. B6-119, RECTANGULAR ENCLOSURE. View from E.



SITE B6-119
BARBERS POINT, OAHU
SEPTEMBER, 1977

2
meters

Fig. 17. PLAN MAP OF SITE B6-119, RECTANGULAR ENCLOSURE.

Previous excavation results. A 1-by-.5-m test trench was excavated along the interior of the east wall of the enclosure during the 1976 survey. No subsurface cultural elements were encountered during this testing.

Salvage excavation results. Three square meters of this crude enclosure were totally excavated, yielding no cultural or faunal remains. An overburden and a sterile, homogeneous matrix of aeolian soil overlying coral substratum were present (Table 6). The soil encountered in this site, characterized by yellowish-brown color and fine powdery texture was markedly different from any encountered in other deposits of sites in Survey Unit A.

Table 6. STRATIGRAPHIC DATA FOR SITE B6-119

Layer	Munsell	Thickness	Soil Type
O.B.	10YR 2/1 black	≈10 cm	
I	10YR 5/6 yellowish-brown	≈ 30-40 cm	Aeolian

Very sharp contact, coloration and texture.
No cultural or avifaunal components.

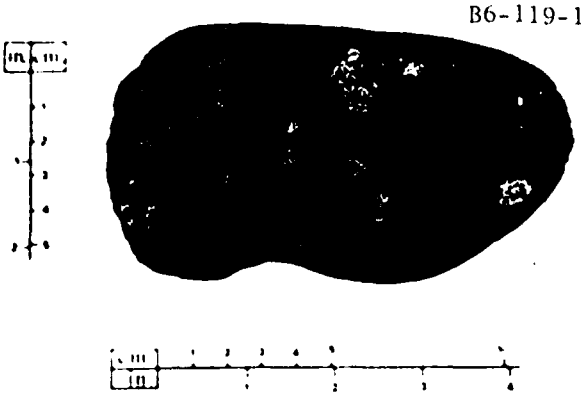
All of the remaining interior grids were then tested by 1-by-.5-m probe pits to solid substratum; all tests were identical in the absence of cultural material. At this point, total excavation was judged unnecessary for this site. Dismantling of wall sections revealed slabs placed above solid substratum or overburden, with no subsurface basal slabs. In areas exhibiting surface deposit, several test trenches were excavated through the structure wall base, exposing deposit extending continuously from the interior of the structure to the exterior. The single sterile layer was found to continue beyond the structure, underlying the overburden. Several more test pits were arbitrarily placed in low-lying areas of soil accumulation on the ground surface in the vicinity of the site. This testing produced the same sterile aeolian soil present elsewhere, but only in ground-level accumulations and absent in sinkholes. Also, the presence of this layer appears localized to a small NW portion of Survey Unit A. The nature of this soil and its color suggest windblown origins from the mountain slopes of the nearby Waianae range.

Summary of Artifact from Site B6-119

Artifact #: 50-OA-B6-119-1 (see photo, p. 37)
Artifact: hammerstone
Material: basalt
Dimensions: *l:* 12.9 cm; *w:* 7.4 cm; *th:* 4.1 cm
Provenience: surface collection near structure wall

(119-1)
Notes: It is fairly weathered, but original waterworn condition still discernible.
Storage location: BPBM, Dept. Anthropology.

B6-119-1



Interpretations. The lack of cultural elements indicates little or no activity within the structure. The placement of basal wall slabs above the overburden deposit (as in the B6-78 wall) suggests recent historic origins. The function of this structure is undetermined. Since the walls were too low and/or easily collapsible, animal containment or exclosure functions can be dismissed. Usage, if any, was brief and temporary, as indicated by the absence of any apparent disturbance to sterile soil layer and the lack of interior deposit. It may have been a recent historic attempt, abandoned before use, to contain the fairly substantial soil deposit for agricultural purposes. No associations can be drawn between the solitary artifact and this site.

Site 50-OA-B6-138 (Figs. 18 & 19)

Survey Unit: E
Site Type: Wall and sinkhole
Not previously recorded

Description. This site was located in a *kiawe* thicket SW and across Malakole Road from the quarry area, amidst a complex of paleontological sites. The wall was T-shaped and constructed of stacked limestone slabs atop an outcrop. Its main axis was oriented NW-SE and measured 7 m long, 1 m wide, and .5 m high. A 3-m wall segment was attached perpendicularly to the NW terminus of the longer wall.

The sinkhole opening measured 2 by 1.5 m at ground surface and lay immediately S of the wall. It was rubble-filled to .25 m below ground surface.

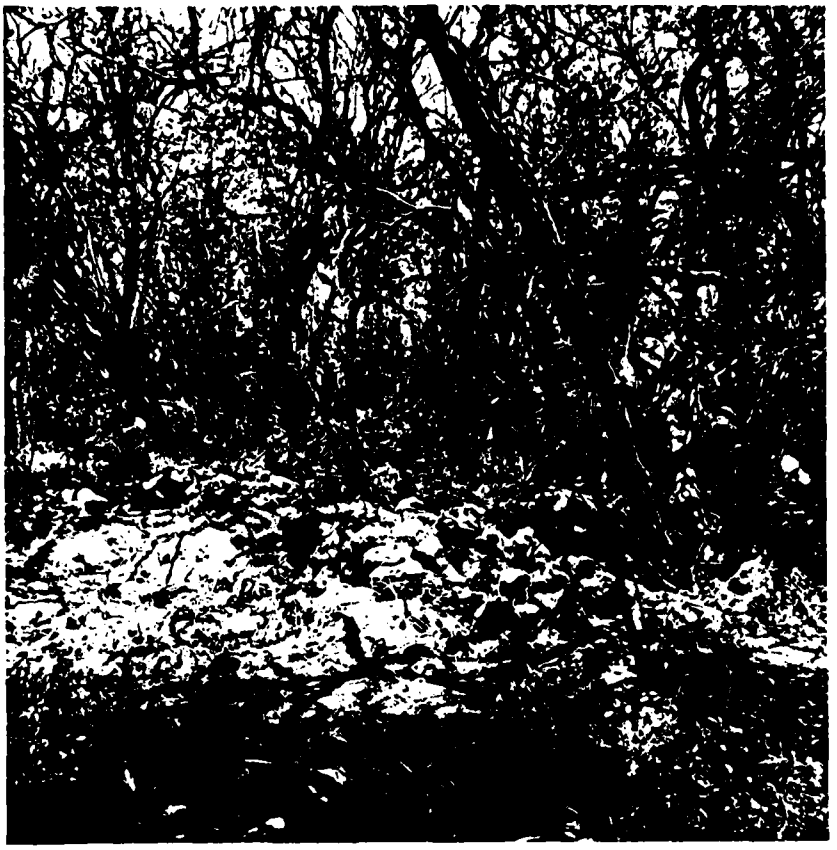


Fig. 18. B6-138, WALL AND FILLED SINK.
View from S.

Salvage excavation results. Portions of the wall were dismantled and showed stacked-slab construction with basal slabs placed directly on the solid substrate outcropping. No deposit was present underlying the structure, but several cracks and small sinkholes were filled with recent vegetable and overburden materials. One small sinkhole was found to be interconnected to the filled sinkhole, and removal of loose fill material revealed vegetable materials, largely recent. It appeared to have served as a burrow for rats or mice.

Excavation of the filled sinkhole revealed an overburden deposit and three subsequent layers below the rubble fill (Fig. 20; Table 7). Much disturbance was evident in Layers I and II. Birdbone was present throughout all layers with

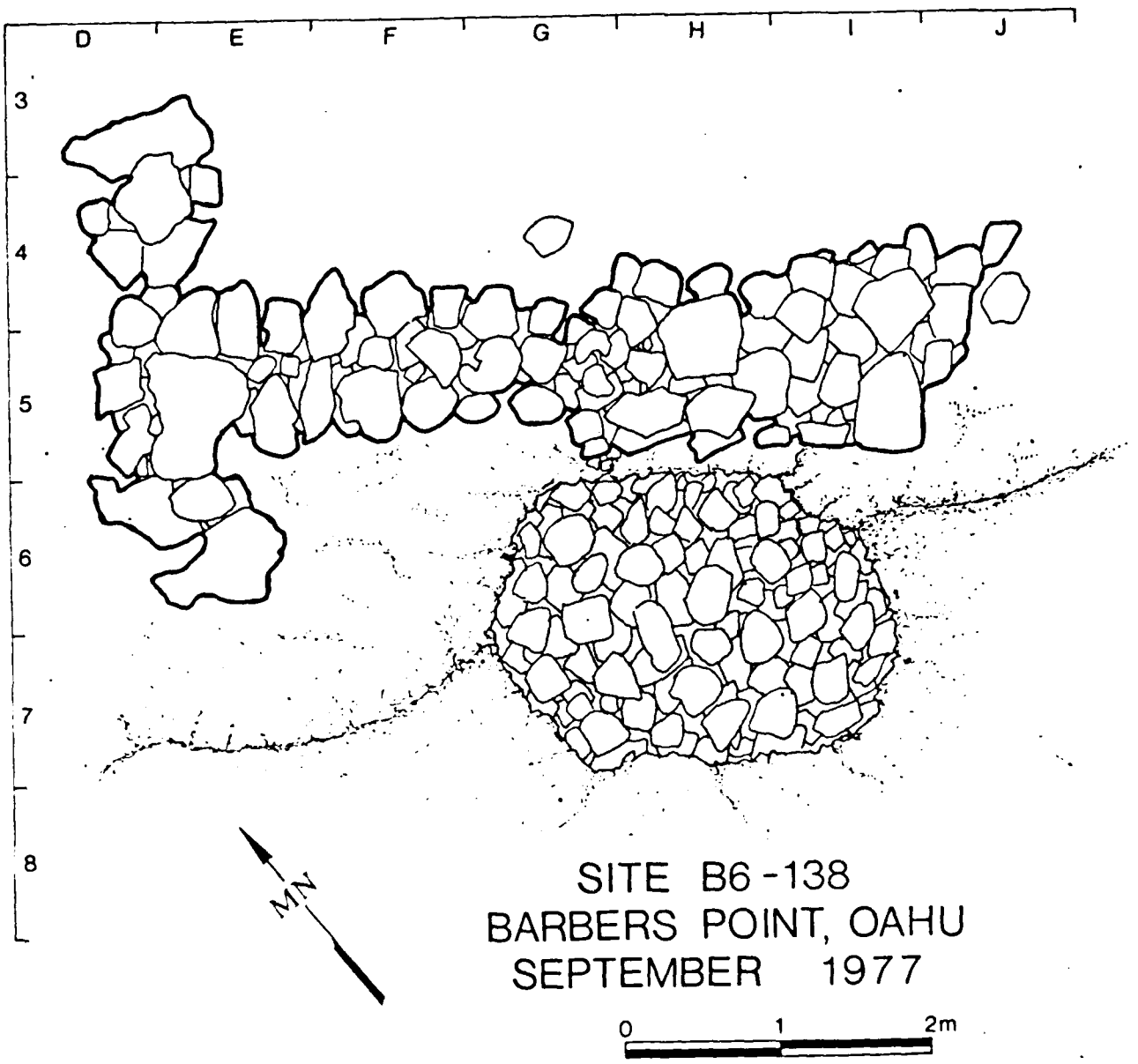
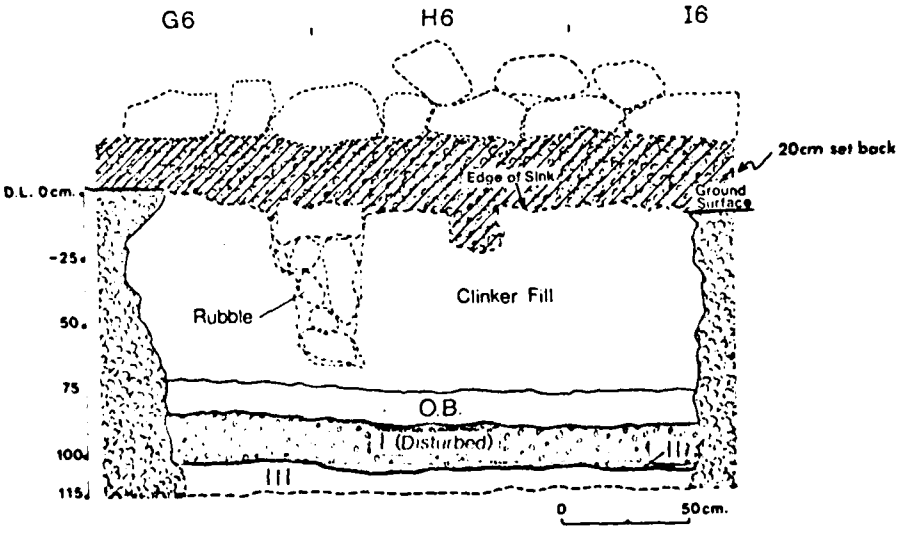


Fig. 19. PLAN MAP OF SITE B6-138, WALL AND SINKHOLE.

highest concentrations occurring in Layer I and small groupings of solitary bones sporadically appearing in Layer III. Scatterings of ash, and minimal midden material, occurred in Layer I; however, the only intact indication of a cultural deposit occurred at the interface of Layers I and III near the southern periphery of the sinkhole. This was primarily an ash deposit about 4 to 5 cm in thickness and 40 cm in diameter, containing sporadic flecks of charcoal and small amounts of midden. A thin deposit of dark, sandy soil with traces of ash and some midden composed the remainder of this discontinuous layer (II). Two artifacts were also recovered from this provenience. The disturbed state of the overlying layer, probably a mixture of a birdbone-laden layer and a cultural component, suggests the artifact and ash-bearing deposit to be only a remnant of a formerly more substantial cultural deposit.

Layer III was a sterile layer, overlying the coral substratum with sporadic pockets of bone, land snails (see Appendix II), and small pieces of organic materials in loose aggregations, much like the pockets exhibited at Site B6-78.

At 1.15 m below datum-level, coral substratum was encountered.



SITE B6-138, Sinkhole
Profile, East Face

Fig. 20. PROFILE OF EAST FACE OF B6-138, SINKHOLE.

Table 7. STRATIGRAPHIC DATA FOR SITE B6-138 (SINKHOLE)

Layer	Munsell	Thickness	Soil Type	Content
O.B.	10YR 2/2 very dark brown	≈ 10-15 cm		
I	10YR 5/3 brown	≈ 15-20 cm	Aeolian silt, Alluvial sand	Cultural and paleontological
II	7.5YR 4/2 brown/dark brown	Mixed remnant, Disturbed ≈ 5 cm		
POCKETS	7.5YR 4/4 brown/dark brown	≈ 10-15 cm		
III	5YR 5/4 reddish brown		Alluvial, and leached limestone	

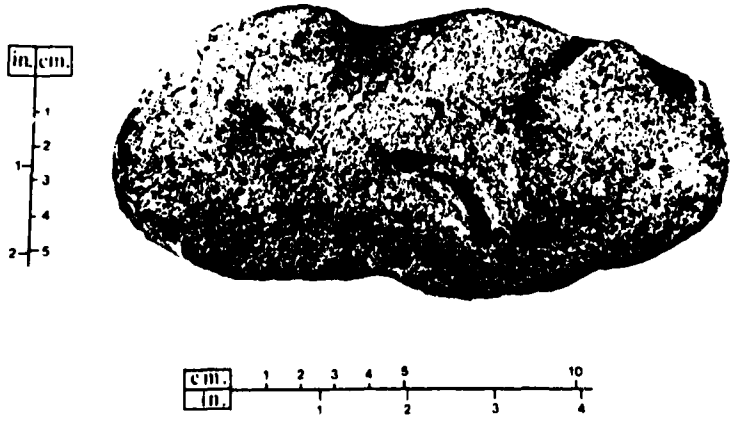
I & II highly disturbed and mixed.

Summary of Artifacts from Site B6-138

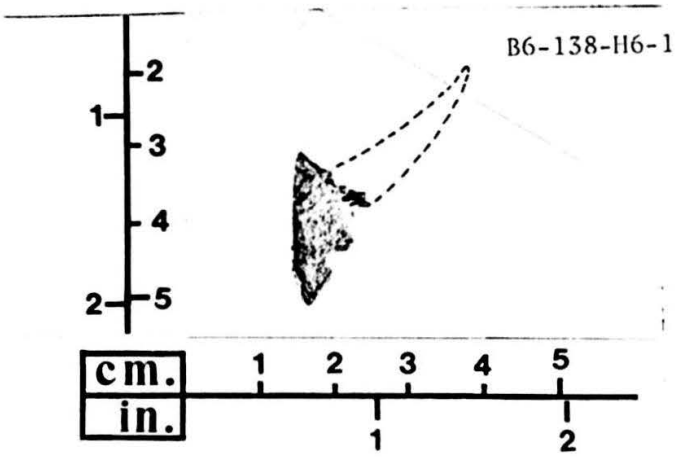
Three artifacts, all prehistoric in type, were recovered from the sinkhole, two from Layer II and one from the rubble fill.

Artifact #: 50-OA-B6-138-G7-1
Artifact: abrader
Material: coral (*Porites*)
Dimensions: *l:* 17.5 cm; *w:* 8.3 cm; *th:* 3.6 cm
Provenience: 80 cm b.d. / clinker rubble fill / Square G7
Storage location: BPBM, Dept. Anthropology

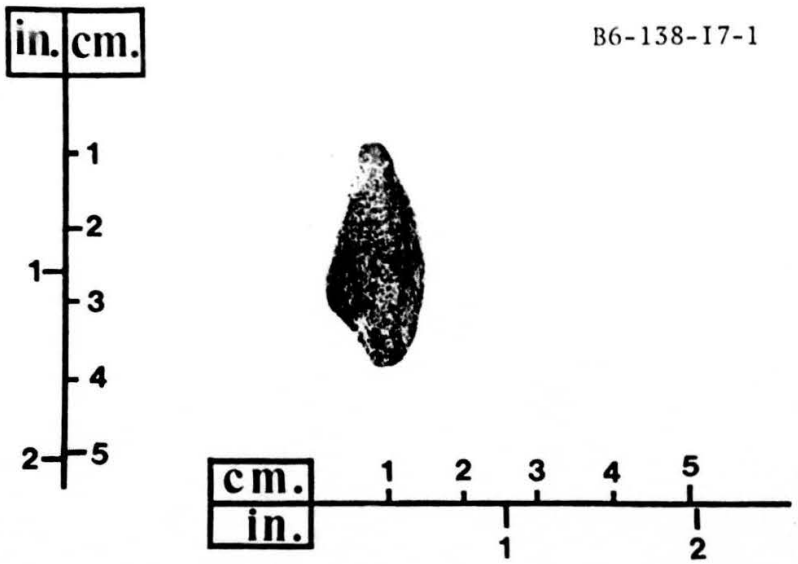
B6-137-G7-1



Artifact #: B6-138-H6-1
Artifact: fishhook fragment
Material: human bone
Dimensions: *l:* 1.7 cm; *w:* 1.5 cm; *th:* .5 cm
Provenience: 120 cm b.d. / Layer II / Square H6
Notes: Probably a fragment of an unfinished composite hook point for bonito or octopus [similar to Type III E 3(1) Ab 1] (Emory, Bonk & Sinoto 1959).



Artifact #: B6-138-I7-1
Artifact: file
Material: c (*Porites*)
Dimensions: *l:* 3 cm; *w:* 1.4 cm; *th:* .7 cm
Provenience: 120 cm b.d. / Layer II / Square I7
Storage location: BPBM, Dept. Anthropology



Interpretation. With much of the land area surrounding Survey Unit E bulldozed for quarry operations, Standard Oil gaslines, and Barge Harbor perimeters, data significant to the understanding of Site B6-138 may have been lost. At present, no other cultural sites are in the vicinity. Determination of its disposition as a solitary site or as part of a cluster could have aided in clarifying its function and perhaps its relative age.

The extensive disturbance observed in the sinkhole has destroyed a major portion of the stratigraphic evidence. Provenience of artifacts, cultural deposit, and even the birdbone-laden layer is unclear. The following is presented only as a highly hypothetical interpretation of the situation at this site.

The spatial situation of the wall and sinkhole suggest associations of the features. Sites exhibiting similar sinkhole/structure associations are apparent throughout the Barbers Point area. Site B6-61, -70, -75, -81, -82, -87, and -97 are just a few such examples (Sinoto Ms.).

The small size and shallowness precluded a habitation or shelter function of the sinkhole. Its use as a refuse pit can also be dismissed due to the small amount of midden materials. The wall, oriented against prevailing winds, may have functioned as a windbreak shelter. The ash deposit in the sink suggests utilization as a firepit, which may account for the disturbance of layers.

The simple construction utilizing natural formations, plus the paucity of cultural materials exhibited and the *in situ* recovery of early fishing-oriented artifacts (coral file and bone hook fragment) at this site suggest a temporary shelter, probably for transient fishermen.

The deposition of substantial overburden below the rubble fill seems to indicate, as in Sites B6-70, -78, and -119, recent historic filling. The coral abrader (B6-138-G7-1) was probably unwittingly deposited ás part of the rubble fill.

PALEONTOLOGICAL SALVAGE

Limestone sinkholes are the most ubiquitous features at Barbers Point. During the 1976 survey, several test excavations were conducted in the floor deposit of both unmodified and modified sinkholes, and revealed the presence of numerous avifaunal skeletal remains. Following this discovery, Dr. Storrs Olson, Associate Curator of Birds at the Smithonian Institution, was contacted. After a field inspection of sites and a brief review of the recovered material, the significance of these avifaunal remains, representing many extinct endemic species as well as new genera and species, was recognized. Olson stated that:

> The various limestone sinks...contain probably the most extensive fossil avifauna in Hawaii with many new species endemic to the island. Such fossils have not and probably cannot be found anywhere else on the island. Furthermore, the nature of preservation is such as to insure that virtually complete skeletons can probably be assembled for most species. Thus, there is much highly significant and totally new biological and paleontological information that can be obtained at the Barbers Point site [Sinoto Ms.:74].

He concluded that further work was mandatory and a total salvage of all sinkholes with potential should be conducted. This recommendation was followed during the current project. Dr. Olson and his assistant, Ms. Helen James, were also able to take part in a portion of the fieldwork.

Field Objectives

Paleontological salvage was conducted to provide for maximum recovery of avifaunal remains, and for recovery of data about association and disposition of skeletal remains, such as articulation or dispersal.

Methodology

The fieldwork was conducted in four phases:

1. Reconnaissance
2. Clearing
3. Mapping
4. Excavation.

Reconnaissance and clearing of paleontological sites were conducted concurrently with the archaeological portion of the project. Only one sinkhole site, B6-139, was located in the quarry area; remaining sites were located in Survey Units A and E, with the majority in Unit E.

The criteria applied for the selection of sites for excavation was simple: all accessible sinkholes. Thus, all sinkholes that one person could enter and excavate were salvaged. No grid system was utilized during the paleontological salvage due to the small size of the sinkholes. Excavation was conducted in quadrants and by stratigraphic layers to permit controls.

Several test excavations utilizing a posthole digging tool were conducted at sinkholes with small openings, revealing a lack of faunal materials.

Stratigraphic provenience was recorded for correlation with archaeological salvage sites. All excavated material was double-sieved in 1/4" and then 1/8" mesh screens. All faunal materials were retained.

In B6-139, a large, flooded sinkhole, SCUBA gear was utilized.

A total of 11 sites, all unmodified sinkholes with no subsurface cultural elements, were investigated. None of these had been previously recorded, although those occurring in Survey Unit A had been included in the tallied sinkholes during the 1976 survey (Sinoto Ms.). The same numbering system used for archaeological sites was applied to these sites. Additionally, some features included in archaeological site clusters (B6-100B and -100E) were found to be non-cultural after testing. The archaeological sites also came under paleontological scrutiny since the layers underlying the cultural deposits were birdbone-laden. Thus, the total number of sites from which paleontological material was recovered amounted to 14 sites, comprising 18 individual sinkhole features.

Site 50-OA-B6-139

Sinkhole B6-139, the unique flooded sinkhole, merits detailed description. This site is a large sinkhole, measuring 11 m in diameter and located near FPL #3 (NE corner of the federal project area). Fresh to slightly brackish water fills 2/3 of the sinkhole to depths of 10 m in some places. The only opening and entrance to the site is where a 2-by-4-m section of ceiling collapsed during quarry bulldozing rs ago (personal communication with equipment operator, Cyprus Hawaiian C The interior underwater floor, especially below the opening, is largely le-filled at present due to attempts by quarry personnel to fill the hole. The rubble floor slopes toward the deeper sections opposite the opening.

Water-level-meter readings showed the water level to be eustatically affected by tidal changes, thus indicating the water to be part of the subterranean freshwater lens floating atop salt water (see Appendix I).

Other than blue-green algae and minute red shrimp (*Halocaridinea rubra*), no aquatic life forms were encountered in the sinkhole. The only other documented fauna present is a marine isopod, which appears at night (Maciolek, personal communication). Due to the depth of the water, the recovery of samples required the use of SCUBA gear and underwater lights. All faunal remains exposed on the floor were first hand-picked, and then floor sediment was screened underwater or water-screened outside the sinkhole.

Perhaps most significant was the recovery of several individuals of *Corvus* (crow), which were found nearly articulated on the sink floor (Fig. 21). Numerous other avifauna were recovered; however, formal identification is still pending.

Fig. 21. BONES OF *CORVUS* SP., ON FLOOR UNDERWATER AT SITE B6-139.

Results

Analysis of the paleontological material has not yet been completed. Dr. Storrs Olson of the Smithsonian Institution is consultant for the paleontological material. Unexpectedly, Dr. Olson and his assistant, Ms. Helen James, came to Hawaii, enabling a more intensive paleontological investigation and facilitating tentative identifications of a portion of the recovered material. However, due to the large amounts of birdbone recovered, preliminary processing was not completed until early in 1978. The bones still require individual cataloguing by Dr. Alan Zeigler, Bishop Museum vertebrate geologist, before shipping to Dr. Olson for final identification and analysis. Dr. Olson is also the consultant for the state-funded salvage at Barbers Point; he has stated that the material recovered from the federal and state project areas should and will be analyzed together, and he expects this task to be a lengthy one.

Thus the paleontological salvage can be treated only in summary in this paper. Table 8 summarizes the stratigraphy of paleontological sites, and Table 9 summarizes birdbone and other bone recovered from paleontological and archaeological sites.

Certain trends observed during the salvage excavations can be summarized as follows:

1. Testing of sinkholes with small openings, .50-m diameter or less, showed little or no deposition of birdbone. Thus, sinkholes that were large enough to be easily accessible generally yielded more birdbone.

2. Stratigraphy showed consistent, typical characteristics. All sites exhibited only one major birdbone layer, occurring directly below the overburden.

3. The most commonly occurring bird was the shearwater/petrel (not extinct) with large representation from all sites.

4. Bones were very rarely in articulated or individual-associated state. Notable exceptions were remains from B6-139 and B6-148. In most cases bones were totally disassociated and mixed with those of other species.

5. Terrestrial gastropods were present with birdbones at all sites except for B6-139.

6. Most of the bones exhibited remarkable preservation; in contrast, however, some appeared to be sub-fossilized.

7. Small rodent bones were found in association with birdbone throughout the bone-laden layer. Although other animal skeletal remains were present, they occurred exclusively in the upper portions of the bone-laden layer.

8. After more finalized identifications the bone-laden layer may be subdivided into separate discrete depositions (as noted for other bones above), spanning a considerable length of time and stratigraphically undiscernable by mere observation.

Note: The presence of the large flooded sinkhole and the manner in which it was discovered suggest the possibility of other, similar sites in the vicinity. Monitoring of the dredging is therefore recommended during the initial construction phase of the Boat Harbor project.

At the completion of Olson's identifications and report, more conclusive statements can be made regarding the paleontological situation at each site, and from the total salvage project area. Perhaps then, the birdbone may shed more light on the prehistoric environment at Barbers Point.

Table 8. STRATIGRAPHIC DATA FOR PALEONTOLOGICAL SITES.

Site	Survey Unit	Dimensions at Opening	Depth to Overburden	Layer	Thickness	Type	Color	Notes
B6-140	A	2.2x2 m	1 m	O.B.	10 cm	Organic matter	10YR 2/1 black	
				I	20 cm	Aeolian/alluvial	7.5YR 5/4 brown	*
				II	unexcav.	Alluvial/decomposed limestone; sterile unexcavated	7.5YR 5/6 reddish-brown	
B6-141	E	1.39x1.68m	1.2 m	O.B.	4 cm	Organic matter	10YR 2/2 very dark brown	poor recovery
				I	10 cm	Aeolian/alluvial	5YR 3/4 dark reddish-brown	*
				II	15 cm	Aeolian/alluvial	5YR 4/6 yellowish-red	sterile
				III	15 cm	Alluvial/decomposed limestone	5YR 6/4 light reddish-brown	sterile
B6-142	E	1.13x1.42 m	1.1 m	O.B.	8 cm	Organic matter	" " " " "	
				I	15 cm	Aeolian/alluvial	" " " " "	inclusion of limestone fragments, *
				II	8 cm	Aeolian/alluvial	" " " " "	sterile
				III	3 cm	Alluvial/decomposed limestone		sterile
B6-143	A/E	2x2 m	1 m	O.B.	5 cm	Organic matter	10YR 2/2 very dark brown	
				I	12-22 cm slope	Aeolian/alluvial	5YR 4/3 reddish-brown	*
				II	18-11 cm slope	Alluvial/decomposed limestone	7.5YR 5/2 brown	sterile
B6-143	B/E	2x1.8 m	.6 m	O.B.	4 cm	Organic matter	10YR 2/2	
				I	50-20-5 cm irregular bottom	Aeolian/alluvial	5YR 4/3	*
				II	3 cm	Decomposed limestone	5YR 5/3 reddish-brown	sterile
B6-144	E	triangular 2x1.9x1.87 m	.9 m	O.B.	10 cm	Organic matter	10YR 2/2	
				I	20 cm	Aeolian/alluvial	5YR 3/3 dark reddish-brown	*
				II	4 cm	Decomposed limestone	5YR 5/3 reddish-brown	sterile
B6-145	E	1.8x1.9 m	.75 m	O.B.	10 cm	Organic matter	" " " "	
				I	35 cm	Aeolian/alluvial	" " " "	*
				II	4 cm	Decomposed limestone	" " " "	sterile

*Birdbone-laden layer

Table 8, Continued

Site	Survey Unit	Dimensions at Opening	Depth to Overburden	Layer	Thickness	Type	Color	Notes
B6-146	E	1.8x1.2 m	1 m	O.B	6 cm	Organic matter	5YR 5/3 reddish-brown	
				I	12 cm	Aeolian/alluvial	" " " "	*
				II	4 cm	Decomposed limestone	" " " "	sterile
B6-147	A	.65x.80 m	1.85 m	O.B.	10 cm	Organic matter	10YR 2/1 black	
				I	20 cm	Aeolian/alluvial	7.5YR 5/4 brown	lacking birdbone
				II	unexcav.		7.5YR 5/6 strong brown	sterile
B6-148	A	1.5x1 m	2.70 m	O.B.	6 cm	Organic matter	7.5YR 2.5/1 black	
				I	12 cm	Aeolian/alluvial	10YR 4/4 dark yellowish-brown	goose bones
				II	16 cm	Aeolian/alluvial	5YR 5/3 reddish-brown	*
				III	unexcav.		7.5YR 5/6 strong brown	sterile

*Birdbone-laden layer

Table 9.

ANALYSIS OF BONE FROM EXCAVATIONS
IN BARBERS POINT SURVEY AREA

Weights in Grams

SITE	BIRD	FISH	RODENT	MAMMAL
B6-141, Lay. I	3.3	.2	1.2	-
B6-146, " "	6.7	-	-	-
B6-142, " "	11.2	-	1.1	-
B6-140, " "	35.6	-	2.1	2.3 (mongoose)
B6-145, " "	31.9	1.3	1.8	-
B6-139* Underwater floor	28.9	-	-	-
B6-144, Lay. I	125.9	.8	3.1	-
B6-143, Sink A, Lay. I	78.3	-	1.5	55.1 (cat)
B6-143, Sink B, " "	100.6	.4	.6	-
B6-138, G6-H6, Lay. I	14.6	11.0	2.1	-
B6-138, G7, Lay. I	21.1	26.3	4.1	-
B6-138, G7, Lay. II	13.7	16.7	2.2	-
B6-138, H6, Lay. II, "Tunnel"	2.5	-	0.4	-
B6-138, H7-I7, Lay. I	-	4.7	0.7	-
B6-138, H8, ground surface	2.4	-	0.3	-
B6-138, I6, Lay. II	15.9	2.4	1.1	-
B6-138, I6, Lay. III	1.5	-	0.3	-
B6-138, I7, ash deposit	3.5	0.9	0.3	-
B6-70, sink, E5-D5, Lay. I	59.8	94.9	15.7	-
B6-70, sink, E5-D5, Lay. II	12.7	-	-	-
B6-70, sink (side hole) D5, Lay. I, 73 cm b.d.	-	-	-	99.4 (human)
B6-70, H4, Lay. I	0.5	-	0.4	0.9 (pig tooth)
B6-70, I4, Lay. II, Top	0.7	-	0.8	1.0 (pig tooth)
B6-70, I5 " "	1.8	0.9	0.4	-
B6-70, I6, Lay. I	0.8	0.3	0.3	-

*Partial weight; some material already taken to Smithsonian Institution by Dr. Storrs Olson.

Table 9, Continued

Weights in Grams

SITE	BIRD	FISH	RODENT	MAMMAL
B6-148, Layer II*	709.2	-	2.6	-
B6-78, Layer II	1284.1	2.5	15.2	-
B6-100B, Layer I	229.5	2.5	4.9	0.9
B6-100C, Test Pit	37.8	0.5	-	-
B6-100C, Layer I	447.4	20.9	2.5	0.5 (mongoose)
B6-100C, Layer II	1452.3	40.9	2.6	9.9 (1.8 is uniden. med.-lg. mammal)
B6-100D, surface	0.6	-	0.5	0.2 (uniden. med.-lg. mammal)
B6-100E, Layer I	0.2	-	-	713.7 (young, large bovid, prob. calf)

*Partial weight; some material already taken to Smithsonian Institution by Dr. Storrs Olson.

LABORATORY ANALYSIS OF RECOVERED MATERIALS

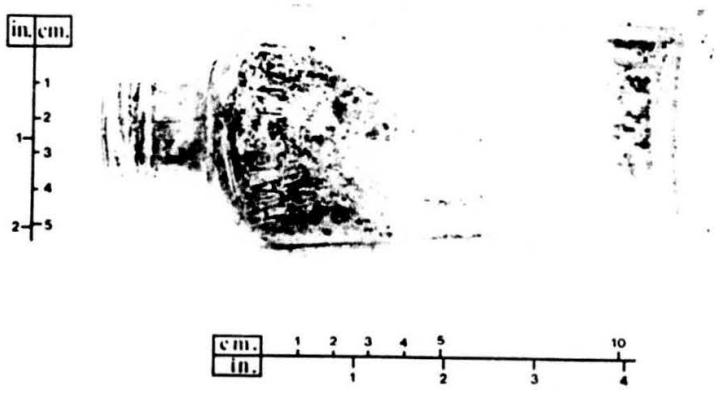
Artifacts

Artifacts recovered from individual archaeological sites have been described and illustrated under the archaeological salvage section. In addition, two artifacts were recovered from paleontological sites that contained no other cultural elements. A fishhook shank and head fragment (Type S-IA/B-HT-4) (Emory, Bonk & Sinoto 1959:10), from birdbone-laden Layer I of Site B6-144 was probably thrown in to the sinkhole in its broken state, or washed into the sinkhole with alluvial deposits during prehistoric times. The medicine bottle found in the overburden at Site B6-143B was probably deposited in a similar manner, but during recent historic times. These artifacts are described below. Table 10 gives the site distribution for all artifacts recovered during the 1977 salvage project.

Site 50-OA-B6-143

Artifact #: 50-OA-B6-143B-1
Artifact: bottle
Material: glass
Dimensions: *l:* 16.6 cm; *w:* 7.1 cm; *th:* 3.9 cm
Provenience: 71 cm b.d. / surface of deposit
Notes: modern
Storage location: BPBM, Dept. Anthropology

B6-144-1



Site 50-OA-B6-144

Artifact #: 50-OA-B6-144-1
Artifact: fishhook fragment
Material: bone
Dimensions: *l:* 1.4 cm; *w:* .3 cm; *th:* .2 cm
Provenience: Layer I, from birdbone deposit 1.29-1.49 m b.d.
Notes: secondary deposit--no cultural associations. Type S-IA/B-HT 4 (Emory, Bonk & Sinoto 1959)
Storage location: BPBM, Dept. Anthropology.

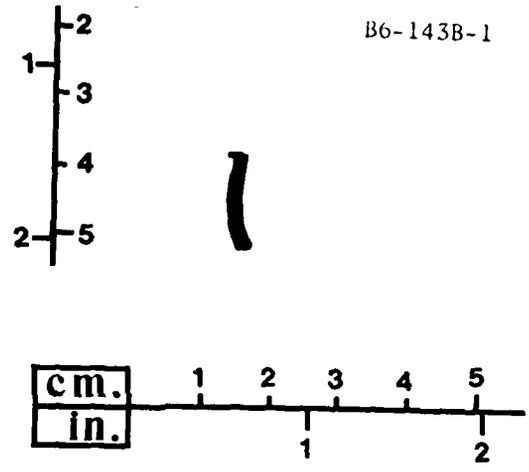


Table 10.

ARTIFACT-TYPE DISTRIBUTION BY SITE

SITES 50-OA-B6-	Adze	Adze Chip	Basalt unmodified	Basalt Flake	Basalt Hammerstone	Coral Abrader	Coral File	Fishhook	Glass Bottle	Modified Birdbone	Polished Hematite Fragment	Volcanic Glass	
-70		1								1	1	3	6
-100-C	1		3	1			1					7	13
-119					1								1
-138						1	1	1					3
-143									1*				1*
-144								1					1
TOTALS	1	1	3	1	1	1	2	2	1*	1	1	10	25

*Historic artifact.

Midden

All midden material was double-screened through 1/4" and 1/8" mesh screens; some material was recovered from finer screening during laboratory analysis of soil samples. Tables 11 through 14 list the various midden materials recovered from individual archaeological sites. Since midden material from all sites was minimal, with the exception of the refuse sinkhole at Site B6-70, a tabulation of midden and sample content by site and stratigraphic origin was judged more informative for this report than a quantitative analysis. In some sites only one or two specimens of certain faunal species were represented.

From the refuse sinkhole at Site B6-70, 763 g of faunal materials were recovered from Layer II. This is a relatively small amount compared to quantities from some of the sites tested during 1976 (Sinoto Ms.:76-85). The two most predominant materials were various fish bones (248.5 g) and the bivalve *Brachidontes cerebristriatus* (263.3 g).

A brief survey of the mollusca, echinoderms, and crustacea represented in the midden material showed these to be commonly occurring species from shallow water, reef, or surge zone habitats (Edmundson 1946). All three habitats occur along the coast fronting the project area, indicating simple exploitation of available marine resources in the immediate vicinity.

Fish and mammal bones were remarkably scarce (see Table 9). Although fish bone recovered is largely unidentified, tuna, a deep-water fish, was represented. Fishing apparently exploited offshore as well as inshore varieties.

The lack of midden material may be attributed to two major factors, which were exhibited at Sites B6-70, -100C, and -138:

1. Specialized use of structures and sinkholes, primarily for sleeping with the majority of cooking and eating occurring elsewhere, outside of the site.

2. The apparent removal of refuse from the site.

Table 11.

ANALYSIS OF MIDDEN FROM SITE B6-70

STRUCTURE

MIDDEN MATERIAL	Layer I
SHELL	
Gastropoda	
Conus sp.	X
Cypraea caputserpentis	X
Hipponix pilosus imbricatus	X
Littorina pintado	X
Nerita picea	X
Turbo intercostalis	X
Pelecypoda	
Brachidontes cerebristriatus	X
Tellina rugosa	X
ECHINODERMATA	
Echinometra mathaei	X
Echinothrix diadema	X
Heterocentrotus mammillatus	X
CRUSTACEA	
Crab	X
BONE	
Pig	X
LAND SNAILS	X
MISCELLANEOUS	
Charcoal	X

Table 12.

ANALYSIS OF MIDDEN FROM SITE B6-70

SINKHOLE

MIDDEN MATERIAL	Layer I	Layer II
SHELL		
Gastropoda (univalves)		
Conus sp.	X	
Cypraea caputserpentis	X	
Cypraea reticulata	X	
Drupa horrida	X	
Drupa ricinus	X	
Helcioniscus exaratus	X	
Hipponix pilosus imbricatus	X	
Littorina pintado	X	
Nerita picea	X	X
Strombus maculatus	X	
Strombus sp.	X	
Turbo intercostalis	X*	
Pelecypoda (bivalves)		
Brachidontes cerebristriatus	X	X
Isognomon californicum	X	
Pinctada galtsoffi	X	
Tellina rugosa	X	
ECHINODERMATA (sea urchins)		
Colobocentrotus atratus	X	
Echinometra mathaei	X	
Echinothrix diadema	X	
Heterocentrotus mammillatus	X	
CRUSTACEA		
Crab shell	X	
BONE		
Bird	X	
Fish	X	
Human	X	
Rodent	X	
LAND SNAILS		X*
MISCELLANEOUS		
Charcoal	X	
Fire-cracked rock	X	
Kakalaeoa seed	X	
Koa haole seed	X	
Kukui-nut shell	X	
Sea-worm casts	X	

*Probable fossil shell

Table 13.

ANALYSIS OF MIDDEN FROM SITE B6-100C

MIDDEN MATERIAL	LAYER I	LAYER II
SHELL		
Gastropoda (univalve)		
Conus sp.	X*	X*
Cypraea caputserpentis	X*	X*
Cypraea fimbriata	X*	X*
Cypraea reticulata	X*	
Drupa ricinus		X*
Littorina pintado		X
Nerita picea	X	X
Peristernia chlorostoma		X*
Turbo intercostalis		X*
Pelecypoda (bivalve)		
Antigona reticulata	X*	X*
Brachidontes cerebristriatu	X	X
Ctena bella		X
Pinctada galtsoffi	X	X
Tellina rugosa	X*	X
ECHINODERMATA (sea urchins)		
Colobocentrotus atratus		X
Echinometra mathaei		X
Echinothrix diadema	X	X
Heterocentrotus mammillatus	X*	X*
CRUSTACEA		
Crab	X	X
BONE		
Bird	X	X
Fish	X	X
Mammal (unidentified)		X
Rodent	X	X
LAND SNAILS	X	X
MISCELLANEOUS		
Charcoal		X
Kakalaioa seed	X	X
Koa haole seed	X	X
Kukui-nut shell	X	X

*Probably fossil shell.

Table 14.

ANALYSIS OF MIDDEN FROM SITE B6-138

	Layer I	Surface above Sink	Ash Deposit	Layer II	Layer III
SHELL					
Gastropoda (univalves)					
Conus sp.	X*		X*	X*	
Cypraea caputserpentis	X*		X*	X*	X
Cypraea fimbriata	X*			X*	
Cypraea reticulata	X*			X	
Drupa horrida				X*	
Drupa ricinus	X*			X	
Hipponix pilosus imbricatus	X*				
Littorina pintado	X		X	X	X
Nerita picea	X	X	X	X	X
Nerita polita	X				
Pisania tritonoides	X*				
Strombus maculatus	X*				
Terebra strigilata	X*			X	
Trocus intextus	X*				
Turbo intercostalis	X*				
Vermetidae	X				
(bivalves)					
Antigona reticulata	X*		X*	X*	X*
Ctena bella	X*				
Pinctada galtsoffi	X		X	X	X
Tellina rugosa	X			X	
ECHINODERMATA (sea urchins)					
Echinothrix diadema	X			X	
CRUSTACEA					
Crab	X			X	
LAND SNAILS	X		X	X	X
MISCELLANEOUS					
Charcoal	X		X	X	
Koa haole seed	X				
Kukui-nut shell	X				
Sea-worm casts	X*				

*Specimen probably fossilized shell from limestone matrix.

Land Snails

During midden and soil analyses, the presence of large numbers of terrestrial gastropods became evident. Snails were represented from all salvaged sites. Dr. Patrick Kirch's report on preliminary analysis of recovered land snails has been included as Appendix II. With further analysis their potential significance as indicators of prehistoric environmental conditions was recognized. However, further efforts both in the field and laboratory are necessary to obtain results useful toward any environmental reconstructions or interpretations.

Geology

Results of geological analysis by Dr. Maury Morgenstein and Marcus Childs of Hawaii Marine Research, Inc., have been included as Appendix I. Cursory examination of the sinkholes by the consultant revealed that the majority of the sinkholes exhibit geologically homogeneous traits. Consequently only two sites were investigated in depth--B6-78, a sinkhole with no stratigraphic cultural evidence, and B6-11, a sinkhole with cultural components. Although other areas outside of the present project limits would have to be examined geologically, it appears that the geological attributes of the two sinkholes can be termed typical for those within the federal project area limits.

Dating

Ten basaltic-glass samples from two cultural sites were submitted for hydration-rind dating to Hawaii Marine Research, Inc. Results are summarized below. For more detailed information refer to HMR Geoarchaeology Report in Appendix I.

Site	Sample	Age Determinations
50-OA-B6-70 Structure	50-OA-B6-70-DS-2	A.D. 1612 ± 30
Sinkhole	-B6-70-E5-2	A.D. 1613 ± 30
Sinkhole	-B6-70-H7-1	A.D. 1650 ± 24
50-OA-B6-100C	-B6-100C-2, -6, -7, -10 through -13	Not datable/no rinds visible

Unfortunately, only one set of dates was obtained from the salvage area. However, two inferences are made apparent here:

1. The date obtained from B6-70 falls within the range obtained in 1976 from neighboring Site B6-58 (1593 - 1801 A.D.), thus indicating the simultaneous occupation of those two sites during a portion of the prehistoric occupation of Barbers Point.

2. The petrological similarities observed in the three datable flakes from B6-70 suggest their origin from a single source; however, the high titano-magnetite content which rendered the seven flakes from B6-100C to be non-datable could imply a different source.

The implication of exploiting different sources of basaltic glass raises socio-economic and ecological questions regarding the nature of the prehistoric population that occupied or utilized the Barbers Point area. Further investigations are needed to answer these questions:

1. How close were the sources to Barbers Point?
2. Did the population have direct access to the source?
3. If not, how was the glass obtained?

The lack of other easily datable materials limits the range of interpretations that could be made regarding the past use of the survey area, especially in regard to settlement patterns.

Charcoal was found to be unfeasible for dating due to four major factors:

1. The high rate of leaching in the soil deposits, with possible effects on sample material.

2. The porosity of the soil, which facilitates downward transport of moderate-sized particles from one soil horizon to another. With indications of recent burning throughout the area, the determination of the origins of charcoal found during excavation becomes extremely difficult and impractical in terms of the time and costs involved.

3. The absence of adequate amounts of charcoal deposits in association with cultural features (fireplaces, firepits) in sites.

4. The disturbed state of otherwise potentially datable deposits in most sites, making recovery of datable amounts of charcoal impossible.

Other possibilities for dating remain, but have not yet been tested on the Barbers Point material.

Collagen is an insoluble fibrous protein that occurs in vertebrate bone tissue. By laboratory processing of archaeologically recovered bones, collagens can be utilized for dating. With the large amounts of bird bones recovered, collagen dating might be an effective method for obtaining dates, especially for the paleontological sites. The Smithsonian Institution has facilities for such analysis and its applicability to the Barbers Point material may be tested at a later time in conjunction with Dr. Storrs Olson.

Another possibility for dating is analysis of the land snails that occur from the sites. Kirch states that "Land snails are excellent indications of ancient environmental conditions and might serve such a purpose in the Barbers Point situation." For a taxonomic breakdown of the Barbers Point land mollusca and their stratigraphic occurrence, refer to Appendix II.

SUMMARY AND CONCLUSIONS

A more complete picture of the whole Barbers Point area is necessary to fully understand the situation and nature of the salvaged sites. At this time, however, intensive investigations have not yet been completed for the remaining sited portions (under state jurisdiction) surrounding the federal project area. An important and necessary consideration here is that the five sites salvaged constitute only a small fraction of a much larger area displaying evidence of prehistoric occupation. Furthermore, with 80% of the federal salvage project area extensively bulldozed by industrial activities, these five sites constituted a remnant portion of what once was a more extensively sited area. Thus, much data, potentially significant to the understanding of the situation in the salvage area, had already been lost. Several previously recorded sites--B6-10, -13, -14, -21, -27, and -35, to name a few--were destroyed before intensive investigations could be undertaken, and undoubtedly many more unknown sites have also been destroyed.

Regarding the "marginal" area, certain observations were made by McAllister in the 1930s that were largely adhered to by archaeologists until quite recently:

> ...[numerous sinkholes] afford shelter and protection, but I would doubt if previous to the time of Cook there was ever a large population here [McAllister 1933:109].

Although the salvage excavations generally encountered a high rate of disturbance, restricting analysis necessary to interpret the sites, certain trends in utilization of the project area for habitation were observed:

1. Construction of surface structures took advantage of natural features, such as outcrops surrounding low-lying areas. This was observed at surface sites B6-70, -100, -119, and -138. By selecting convenient locations, labor and construction resources could be economized. A second advantage and possible explanation for this practice is that low-lying areas hold more surface deposit than does the solid limestone substratum at ground surface; thus the interior floor of the structures would be more favorable for habitation in such areas.

2. All sites that were possible surface habitations or shelters exhibit walls oriented to the NE, against the prevailing wind in this region.

3. Proximal sinkholes are often utilized in association with surface habitation sites. The proximity of sinkholes to sites may prove significant in the spatial analysis of sites and settlement pattern determinations at Barbers Point.

4. In the salvage area, all easily accessible sinkholes with adequate size and depth to afford shelter were utilized for human habitation. This was also indicated from the results obtained during the 1976 survey.

5. Crude construction techniques utilizing stacked slabs seem to characterize structures of later historic origins.

6. The characteristics of the stratigraphic components displayed from site to site are consistent.

   a. Cultural deposits are thin, suggesting either short-term occupation or major cultural activities occurring outside the habitation area.

   b. Cultural layers overlie the avifaunal depositions.

7. Coeval occupation of the cultural sites was indicated by consistency of stratigraphic record and also inferred by age determination for B6-70, which coincides with a portion of the range of dates obtained from B6-58 during 1976.

8. All artifacts recovered through excavation were prehistoric in type.

9. The size and character of the sites, together with the cultural remains, infer short-term occupations for the sites investigated during the current project.

10. There appears to be no apparent association between the cultural elements and the fossil avifaunal assemblage.

Traditionally, environmental conditions at Barbers Point were considered too harsh to support a substantial population:

> The SW and NW coasts were and are quite dry and the population was therefore relatively sparse despite the fact that the waters off the northern end of SW Oahu were the best in this region for deep-sea fishing [Handy & Pukui 1972:271].

This illustrates a significant aspect of the Barbers Point area, the proximity to the coast, suggesting fishing or marine-oriented subsistence. Morgenstein states:

> ...Karst regions are generally unfavorable today because of their undulating topography; however, prehistoric use of these limestone regions was obviously favorable in Hawaii because of the nature of the resources made available by slumping. These resources include fresh water, shelters, and construction materials. At Barbers Point, the proximity to the shoreline must also be considered [Appendix I].

From the data recovered from the immediate salvage project area a series of tentative conclusions can be drawn regarding marine-oriented subsistence:

1. The age determination from Site B6-70, A.D. 1612-1650, clearly indicates prehistoric occupation.
2. Sites investigated in this area appear to be for temporary habitation, as indicated by simple construction, paucity of cultural materials, and lack of interior features such as fireplaces; thus, transient or seasonal populations are suggested.
3. Artifacts strongly suggest fishing-oriented activities. Of artifacts recovered from the 1977 salvage project, 24% can be directly related to fishing activities or to the manufacture of fishing gear.
4. The prehistoric focus on fishing is further indicated by the apparent exploitation of inshore and offshore fish, suggested by cursory examination of the midden fish bones and by the recovery of a composite hook point, probably a bonito hook (Type III E3(1) Ab1). The secondary importance of supplementary marine resources, such as molluscs, echinoderms, and crustaceans, is suggested by the presence in the midden of species exploited in the immediate vicinity.

5. The importance of fishing is further substantiated by the presence of fishing shrines. One, Site B6-13, was recorded in 1966 and subsequently destroyed. Another such site, B6-96, was recorded during the 1976 survey. Both of these sites are in or near the federal salvage area.

6. Unlike the Barbers Point region, the Ewa Plain near Pearl Harbor was heavily populated, with intensive agriculture and some in-shore fishing enhanced by freshwater runoff along the shore (Handy & Handy 1972). This region may have been the place of origin for the transient fishermen at Barbers Point. They could have fished for species not available near Pearl Harbor, and taken the catch back.

Although no evidence for more long-term or permanent occupation was exhibited during the current project, such occupation is indicated by some sites in the surrounding area. In these cases, agriculture may have been practiced to supplement the subsistence. This is suggested by the sinkholes with plants still growing in them, and by agricultural terrace-like structures. Populations have existed and practiced certain types of agriculture in other "marginal" areas of Hawaii. Similar indications are present in Waiahukini, Hawaii (Sinoto & Kelly 1975):

> And all across the plain, unwatered save by rain, and in moist crannies in the lava, sweet potatoes (*'u'ala*) were the staple. Everywhere in pockets of good soil bananas, sugarcane, gourds, and other supplementary food stuffs flourished. The early visitors saw the fertile sections of this now largely barren, lower land as "one continuous garden" [Handy & Pukui 1958:242].

Perhaps the most significant and intriguing aspect of the Barbers Point area elucidated by the recent investigations is the occurrence of archaeological and paleontological resources from a localized region and frequently from the same site.

Thus far, this report has focused largely upon the archaeological remains; however, the importance of the paleontological resources, apparent even at this preliminary stage of evaluation, cannot be overlooked. Upon completion of more intensive laboratory analysis, Dr. Storrs Olson will undoubtedly treat the biological and paleontological situation fully. The potential archaeological significance of the paleontological materials will be discussed here.

Although no direct evidence of contemporaneous association of the two resources was indicated by the results of the current salvage project, such possibilities should not be ruled out for the remaining sites in the area outside of the federal project limits.

During the current project several new research problems dealing with the possible association of the avifaunal assemblage and the prehistoric human occupation were recognized. These problems still remain unanswered. Major ones are presented below in the form of testable hypotheses.

1. The fossil avifaunal deposit and cultural deposits were non-coetaneous elements.

   a. Dating is a critical factor here as with all the other hypotheses. With several possible methods for dating recovered material (C-14, hydration-rind, land-snail, and collagen), conclusive age determination could be obtained.

   b. Closer geo-archaeological examination of the stratigraphic record with emphasis on the possible hiatus between the cultural and paleontological components.

   c. Careful examination of intact stratigraphic records for any disturbance or intrusive character of the cultural deposit, suggesting that the birdbone deposition antedated the prehistoric human occupation.

   d. Ground surface areas outside of sinkholes should be investigated and surface deposits tested to determine possibilities of bone deposited into sinkholes from the surface through alluvial action.

   e. After determinations of extinct/non-extinct species of birds are finalized, more conclusive evidence of relationships indicating contemporaneity may become apparent.

2. The archaeological and paleontological resources were contemporaneous.

   a. Dating should be given first priority in determining the coexistence of the two resources.

   b. Stratigraphic records need to be examined in detail, especially focusing on geological and pedalogical components to aid in relating the two elements.

3. The archaeological resources existed concurrently with only a portion of the avifaunal assemblage.

   a. Definite identifications of the faunal materials and their stratigraphic proveniences may reveal subdivided deposits within the major birdbone deposit, especially between extinct and non-extinct species. Land snails associated with some birdbone deposits may prove to be an invaluable tool aiding in this type of determination.

b. Current salvage results from paleontological sites exhibit birdbone deposition underlying the overburden, and since the archaeological sites exhibit cultural deposit, no real hiatus is evident. Either the disturbance of the birdbone deposits by cultural activities is prevalent here or continued deposition of birdbone in unmodified sinkholes concurrent with human occupation is indicated. Furthermore, the present overburden was apparently formed quite recently and no variations from site to site are discernible. Thus, more meticulous examination of overburden is necessary, including rates of deposition, content, and subsurface indications of other, older overburden or hiatus.

c. The variety of birds represented in the recovered material may not have been contemporaneous, in which case the birdbone deposit, unlike the cultural layer, must be considered to be an expression of a number of depositions taking place and accumulating over a very long period of time.

4. The paleontological resources were exploited by prehistoric humans.

a. Birdbone artifacts require identification of the bone and dating. With the excellent preservation of bones in the karstic environment, the possibility of manufacturing artifacts from previously deposited bone, pre-dating human occupation, cannot be neglected.

b. Other non-artifactual birdbone material from cultural deposits should be closely examined for signs of artificial breakage, battering, cutting, and burning, especially if identified to be of extinct species.

c. Birdbone deposition should be examined closely for species-specific concentrations. The majority of sinkholes currently investigated exhibited highly disturbed and disassociated bones with only infrequent occurrences of intact associated deposits (skeletal remains of one individual). Such determinations may prove indicative of sinkhole bird traps or storage pits for human predators. One such example encountered during the recent salvage was at Site B6-148, where extinct flightless goose bones were exposed during excavation overlying the birdbone-laden layer. These bones appeared to be fairly intact and associated by individual. The fact that these bones occupied a provenience corresponding to the cultural layer location in archaeological sites could be significant.

The preceding problems apply to the majority of sites in the Barbers Point area; thus they have been presented here primarily as possible guidelines for future research. In order to fully understand the prehistoric situation at Barbers Point, more archaeological, paleontological, and environmental research is still needed to clarify the relationships among these factors.

Recent alterations to the environment at Barbers Point--either man-made, such as sugarcane-growing, ranching, etc., or natural such as the reforestation

of the area by hardy exotics such as *kiawe*--have changed the conditions to what we see there today. It was probably a combination of such changes and the lack of knowledge regarding the adaptability of prehistoric peoples that resulted in Barbers Point being largely ignored until recently. These investigations, with others, will hopefully aid in shedding more light on the understanding of the prehistory of Barbers Point and Oahu.

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APPENDIX I

GEOARCHAEOLOGICAL RECONNAISSANCE OF BARBERS POINT*

By

Hawaii Marine Research, Inc.

INTRODUCTION

At the request of the Department of Anthropology, B. P. Bishop Museum, Maury Morgenstein and Marcus Child of Hawaii Marine Research conducted a geological and geoarchaeological reconnaissance in the form of examination of several sinkholes at Barbers Point. Standard observations were made in July and August, 1977, at representative sinkholes from each survey unit, and two major sinkholes (B6-78 and B6-100C) were exacavated. Additional field data were collected from one large wet cave (B6-139). Not all the data collected has been analyzed or included at this time. The field director of the project, Aki Sinoto, provided valuable assistance during this study.

GENERAL BACKGROUND

The Barbers Point area is unique in Hawaii because it is situated on the raised Ewa Plain, which once hosted a massive coral-algal reef. The reef probably emerged some time during the Post-Pleistocene, when terrestrial geomorphic modifications began. These modifications commenced with rain and groundwater leaching of reefal bio-carbonates, which resulted in a major increase in reef porosity as well as in the formation of caves, sinkholes, and subsurface water channels. Sinks are formed in response to failure of subsurface cave roofs, resulting in collapsed area depressions that are oblate to rounded in shape. A few sinks are the result of the leaching action of surface runoff in fractures of the reefal limestone. One characteristic feature of gravity-subsided sinks--which are by far the most numerous at Barbers Point--is nearly vertical walls.

The resulting Karst topography was first recognized on the eastern shore of the Adriatic Sea, where it received its name. With regard to land

*A glossary of terms used in this report is given on p. A-38.

utilization, Karst regions are generally unfavorable today because of their undulating and dangerous topography; however, prehistoric use of these limestone regions was obviously favorable in Hawaii because of the nature of the resources made available by gravity slumping. These resources include fresh water, shelters, and construction materials. In particular at Barbers Point the proximity to the shoreline must also be considered as an incentive to prehistoric use.

GENERAL SEDIMENTATION

During the chemical solution of reefal limestone, calcium carbonate is removed and basaltic mineral grains and clays are lagged behind (the non-biogenetic components of the reef accumulate during normal marine sedimentation and are included between biocarbonate crystals). These lagged sediments form the first soils for vegetation. Eolian and surface runoff sediments rapidly accumulate within the sinks because these features act as sediment traps. Much of the surface topography can be virtually barren of sediment accumulations and the associated sinks still tend to fill rather quickly. Beneath the floor of a sinkhole there is generally abundant rubble, formed during roof collapse and consisting of angular fragments of varying sizes and orientations. In some cases, these rocks will form small, irregular, dry caves where sediment does not accumulate. In other instances, the eolian and alluvial overland wash sediments completely fill the voids between gravity-slumped limestone blocks. Further, where there has been sufficient groundwater over time, the collapsed limestone fragments become cemented into coherent masses known as collapse breccias. In still other situations the collapsed rubble is leached to a deposit of carbonate and lagged silty clay (mud), which contains more residual biocarbonate pebbles and granules. Groundwater tends to partially cement this "saprolite-like" carbonate sediment.

Barbers Point sinks contain each of the described sediments in varying stratigraphic positions and varying degrees of induration, shape, and intermixing.

PURPOSE OF STUDY

This study commenced as a support investigation to determine the cultural chronologies by hydration-rind dating, to determine the genesis of the landforms

and sediments, and to describe the paleoenvironmental parameters of the area. In addition, it was within the scope to determine the relationships between fossil "aviaries" and human occupation.

METHODS

Initial observations were made at sites B6-70, -78, -100, -119, -138, -139, -140. Three of these sites were intensively studied. Two fairly typical semi-dry sinkholes, B6-78 and -100C, were excavated and B6-139, a wet cave located in the active quarry floor, was intensively studied. Field temperatures were recorded using a digital thermometer (see Table 1), basaltic glass was collected, soil and sediment samples were collected, and complete stratigraphic profiles of the excavated sinks were made.

Analyses of soil and sediment samples were run for total organic content, sediment size, and micropaleontology, using the following procedures.

Total Organic Content

A hydrogen-peroxide dissolution method was used to determine the total organic content of the sediments. Concentrated hydrogen peroxide was added to a known quantity of sediment, the reaction was taken to completion, and the residue was weighed. The weight difference was converted into percent total organic matter (Table 2).

Sediment-Size Analysis

Sediment-size analysis was done by wet sieving at ½ Ø intervals from -2 Ø to +5 Ø. The contents of each sediment-size fraction was described. Cumulative probability weight percent curves were drawn and Folk (1968)* size statistics were calculated (see graphs and tables at end of Appendix).

Micropaleontology

During sediment content descriptions of each size fraction, number of species and total percent of terrestrial gastropods were noted (Tables 3 & 4). These data

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* Folk, Robert. 1968. Petrology of Sedimentary Rocks. Hemphill Publ. Co., Austin, Texas.

are used to indicate environmental parameters of Barbers Point.

In addition, smear slides were prepared for each sediment sample and scanned at 100, 400, and 1,000 magnifications for pollen, spores, and opal phytoliths. No chemical separations were used to prepare the pollen, spores, and phytoliths, as the scope of the project did not allow for such investigations. Future micropalcontological work would be very desirable for the collection of accurate bio-stratigraphic profiles and associated climatic data.

RESULTS -- Site 50-Oa-B6-78

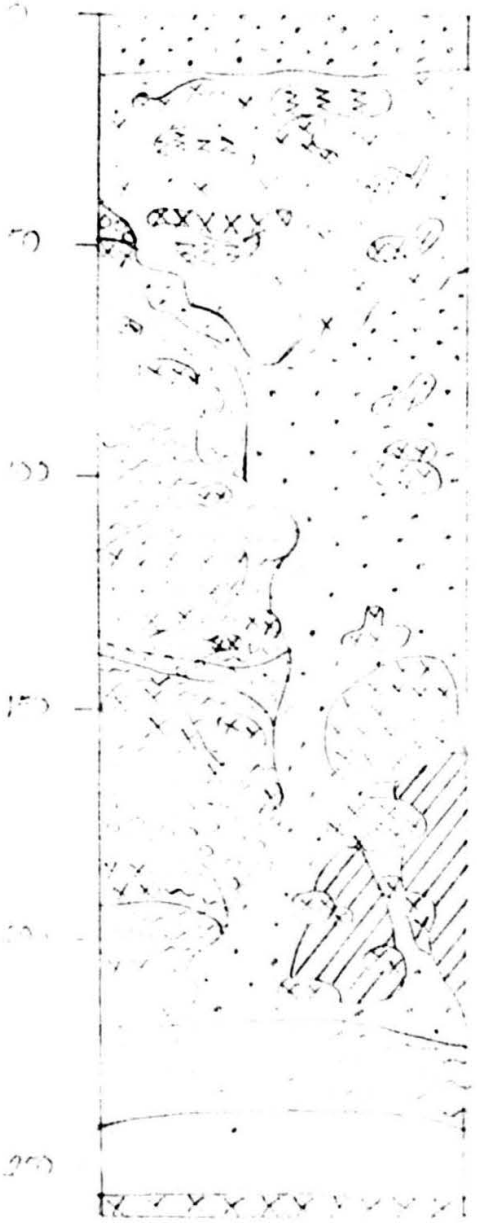
A composite sedimentary profile and description of the site follows.

North Face Composite Section Sediment Description

Layer I. 0-12.5 cm. Organic matter (average 50.34% organic matter), top soil - 0 and A1 soil horizon; dry, 10YR 2/2 matrix with light-grey 10YR 7/1 coarse sand to granular salt in a pepper matrix. At 0-5 cm, fine sand, very poorly sorted, near-symmetrical, very platykurtic bimodal sediment with coarse sand and medium silt to clay modes. At 10 cm, very fine sand, poorly sorted, coarse-skewed, platykurtic, bimodal sediment with very fine sand and medium silt to clay modes with a secondary pebble mode. The sediment is composed of a cohesive, intact, dry organic matrix with well-rounded peds, slightly hard to loose to singular-grain, non-sticky, non-plastic with small, angular to sub-rounded limestone pebbles and granules. Abundant terrestrial gastropods with a variety of species without preferred orientation, matrix homogeneous, few horizontal and vertical root-molds, sediment voids 2-4 cm x 1-3 cm random scatter and distributed throughout the horizon. Sediment fracturing common, not oriented, and generally associated with the larger limestone fragments--cobble sized. Birdbone observed randomly, more abundant and concentrated near edges of the sink and where large limestone cobble debris is concentrated. Common insect fragments, seed pods, bark, twigs, leaves and a few grasses associated with the O-horizon. Bottom contact sharp, wavy, drawn on the basis of color and texture change.

Layer II. 12.5 - 40.0 - 57.3 cm. Eolian silt and alluvial sand with slumped angular limestone fragments of boulder to granule size; fossil avian zone, containing pockets of angular to sub-angular granules with terrestrial gastropods

NORTH FACE COMPOSIT SECTION, SITE B6 - 78



Pocket with terrestrial gastropods, bird bone, and limestone

Limestone

Saprolitized limestone

Limestone soil

Silt and Sand

Dry Cave , void

Fresh water

and birdbone. Soil horizon, A3, transitional, dry consistence, weak peds of angular to sub-rounded modified structure associated with matrix peds that are rounded to sub-rounded, dry, moderately hard, non-sticky, non-plastic; 7.5YR 4/4 dry matrix with darker pockets-(A) 10YR 3.5/3, (B) 10YR 3/4; with all matrix speckled with 10YR 7/1 salt. At 15 cm, medium sand, very poorly sorted, near-symmetrical, very platykurtic trimodal sediment with pebbles, fine sand, and medium silt to clay modes. At 35 cm, medium sand, very poorly sorted, strongly coarse-skewed, platykurtic trimodal sediment with pebbles, fine sand, and medium silt to clay modes. At 55 cm, coarse sand, very poorly sorted, fine skewed, very platykurtic trimodal sediment with pebbles, fine sand and medium silt to clay modes. Pocket A is at a 31° inclination to the bedding and contains abundant terrestrial gastropods, sub-angular to sub-rounded limestone; rounded, moderately cohesive soil peds, very slightly sticky, and non-plastic. The sediment has a large number of pore spaces; birdbone is abundant. Pocket B is rounded, 41 cm high and 47 cm wide with a top at 17 cm that is coarse sand, very poorly sorted, fine-skewed, platykurtic trimodal sediment with pebbles, medium sand, and medium silt to clay modes.

Root molds are large to very small, discordant and vertical.

Bottom contact is sharp, wavy, pocket-like in several locations, and drawn because of texture change.

Layer III. 40.0 - 220 cm. Facies: lithofacies A of eolian silt and alluvial overland wash; lithofacies B of slumped and collapsed limestone, limestone breccia, and diagenetic subfacies of leached limestone, *in situ* with sand.

Eolian-alluvial lithofacies A, 55 - 220 cm. Dry, 7.5YR 5/6, homogeneous with angular pebbles of limestone, common alluvial pocketing and interlayering, apedal, dry, loose, single grain to moderately moist B soil horizon with angular peds, non-sticky, non-plastic. At 105 cm, fine sand, very poorly sorted, strongly coarse-skewed, platykurtic, trimodal sediment with pebbles, fine sand, and medium silt to clay modes. At 110 cm, fine sand, very poorly sorted, near-symmetrical, platykurtic bimodal sediment with medium sand and medium silt to clay modes. At 200 cm, medium sand, very poorly sorted, coarse-skewed, very platykurtic, trimodal sediment with pebbles, medium sand and medium silt to clay modes. Containing little evidence of bioturbation with few small, vertical roots.

Sub-facies: dry caves, voided, capped by sub-angular to angular limestone boulders. Limestone cobbles and boulders are scattered throughout the main eolian facies. Very few terrestrial gastropods and fossil birdbones are associated with the uppermost stratigraphic boulders. Terrestrial gastropods do occur to about 200 cm.

The bottom contact is very sharp and drawn because of a change in lithology. The facies' lateral contacts are very sharp to almost gradational, at times diagenetically masked by leached limestone silts.

Collapsed limestone lithofacies B, 40 - 220 cm. Dry to moist--normal graded moisture content, compact, with three sub-facies: limestone boulders and *in situ* sink walls subfacies, 2.5YR 7/2; saprolitic limestone subfacies, 2.5YR 7/2 to 2.5 YR 5/2; diagenetic and clastic soil horizon, C horizon, with alluvial and eolian sediments, 2.5 YR 6/2. The limestone in each subfacies shows evidence of pitting, scouring and leaching. Sub-facies: diagenetic soil C horizon with eolian and alluvial overwash, slightly sticky and slightly plastic, compact, apedal, pockety in form, in association with altering saprolitic fragments of highly porous limestone composing the saprolitic limestone sub-facies, which at 55 cm is a medium sand, very poorly sorted, near-symmetrical, very platykurtic, trimodal sediment with pebbles, fine sand, and medium silt to clay modes. No evidence of bioturbation and no roots. Very sharp bottom contact drawn because of structural change.

Layer IV. 220 - 255 cm. Altered limestone capped sink, wet cave, with 220-235 (240)-cm altered saprolitic limestone and diagenetic C soil horizon acting as a wet cave cap; 235 (240) to 255 cm--fresh-water cave with 255 cm acting as *in situ* limestone cave and sink bottom. Note: at 240 cm into fresh water table. The 220-235 (240)-cm C soil horizon is wet, 2.5Y 6/2, at 230 cm, medium sand, very poorly sorted, strongly coarse-skewed, platykurtic, trimodal sediment with pebbles, very fine sand and medium silt to clay modes. The soil is slightly sticky to sticky, and slightly plastic to moderately gritty plastic, compact, without visible sediment pores, homogenous, slightly granular, sandy, silty, and composed of mostly chemically leached limestone with basaltic residue of rare silts and clays.

RESULTS--Site 100C

A composite, stratigraphic profile and description of the sediments follows.

Layer I. 0 - 11 cm. Organic mat - eolian silt and alluvial sand with slumped angular limestone pebble and cobble fragments, dry, 7.5YR 4/4, non-sticky and non-plastic, rounded to sub-rounded, moderately hard ped, A1 soil horizon. Sharp bottom contact.

Layer II. 45 cm. Eolian silt and alluvial sand with a fire-ash horizon at 21 cm (20-21.5 cm). The sediment is churned, disrupted, without bedding from 11 to 20 centimeters. The sediment from 11 to 20 cm contains portions of Layer I sediments in the form of pepper in a salt matrix. The matrix is 7.5YR 4/4 with facies coloration of 7.5YR 6/4, dry; while the ash horizon is 5YR 6/2 to 5YR 3.5/4, dry. The soil peds are medium-sized, rounded, dry to medium-dry consistency, homogeneous in color and texture, non-sticky and non-plastic, containing fragments of insects and land snails; bioturbated with very fine to medium vertical root tubes. Gradational bottom contact sharp and wavy.

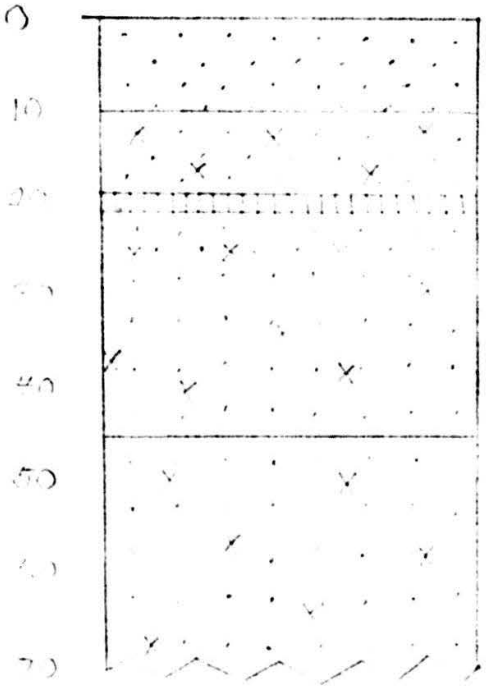
Layer III. 45 cm - bottom. Eolian silt, alluvial sand, and limestone fragments, dry, 5YR 4/8, with abundant pebble to granular and occasional angular to sub-angular cobbles of limestone. The soil peds are sub-angular when apparent, less cohesive than above, mostly apedal, non-sticky, and non-plastic. Bioturbation occurs with vertical and horizontal medium-sized roots. No bottom contact.

Summary of Size Analysis for Site B6-100C

0-5 cm. Coarse sand, very poorly sorted, near-symmetrical, platykurtic trimodal sediment with pebble, medium sand and medium silt to clay modes indicating various modes of deposition. The pebble fraction is formed during sink collapse as secondary slumping; the medium sand is from alluvial wash and some slumping, the medium silt to clay is from eolian deposition. There is a minor contribution to the sediments from *in situ* terrestrial gastropods.

21 cm. Fine sand, fire-ash, poorly sorted, coarse-skewed, very lepto-kurtic unimodal sediment.

COMPOSIT STRATIGRAPHIC SECTION OF SINK 100 - C



LAYER I

Churned from 11 to 20 cm

LAYER II

LAYER III

Silt and Sand

Fire ash, Cultural

Limestone

37 cm. Fine sand, very poorly sorted, strongly coarse-skewed, mesokurtic trimodal sediment with pebble, fine sand and medium silt to clay modes. Eolian sedimentation appears to be more evident here than alluvial deposition.

50 cm. Medium sand, very poorly sorted, strongly coarse-skewed, very platykurtic bimodal sediment with pebble, and medium silt to clay modes. Alluvially washed and gravity-slumped sediment with very minor eolian contribution.

POLLEN, SPORES, AND PHYTOLITHS

The phytolith profile of Sites B6-78 and -100-C are similar. There are abundant phytoliths in the Layer I (highly organic) sediments. Those phytoliths observed were all rod-shaped. Layer II sediments contain abundant to rare phytoliths, mostly rare, and again are all rod-shaped. No phytoliths were observed in Layer III. The pollen-spore profile is somewhat similar to the phytolith profile in that there is a very large variety of pollen and spores in Layer I sediments, some in Layer II, and very few if any in Layer III. Table 5 reports the general micropaleontology scan results.

The results of the pollen, spore, and phytolith scan analysis must be viewed as a minimum expectation of the distribution and quantity of microfossils present. These scan data indicate that future work in this area is worthwhile.

RESULTS--UNMODIFIED WET SINK-CAVE

An Instruments Corporation Continuous Water Level Recorder was used in the wet cave on August 10, 1977, to record variations in the water height, in order to determine if the water in the cave was part of the underground fresh-water lens. It was operated for a 30-hour period, starting at 10:45 AM on the 10th of August. A total water-level displacement of 16 inches was recorded with maximum levels approximating high tide (2.0 ft) and minimum levels at or before low tide (0.4 ft). An example of the tidal fluctuation recorded is given in Table 6.

The wet sink (cave) contains well-formed stalagtites and stalagmites, some of which are subsurface. Algal coloration of the high cave aragonite skins indicate that the water levels were at one time elevated above the present mean water table. Various fossil birds are impregnated and cemented with aragonite on the rubble terraces of the cave. The cave was therefore actively precipitating aragonite prior to the birds' arrival, during their entrance into the cave and after their departure. In addition, there are various deposits of rat bones in the dry portion of the cave. Abundant fossil bird bones were found underwater at the bottom of the cave. These bones appear to be in relatively intact associations.

BIRDBONE STRATIGRAPHY

Bird bones are found in Layers I and II from dry-sinkhole deposits. Most of the bones are geographically scattered, not oriented and not stratigraphically concentrated in any particular portion of Layer II. However, there are two situations where the bones are possibly actively related. When bones are found in groups of about five or more they are generally associated in pocket orientations, above or below a cobble of limestone. These pockets contain abundant terrestrial gastropods of various species. The bones are usually mixed, e.g., more than one species of bird per pocket. Complete skeletal material is generally absent. The second pattern grouping occurs at the edges of the sink where bones tend to concentrate in agglomerates of five or more; and again of varied species in each area. Only in rare cases do any of the pocket bone groups appear to contain one dominant species of intact composition, and when this happens, the bones are usually those of petrel. Juvenile bones are very rare. In several cases the bones rest on small ledges in the walls of the sink. Most of the bones are intact, unbroken, and well-preserved. There are, however, many bones that are fragmented, splintered, and even appear crushed. Intact bones about 1 mm long were noted during sieving operations. During sediment sieving, there were abundant fragmented bones, splinters, and small bone fragments in many of the sand-to-coarser-sized fractions from Layer II. It appears from all observations that the bones represent a thanatocoenose.

HYDRATION-RIND DATING

Standard hydration-rind dating procedures were followed. The results are presented in Table 7 at end of Appendix.

LANDFORM AND SEDIMENT GENESIS

The following events appear to have occurred:

1. Stable island reef formation
2. Pleistocene sea-level changes
3. Raised Barbers Point reef
4. Solution of the reefal limestone
5. Formation of wet and partially wet caves
6. Gravity collapse of some of the wet caves
7. Sink formation of Layer III with sea-level control of fresh water; *in situ* deposition of terrestrial gastropods
8. Minor vegetation growth with eolian and alluvial deposition
9. Development of Layer II sediments through:
   a. Continued sink wall collapse
   b. Eolian sedimentation
   c. Minor alluvial overland wash sedimentation
   d. *In situ* deposition of terrestrial gastropods
   e. Minor organic contribution to the sedimentary profile, probably from small shrubs
   f. Deposition of fossil avian fauna
10. Hiatus of at least 40 years (est. 50-250 yrs)
11. Development of a major vegetation cover
12. Cultural modification of Barbers Point sinks and surface topography at about 1600 A.D. with minor continuation of petrel fauna; formation of Layer I, organically enriched sediments; churning of the upper portion of Layer II sediments where indicated
13. Abandonment of the area by the prehistoric community at about 1800 A.D.
14. Forest change to *kiawe*; water-resources modification due to changes in the uplands usage--agriculture in the 1900s. Continuation of Layer I sedimentation.

DISCUSSION

The geological and paleontological data accumulated during this study must be viewed on a preliminary basis since only a few sites have been investigated in the Barbers Point area. These data then serve as preliminary information to develop hypotheses for further testing at Barbers Point. Of the observations and hypotheses recorded in this test, several are important relative to the various problems encountered:

1. The wet cave and sink B6-78 contain fresh to fresh-brackish water that rests upon the salt water and is tidally controlled. Tidal fluctuations at these locations have lag times that are probably related to the limestone porosity and distance of tidal travel. In addition, fluctuations in rainfall patterns affect the height of the freshwater table.

2. The wet cave contains abundant bird bones and yet the cave is not collapsed, nor is there an apparent outlet. Consequently, it is assumed that the birds:

   a. Came into the wet cave through a small access in search of water and could not find their way out;
   b. Were brought into the wet cave by predators.

Since the birdbone is, for the most part, from various extinct species, it was probably deposited before or at the same time as Layer II sedimentation. Why the birds were in the area, and especially in the wet cave, is a highly problematic question that is critical to the reconstruction of the presence of the fossil aviary at Barbers Point. In addition, it is to be noted that for the most part, the birds are in species-related intact accumulations. This observation differs greatly from those at the open sinks.

3. There is a complete, continuous, biostratigraphic profile of terrestrial gastropods with species diversification and confinement within the time stratigraphy. The size distribution of species indicates a biocoenose which can be related to the clisere in the Barbers Point area. There appears to be a unique climax community of terrestrial gastropods related to Layer III. These data are critical for interpretation of the paleo-environmental history of Barbers Point.

4. Pollen, spores, and phytolith assemblages correlate in part with total-organic profiles and indicate a major biomass expansion in the Layer I sediments. There is no gradation from Layer II to Layer I; since the contact is not due to soils development, a hiatus is indicated. The duration of this hiatus must be related to the necessary time needed to develop a stable aboreal vegetation.

5. There is a complete and unique time-stratigraphic separation between prehistoric cultural activity at Barbers Point and fossil-aviary deposition.

6. The fossil aviary thanatocoenose of the sink deposits ends at the hiatus and at the appearance of forest vegetation. Therefore it occurs at an environmental optimum and not an environmental minimum. This suggests (and is supported by the rather low total-organic content of Layer II) that the birds did not choose the Barbers Point habitat because it was under heavy vegetation; rather, the habitat was possibly advantageous because of the lack of heavy vegetation. This may indicate that the area was covered by small shrubbery and possibly utilized as a source of food and/or an area for nesting. Pollen and phytolith assemblages indicate that the area was not under major grass cover, and total-organic analysis indicates that the area was not under heavy forest vegetation.

In addition, the availability of water at Barbers Point would provide ample reason to attract a variety of species, especially if there was a drought in the surrounding area. This will be discussed further.

7. The death of a large quantity of birds of varied species is certainly unique and has no known present-day corollary in Hawaii. Since the Layer II sediments indicate a vegetation minimum for Barbers Point, there might be a correlation between vegetation and climatic control of vegetation. In which case, there may be a reason for the extinction. This hypothesis, however, is not well-supported because the Layer II sediments probably represent between 600 and 2,500 years of deposition--a rather long period of time for a climatic minimum. The time of deposition is postulated assuming the rate of sedimentation was between 1 cm per 11 yrs. to 1 cm of deposit per 45 years. Layer I sediments were probably deposited at a rate of 1 cm per 40 yrs. rate.

8. Deposition rate for Layer III sediments can not be ascertained because of the mode of deposition. Since they are presumably of sink origin, they are related to:

a. The collapse of the sink

b. Sediment accumulation on the paleo-land surface prior to collapse.

c. Sedimentation into the cave prior to total collapse.

The organic concentrations are mostly clastic rather than *in situ*.

9. The appearance of a relatively large quantity of fossil birdbone within the Layer II stratigraphy suggests at the onset that there was a massive population of birds at Barbers Point. However, this might not be the proper perspective. In order to clarify the issue, Table 8 utilizes the probable sedimentation rate range with various estimates of fossil birdbone deposition. If we assume only petrels are present in a 4-meter-square sinkhole, and we excavate a 1-meter-square test pit, we should find about one whole petrel skeleton for every 4 cm of depth, if we assume that one bird died every 10 years with a sedimentation rate of 1 cm per 11 years and a total Layer II thickness of 55 centimeters. If, in the same hypothetical situation, we assume a slower sedimentation rate of 1 cm per 45 years, we should find about 4.5 petrels for the same 4 cm of depth. Since in actuality generally less than one complete bird skeleton is found per 4 cm depth in 1 square meter, and the 1 cm per 45 years sedimentation rate is fairly realistic, we can assume that probably less than 1 bird per 10 years was deposited in the sinkhole. In reality, then, we do not have a huge number of whole bird skeletons accumulating at one time. Nor is the actual ecological relationship between different species as tight as it seems when all the bones are piled in the same box. This exercise also brings up the possibility that the death assemblage of birds is not really as striking as it appears; rather, it is a uniformly realistic deposit representing a few birds per decade whose remains have accumulated in physiographic depressions, and only the degree of bone preservation is actually unique.

Table 1.

Field Temperature Data

Location	Date	Time	Temperature C		Remarks
site 78	Aug 5 1977	11:50	air =34.1	soil	shade
		1200		25.10	6 " below surface
		1330		25.35	
		1405		25.45	
		1430		25.5	
		1500		25.65	
		1510		25.6	
site 78	Aug 8	1041		25.7	
		1123		25.7	
		1207		25.7	
		1315		25.9	
		1350		25.9	
		1438		26.1	
		1605		26.2	
site 100C	Aug 10	1400		26.3	
		1422		26.3	
		1430		26.3	
		1447		26.3	
		1500		26.3	
		1515		26.4	
		1530		26.3	
site 100C	Aug 12	1030		25.1	
		1045		25.1	
		1114		25.7	moved probe
		1130		25.7	
		1144		25.7	
		1200		25.7	

Table 2.

TOTAL ORGANIC CONTENT, SITE B6-78

LAYER	DEPTH(cm)	% OF ORGANIC MATTER	AVERAGE % FOR LAYER
I	0 - 5	48.00	
I	10	52.67	50.34
II	15	25.00	
II Pocket A	14	26.00	
II Pocket B	17	25.67	
II	35	25.67	
II	55	25.33	25.53
III	55	32.67	
III	105	34.67	
III	110	28.33	
III	200	34.67	32.59
IV	230	33.33	33.33

TOTAL ORGANIC CONTENT OF SITE B6 - 100 - C

LAYER	DEPTH(cm)	% ORGANIC MATTER	AVERAGE % FOR LAYER
I	0 - 5	32.67	32.67
II	21 fire ash	36.25	
II	37	43.00	39.63
III	50	33.00	33.00

Table 3.

Content of Sediment Size Fractions , Site B6 - 78

Sample Ø size	% Reefal Limestone	% Charcoal Ash	% Organic Matter	% Basaltic Materials	% Bird Bone	% Land Snails*
0-5cm Layer I						
-2Ø	100					
-1.5	95					5 (1)
-1.0	95					5 (2)
-0.5	98		2			
0.0	92		5	2	1	
0.5	49		50		1	
1.0	20		80			
1.5	15		85			
2.0	10		90			
2.5	10		90			
3.0	5		95			
3.5	5		95			
4.0	5		95			
4.5	4		96			
5.0	3		97			
10cm Layer I						
-2.0	100					
-1.5	60					40 (2)
-1.0	65					35 (2)
-0.5	95					5 (1)
0.0	90					10 (2)
0.5	80		10			10 (2)
1.0	70		20			10 (frag
1.5	40		55			5 (frag
2.0	30		70			
2.5	25		75			
3.0	15		85			
3.5	10		90			
4.0	5		95			
4.5	5		95			
5.0	5		95			
14 cm Pocket A						
-2.0	100					
-1.5	80					20 (4)
-1.0	75					25 (4)
-0.5	74				1	25 (3)
0.0	69				1	30 (5)
0.5	60					40 (5)
1.0	80					20 (2)
1.5	90					10 (1)
2.0	90			5		5 (fra
2.5	95			5		
3.0	95			5		
3.5	95			5		
4.0	90			10		
4.5	90			10		
5.0	90			10		

* Numbers in ( ) are number of species.

Table 3, continued

Sample Ø size	% Reefal Limestone	% Charcoal Ash	% Organic Matter	% Basaltic Materials	% Bird Bone	% Land Snails
15 cm Layer II						
-2.0	100					
-1.5	90					10 (2)
-1.0	90					10 (3)
-0.5	80					20 (3)
0.0	60					40 (3)
0.5	70					30 (3)
1.0	95					5 (2)
1.5	97					3 (frag)
2.0	99					1 (frag)
2.5	98			2		
3.0	95			5		
3.5	95			5		
4.0	95			5		
4.5	95			5		
5.0	90			10		
17 cm Pocket Layer II						
-2.0	100					
-1.5	99					1 (1)
-1.0	78				7	15 (1)
-0.5	85				5	10 (2)
0.0	80				5	15 (5)
0.5	75				5	20 (4)
1.0	80				5	15 (4)
1.5	93			2		5 (frag)
2.0	90			8		2 (frag)
2.5	80			20		
3.0	80			20		
3.5	80			20		
4.0	85			15		
5.0	80			20		
35 cm Layer II						
-2.0	95					5 (1)
-1.5	95					5 (1)
-1.0	90					10 (2)
-0.5	95					5 (2)
0.0	95					5 (2)
0.5	99					1 (2)
1.0	99					1 (2)
1.5	100					
2.0	100					
2.5	100					
3.0	100					
3.5	100					
4.0	95			5		
4.5	95			5		
5.0	95			5		

Table 3, continued

Sample Ø size	% Reefal Limestone	% Charcoal Ash	% Organic Matter	% Basaltic Materials	% Bird Bone	% Land Snails
55 cm Layer II						
-2.0	100					
-1.5	100					
-1.0	98					2 (1)
-0.5	95					5 (1)
0.0	95					5 (2)
0.5	95					5 (2)
1.0	95					5 (2)
1.5	100					
2.0	98		2			
2.5	92		8			
3.0	85		15			
3.5	75		25			
4.0	75		25			
4.5	75		25			
5.0	75		25			
55 cm Layer III						
-2.0	95					5 (1)
-1.5	95					5 (2)
-1.0	95					5 (2)
-0.5	90					10 (2)
0.0	90					10 (3)
0.5	92					8 (3)
1.0	90					10 (3)
1.5	95					5 (frag)
2.0	100					
2.5	100					
3.0	100					
3.5	100					
4.0	100					
4.5	100					
5.0	100					
105 cm Layer III						
-2.0	100					
-1.5	100					
-1.0	95					5 (2)
-0.5	97					3 (1)
0.0	95					5 (2)
0.5	98					2 (2)
1.0	98					2 (1)
1.5	95					5 (2)
2.0	100					
2.5	100					
3.0	100					
3.5	100					
4.0	100					
4.5	100					
5.0	100					

Table 3, continued

Sample Ø size	% Reefal Limestone	% Charcoal Ash	% Organic Matter	% Basaltic Materials	% Bird Bone	% Land Snails
110 cm Layer III						
-2.0	100					
-1.5	95					5 (2)
-1.0	95					5 (3)
-0.5	97					3 (2)
0.0	93					7 (3)
0.5	90					10 (3)
1.0	96					4 (2)
1.5	95					5 (frag)
2.0	100					
2.5	100					
3.0	100					
3.5	99		1			
4.0	99		1			
4.5	99		1			
5.0	98		2			
200 cm Layer III						
-2.0	100					
-1.5	100					
-1.0	98					2 (1)
-0.5	100					
0.0	95					5 (2)
0.5	95					5 (3)
1.0	100					
1.5	100					
2.0	100					
2.5	100					
3.0	100					
3.5	98			2		
4.0	98			2		
4.5	98			2		
5.0	98			2		
230 cm Layer IV						
-2.0	100					
-1.5	100					
-1.0	100					
-0.5	100					
0.0	100					
0.5	100					
1.0	100					
1.5	100					
2.0	100					
2.5	100					
3.0	100					
3.5	100					
4.0	100					
4.5	100					
5.0	100					

Table 4.

Site B6-100C

Sample Ø size	% Reefal Limestone	% Charcoal Ash	% Organic Matter	% Basaltic Materials	% Bird Bone	% Land Snails*
0 - 5 cm Layer I						
-2.0	98		1		1	
-1.5	94		5			1 (1)
-1.0	88		2			10 (2)
-0.5	92		7		1	
0.0	13		2			85 (3)
0.5	14		10		1	75 (3)
1.0	10		70			20 (3)
1.5	5		90			5 (frag)
2.0	5		90			5 (frag)
2.5	5		95			
3.0	5		95			
3.5	5		95			
4.0	3		97			
4.5	3		70	27		
5.0	3		60	37		
21 cm Fire Ash Horizon						
-2.0	100					
-1.5	100					
-1.0	100					
-0.5	95		2			3 (2)
0.0	89		1			10 (3)
0.5	85		5			10 (3)
1.0	80	5	5			10 (3)
1.5	25	5	5			65 (3)
2.0	80	10	8			2 (frag)
2.5	60	35	5			
3.0	50	45	5			
3.5	40	59	1			
4.0	25	73	1	1		
4.5	20	74	1	5		
5.0	14	75	1	10		
37 cm Layer II						
-2.0	100					
-1.5	100					
-1.0	70		20		10	
-0.5	70		15		10	5 (2)
0.0	80		5	5	5	5 (2)
0.5	80		5	10	3	2 (1)
1.0	75		12	10	1	2 (1)
1.5	40		20	40		
2.0	30		30	40		
2.5	10		20	70		
3.0	5		15	80		
3.5	5		5	90		
4.0	3		2	95		
4.5	2		2	96		
5.0	1		2	97		

* Numbers in ( ) are number of species.

Table 4, continued

Sample Ø size	% Reefal Limestome	% Charcoal Ash	% Organic Matter	% Basaltic Materials	% Bird Bone	% Land Snails
50 cm Layer III						
-2.0	100					
-1.5	100					
-1.0	100					
-0.5	98		2			
0.0	97		2			1 (1)
0.5	70		5	25		
1.0	75		5	20		
1.5	80		2	18		
2.0	50			50		
2.5	15			85		
3.0	5			95		
3.5	3			97		
4.0	2			98		
4.5	2			98		
5.0	2			98		

TABLE 5

POLLEN, SPORES AND PHYTOLITHS

Site	Sample	Phytoliths	Pollen and Spores
78	0-5 cm	abundant rods	very large variety
	10 cm	abundant rods	very large variety
	15 cm	rare rods	few monoporate grains
	14cm pocket	abundant rods	few triporate and monoporat
	17cm pocket	rare rods	few monoporate grains
	35	very rare rods	None
	55cm II	very rare rods	None
	55cm III	None	None
	105cm	"	"
	110cm	"	"
	200cm	"	"
	230	"	"
100C	0 -5 cm	Abundant rods	very large variety
	21 cm	None	None
	37 cm	None	None
	50 cm	None	rare pollen

Table 6

FRESH WATER TIDAL FLUCTUATION

TIME	RECORDED HEIGHT (inches)	Published Oahu Tidal Record
1200	11.0	(Tide comming up)
1300	16.0	
1400	16.0	HIGH TIDE (2.0)
1500	16.0	
1600	15.0	
1700	1.0	
1800	0.0	
1900	0.0	
2000	0.0	
2100	0.0	LOW TIDE (0.4)

Table 7.

HYDRATION-RIND DATING

RESULTS

SITE B6 - 70

HMR Sample #	Depth	Age (A.D.)	
3099	3 cm	A.D. 1650 ± 24	H7-1
4001	93 cm	1612 ± 30	D5-2
4002	108 cm	1613 ± 28	E5-2

SITE B6- 100 C *

4000	5	no date
4003	5	"
4004	4	"
4005	6	"
4006	5	"
4007	215	"
4008	200	"

* No date possible because the glass is a chill border of basalt and contains an extreemly high concentration of titanomagnetite which renders the sample opaque. Thus, no palagonite rind can be observed.

Artifact typology and basaltic glass petrology data are located in the appendix.

TABLE 8

Number of Birds (or fraction of a Bird) Present in one square meter by 1 cm of depth in a 4 square meter sink hole.

Assumed No. of Birds/ year	Number of birds if the sedimentation rate = 1cm/ 11 years	Number of birds if the sedimentation rate = 1cm/ 45 years
1 bird/ 10 years	0.28	1.13
1 bird/9 years	0.31	1.25
1 bird/8 years	0.34	1.41
1 bird/7 years	0.39	1.61
1 bird/6 years	0.46	1.88
1 bird/ 5 years	0.55	2.25
1 bird/ 4 years	0.69	2.8
1 bird/ 3 years	0.92	3.7
1 bird/ 2 years	1.38	5.6
1 bird/ year	2.75	11.2
2 birds/ year	5.50	22.50
5 birds/ year	13.75	56.25
10 birds/ year	27.50	112.50
Time Stratigraphy for 55 cm	600 years	2500 years

SEDIMENT SIZE ANALYSIS

Statistics

Kurtosis measures the ratio between the sorting in the tails of the curve and the sorting in the central portion of the curve. If sorting is better in the central portion of the curve it is said to be leptokurtic; if the tails are better-sorted than the central portion, the curve is platykurtic. Strongly platykurtic curves are often bimodal. Mesokurtic curves are normal Gaussian probability curves. Skewness measures the degree of asymmetry and if the curve contains excess coarse or fine sediments.

Inclusive Graphic Standard Deviation is a measure of the sorting of the sediment. Graphic mean is the standard measure of the size of the sediment.

Graphic Mean: $Mz = (\emptyset 16 + \emptyset 50 + \emptyset 84)/3$

Inclusive Graphic Standard Deviation: $\frac{\emptyset 84 - \emptyset 16}{4} + \frac{\emptyset 95 - \emptyset 5}{6.6}$

Inclusive Graphic Skewness: $\frac{\emptyset 16 + \emptyset 84 - 2(\emptyset 50)}{2(\emptyset 84 - \emptyset 16)} + \frac{\emptyset 5 + \emptyset 95 - 2(\emptyset 50)}{2(\emptyset 95 - \emptyset 5)}$

Graphic Kurtosis: $\frac{0\,95 - 0\,5}{2.44\ (0\,75 - 0\,25)}$

Size Statistics

Site 78	0-5cm	10cm	15cm	14cm	17cm	35cm	55cmII	55cmIII	105cm	110cm	200cm	230cm
Graphic Mean	+2.55	+3.50	+1.08	+1.87	+0.73	+1.93	+0.70	+1.10	+2.83	+2.23	+1.41	+1.92
Inclusive Graphic Standard Deviation	+2.22	+1.79	+3.57	+3.19	+3.52	+3.34	+3.60	+3.65	+2.94	+2.78	+3.64	+3.6[illegible]
Skewness	+0.10	-0.21	-0.04	-0.17	+0.15	-0.39	+0.24	+0.02	-0.46	-0.03	-0.19	-0.52
Kurtosis	+0.62	+0.73	+0.61	+0.59	+0.76	+0.68	+0.54	+0.52	+0.92	+0.68	+0.52	+0.67

Site 100C	0-5cm	37 cm	50cm	31cm
Graphic Mean	+0.97	+2.88	+1.60	+2.83
Standard Deviation	+3.33	+3.36	+3.64	+1.48
Skewness	-0.02	-0.31	-0.60	-0.19
Kurtosis	+0.87	+1.02	+0.53	+2.05

Size Data Weight Percent

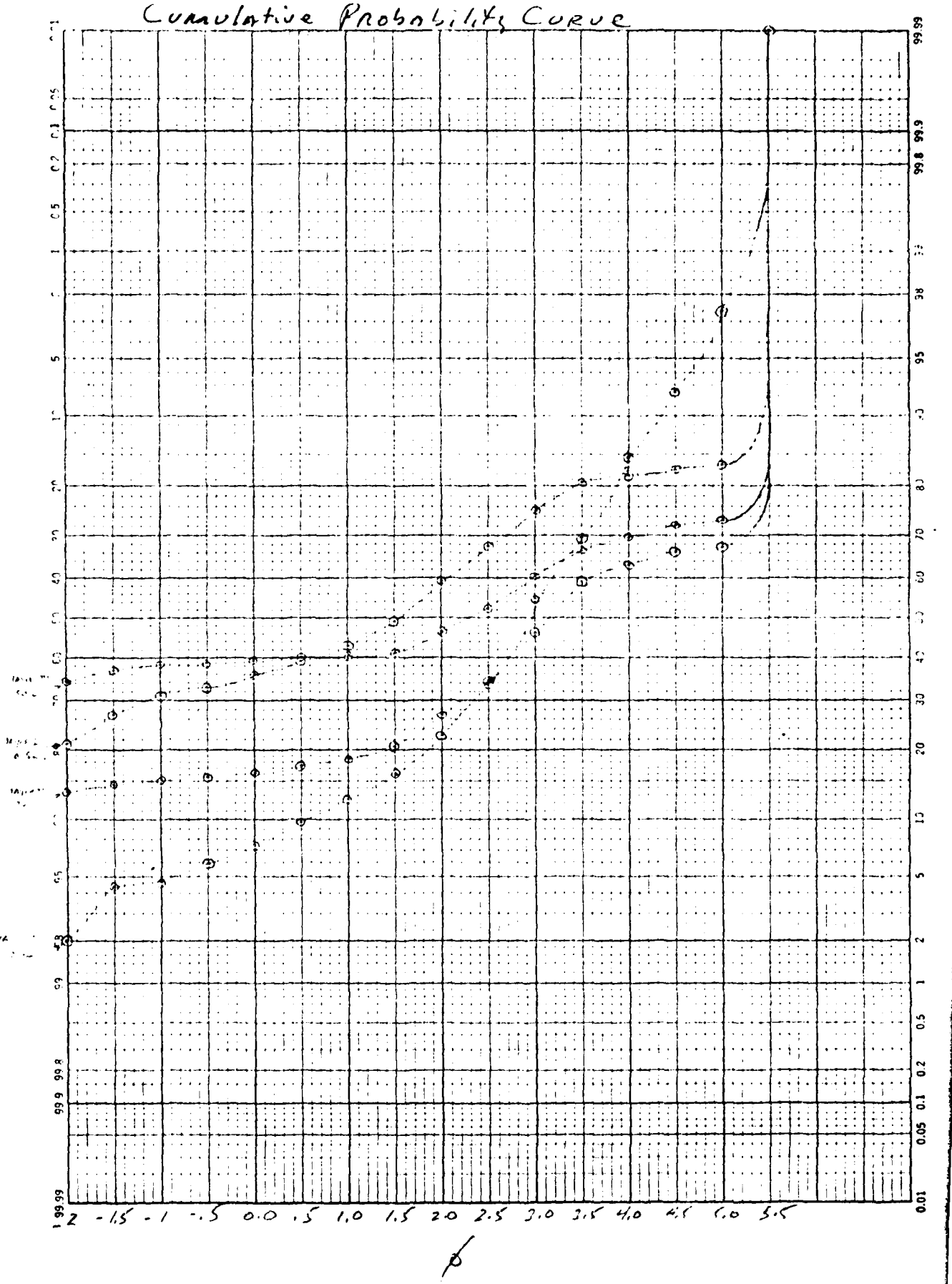
Site 78

ø	0-5cm	10cm	15cm	14cm	17cm	35cm	55cmII	55cmIII	105cm	110cm	200cm	230cm
-2.0	1.03	1.87	37.27	15.37	33.73	18.33	43.40	26.97	11.07	5.03	26.47	20.63
-1.5	2.30	0.77	2.80	5.63	5.66	1.77	3.30	1.93	1.27	2.60	2.40	1.37
-1.0	3.33	0.93	2.10	4.07	3.27	1.67	1.90	3.00	1.90	1.63	1.83	0.93
-0.5	3.23	0.93	1.80	3.17	3.70	2.03	1.37	2.90	1.77	3.27	1.97	1.63
0.0	2.66	0.70	1.97	3.07	3.67	2.10	1.10	2.10	2.00	4.93	1.90	1.83
0.5	6.80	0.67	2.03	3.63	3.67	2.34	1.00	2.13	1.76	6.67	2.40	2.01
1.0	9.96	1.40	2.33	5.00	4.77	3.27	0.94	1.50	2.67	8.10	4.30	2.73
1.5	9.00	7.00	2.07	5.60	7.27	3.03	1.23	2.57	6.63	8.70	5.76	4.33
2.0	9.26	8.30	2.33	3.00	5.20	3.57	2.37	3.27	3.73	8.17	5.27	4.10
2.5	8.38	7.93	5.40	8.03	3.00	7.73	4.13	4.67	9.77	5.70	3.83	3.97
3.0	7.39	8.37	6.30	6.70	2.00	5.03	3.80	5.97	1.57	4.87	3.30	3.73
3.5	3.63	9.53	4.67	5.73	2.47	5.83	6.83	2.73	6.97	3.13	3.00	6.57
4.0	3.00	5.33	2.63	1.33	0.70	2.73	1.60	1.40	1.00	1.70	1.47	0.97
4.5	2.30	5.03	1.47	1.37	0.60	3.07	0.73	1.00	1.43	1.73	1.00	1.63
5.0	1.33	1.17	1.63	1.67	1.16	1.37	1.00	1.70	1.96	1.27	0.87	1.47
+5.0	26.40	40.07	23.20	26.63	19.13	36.13	25 30	36.16	44.50	32.50	34.23	42.10

Site 100C

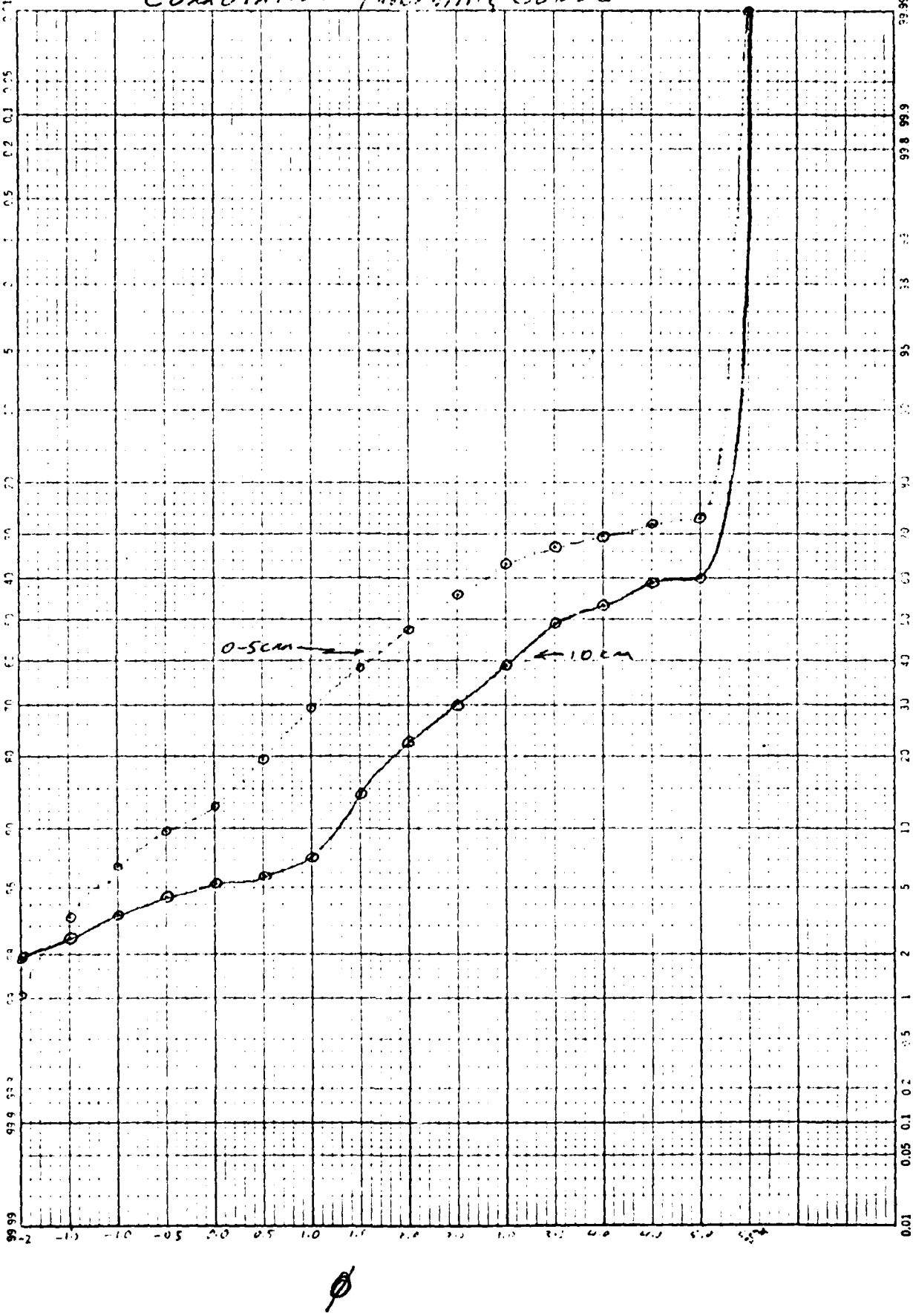
ø	0-5	37	50	21
-2.0	21.40	13.37	34.17	2.00
-1.5	5.57	1.27	2.63	2.37
-1.0	3.97	0.43	1.23	0.37
-0.5	2.07	0.63	0.67	1.25
0.0	3.03	0.70	0.61	1.50
0.5	3.00	0.93	0.67	2.37
1.0	3.66	1.00	0.70	2.50
1.5	6.40	2.30	1.00	3.74
2.0	10.57	5.97	4.63	6.63
2.5	8.20	7.60	6.03	11.88
3.0	7.30	11.80	8.10	20.00
3.5	5.47	13.43	6.00	15.13
4.0	3.16	4.00	3.43	15.00
4.5	2.03	2.73	2.40	7.50
5.0	0.57	1.67	1.40	5.13
±5.0	13.60	32.17	26.33	2.63.

Cumulative Probability Curve



LAYER I

Cumulative Probability Curve



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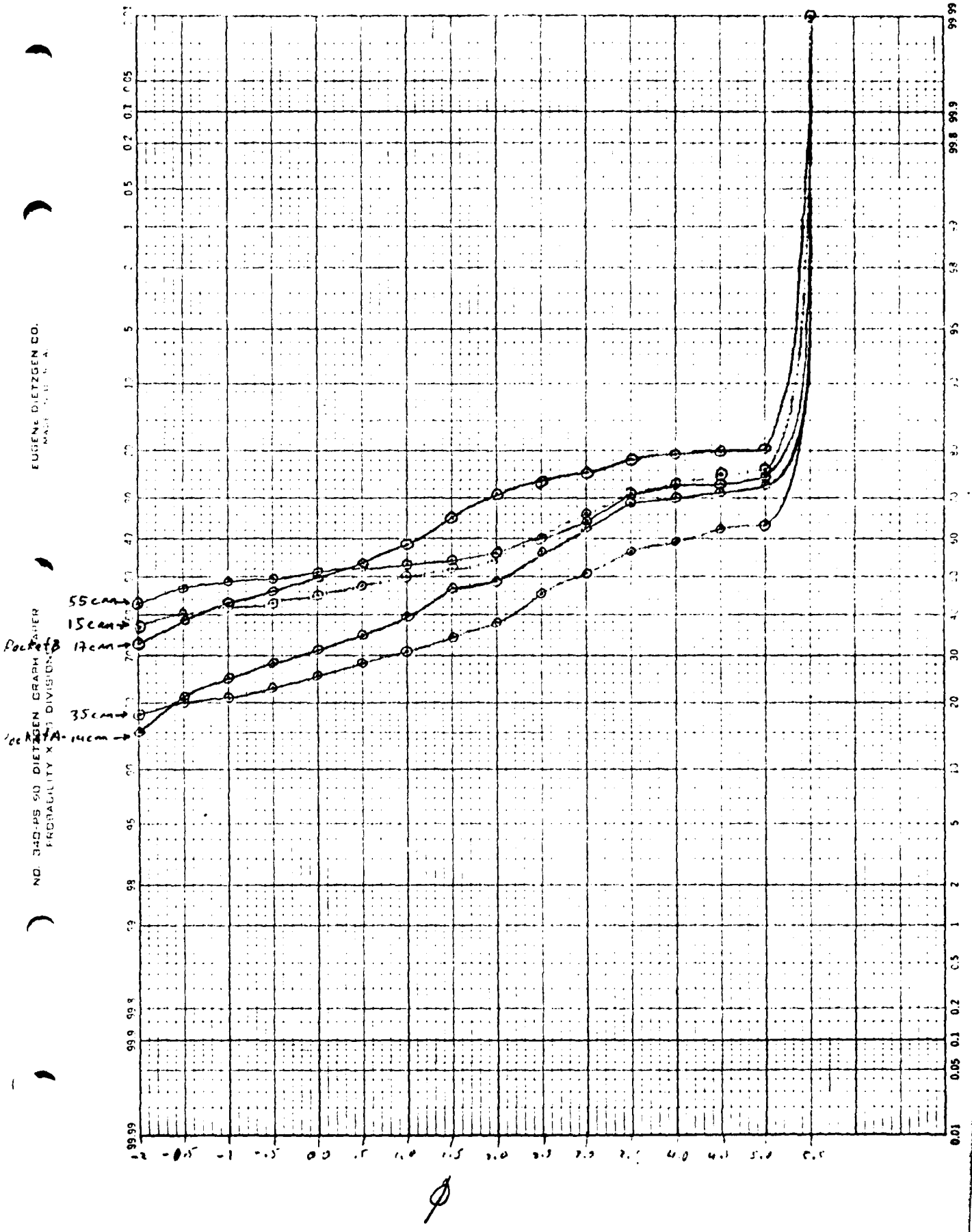
55cm
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EUGENE DIETZGEN CO.
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PROBABILITY X DIVISIONS
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NO. 340-PS-10 DIETZGEN GRAPH PAPER
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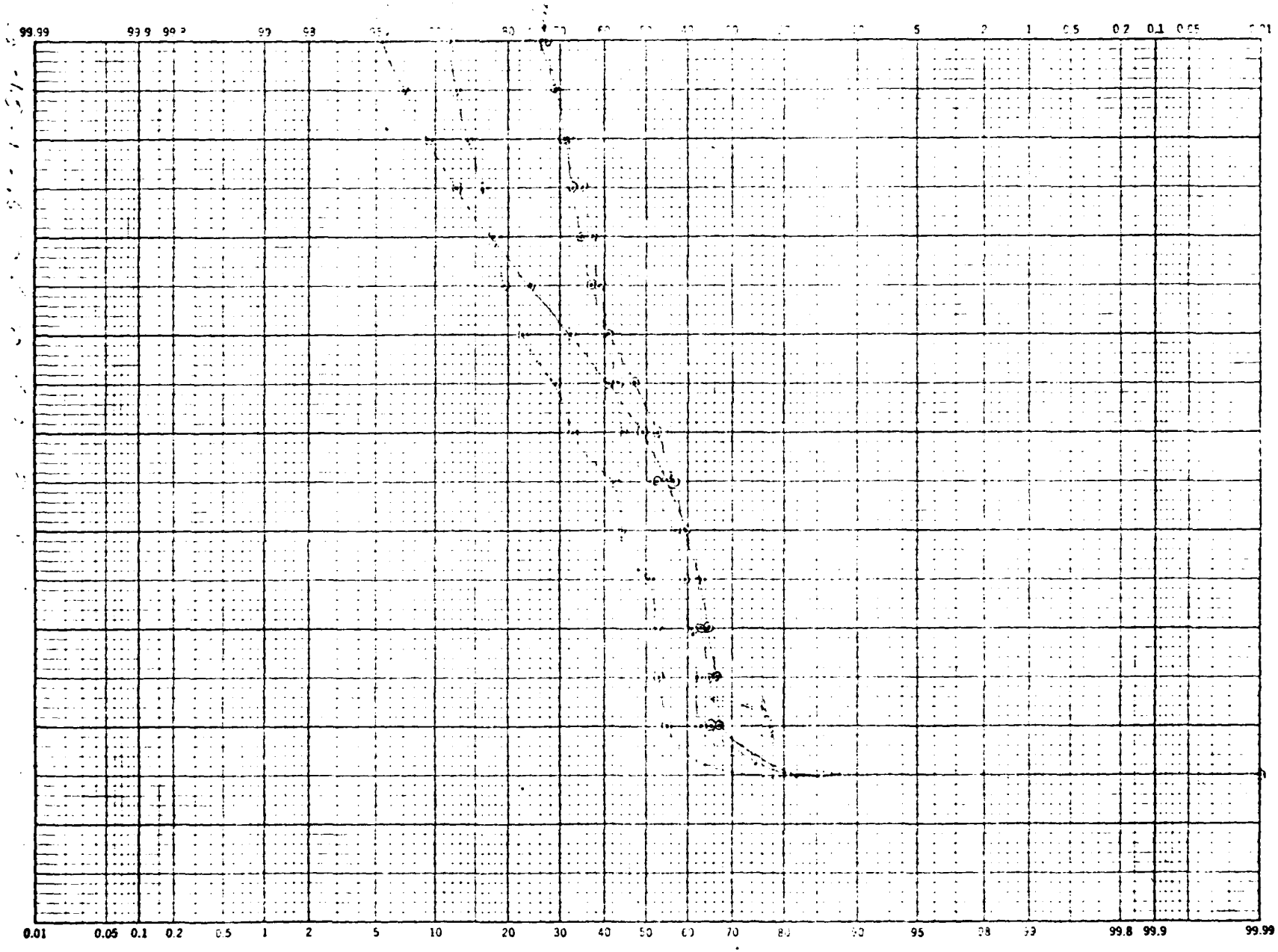
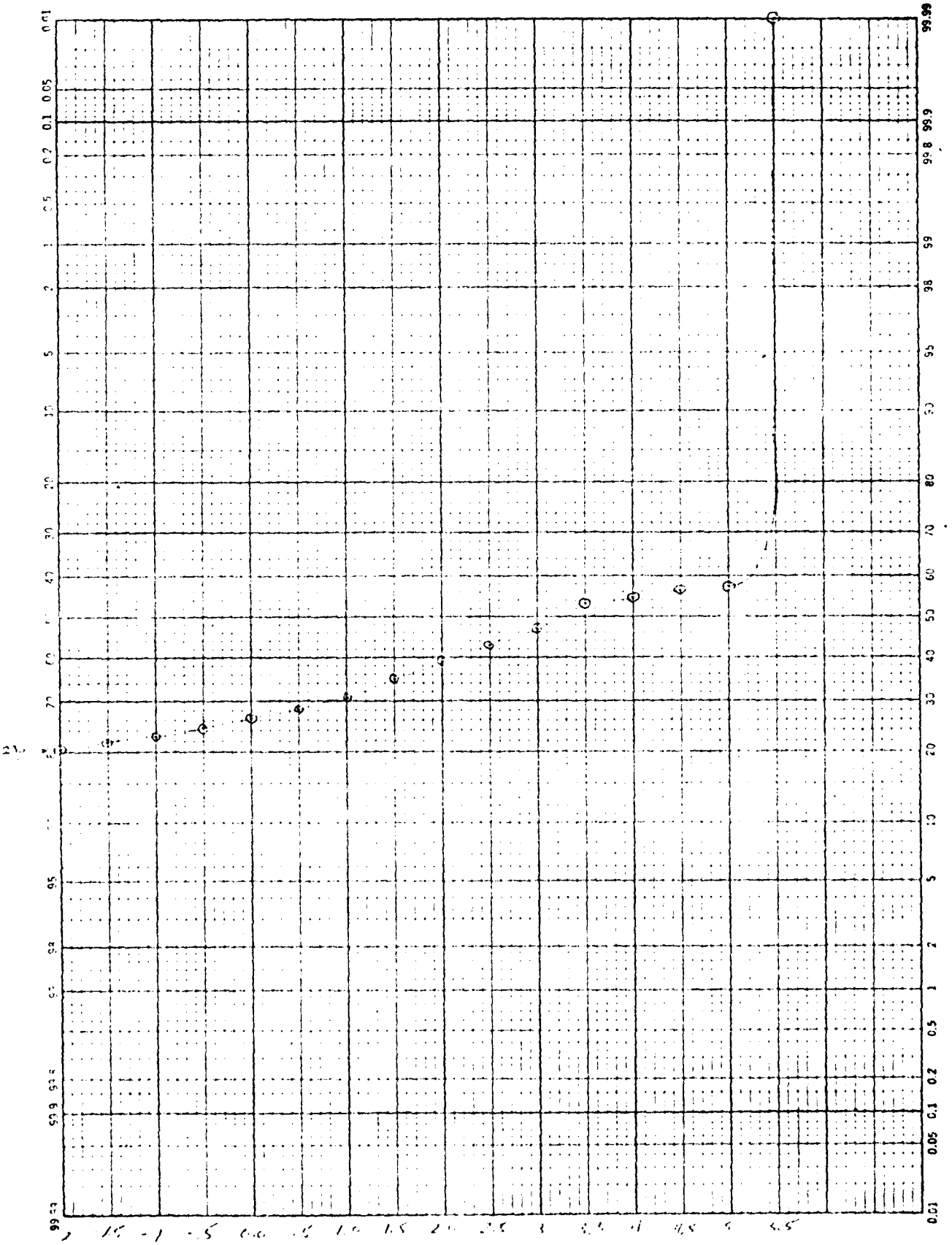
MADE IN U.S.A.



SITE 78
LAYER IV



BARBERS POINT BASALTIC-GLASS PETROLOGY

HMR #3099 Sideromelane, medium-dark brown, opaque dust uniform. Ferruginous spherules--small to medium in size and randomly scattered throughout. Vesicles very small-small, abundant, and elongated in the direction of parent flow. Small olivenes with iddingsite alteration present but uncommon. Microlites of calcic - plagioclase flow-oriented, associated with ferruginous alteration and common. Cortex present as palagonite.

HMR #4000 High magnetic content renders sample opaque.

HMR # 4001 Sideromelane, medium-brown, opaque dust uniform. Ferruginous spherules very small and very rare. Vesicles very small-small, slightly flow-oriented, and common. Small olivenes with idding-site alteration present but rare. Small fractured lathes of calcic - plagioclase, flow-oriented, and uncommon. Microlites of calcic - plagioclase, flow-oriented and uncommon.

HMR #4002 Sideromelane, medium-brown, opaque dust uneven. Ferruginous spherules small and concentrated in linear clusters, sample void of vesicles. Small to medium exolved olivine, some pyroxenes, exolved, fractured with titanomagnetite, uncommon. Small, fractured laths of calcic-plagioclase randomly oriented and uncommon. Micro-lites of calcic-plagioclase, flow-oriented and common.

BARBERS PT. [illegible] 86
BISHOP

HMR#	Sample Prov	Sample type	Wt gm.	L cm	Width cm	Thick cm	L of Bulbar Scar	Angle of Bulbar Scar to S.P.	Spec Gravity	Bi or Uniface Edge Wear	Edge Charac	Cortex on S.P.	Cortex on - side	# of Surfaces	# of Flake Scars	Bulbar Percussion	Bulbar Scar
3077	B6-70-[illegible]-1 3 [illegible]	FLAKE	.53	1.3[illegible]	1.12	.47	.32	45	2.5[illegible]	-	SHARP [illegible]	YES	NO	-	3	YES	YES
4002	[illegible]-C-2 [illegible]	FLAKE	.4[illegible]	1.19	1.11	.22	.32	45	[illegible]	-	[illegible]	YES	YES	1	1	YES	YES
4001	B6-70-[illegible]-2 93 [illegible]	FLAKE	.2	.6[illegible]	[illegible]	[illegible]	.1[illegible]	7[illegible]	[illegible]	-	SHARP [illegible]	NO	YES	1	1	YES	YES
4002	B6-70-[illegible]-2 105 [illegible]	FLAKE	.2[illegible]	[illegible]	1.15	.30	.07	135	2.8[illegible]	UNI	SHARP [illegible]	YES	YES	1	2	YES	YES
4003	B[illegible]-6 [illegible]	FLAKE	.1[illegible]	1.0[illegible]	1.23	.17	.13	1 0	[illegible]	-	SHARP [illegible]	[illegible]	YES	1	1	YES	YES
[illegible]	B[illegible]	FLAKE	[illegible]	.7[illegible]	.81	.12	-	115	[illegible]	-	SHARP [illegible]	YES	YES	2	2	YES	YES
4005	[illegible]	FLAKE	-	[illegible]	.7[illegible]	.22	.14	2[illegible]	[illegible]	-	SHARP [illegible]	YES	[illegible]	-	2	YES	YES
[illegible]	[illegible] C-2	FLAKE	[illegible]	1.3[illegible]	1.[illegible]	.42	.0	90	2.[illegible]	-	SHARP [illegible]	YES	YES	2	2	YES	YES
[illegible]	[illegible]	FLAKE	[illegible]	1.2	.45	.26	-	-	[illegible]	-	SMOOTH [illegible]	NO	YES	1	1	YES	NO
4008	B[illegible]	FLAKE	.1[illegible]	.[illegible]	.77	.20	.20	85	[illegible]	-	SHARP [illegible]	NO	YES	1	1	YES	YES

# of Surfaces	# of Flake Scars -	Bulbar Percussion	Bulbar Scar	Ripple Marks	Fissures	Impact Crater	Descrip & L of Impact Crater	Descrip & # of Edges	# of Flake Scars +	# of Flake Scar Angle to S.P. -	Descrip for S. P. Side Struck Flake Scar	Megascopic Descrip of Sample	Core & Flake Shape	Source Data	Mean Age Yrs A. D.
-	3	yes					.20	-	2	N->S	NE->SW				
1	1	yes					.29	-	1	N->S	-				
1	1	yes					.10	-	1	N->S	-				
1	2	yes					.16	-	1		-				
1	1	yes					.19	-	1	N->S	-				
2	2	yes					.12	-	1						
-	2	yes					.16	-	1		-				
2	2	yes	yes	yes	yes	yes	.11	-	1						
1	1	yes	yes	yes	yes	yes	.25	-	1	N->S	-				
1	1	yes	yes	yes		yes	.12	-	1	N->S	-				

Sample	Location	Depth from Surface	No. of Traverses	Name of Glass	Range in Rind Thickness μ	Average Thickness μ	Quali Surf Dat
3099	B6-70-47-1 3cm	3cm	10	Sideromelane	4.04 - 3.66	3.85	VERY G
4000	B6-100-C-2 5cm	5cm	0	No Date Possible - High titano			
4001	B6-70-D5-2 93cm	93cm	10	Sideromelane	4.43 - 4.04	4.30	Good
4002	B6-70-E5-2 108cm	108cm	10	Sideromelane	4.43 - 4.04	4.28	Good
4003	B6-100-C-6 5cm	5cm	0	No Date Possible - High titano			
4004	B6-100-C-7 4cm	4cm	0	"			
4005	B6-100-C-10 6cm	6cm	0	"			
4006	B6-100C-11 5cm	5cm	0	"			
4007	B6-100-C-12 215cm	215cm	0	"			
4008	B6-100C-13 200cm	200cm	0	"			

Range in Rind Thickness μ	Average Thickness μ	Quality of Surface Dated	Ave. Date BP	Total ± Years	Date BP	Corres. Date A.D.	Remarks
3.64 – 3.66	3.85	Very good	327	24	327±24	1650±24	
Possible – High titanomagnetite glass – chilled Basalt border.							No Date
3.93 – 4.04	4.30	Good	365	30	365±30	1612±30	
3.93 – 4.04	4.28	Good	364	28	364±28	1613±28	
Possible – High titanomagnetite glass – chilled Basalt Border							No Date
							"
							"
							"
							"
							"
							"

2

GLOSSARY

Apedal - Without peds.

Biocoenose - A living community.

Bioturbated - Biologically churned sediment.

Climax community - The well-developed community located in a particular habitat under stable conditions.

Clisere - Succession of climax communities in an area, resulting from major physiographic changes.

Diagenetic - Chemically produced *in situ* after deposition.

Facies - A lateral change in sediment type.

Ped - Cohesive aglomerate of soil produced during soil formation.

Phi Ø - Size scale used for sediment size analysis (see Folk 1968).

Phytolith - An opaline structure found in grasses, and generally located in the leaf of the grass.

Saprolite - *In situ* chemically weathered rock.

Taphocoenose - Burial assemblage.

Thanatocoenose - Death assemblage.

Ms. 120777

APPENDIX II

Report on Recent and Subfossil Land Mollusca From Barbers Point, Oahu

P. V. Kirch
B. P. Bishop Museum

INTRODUCTION

Recent archaeological investigations at Barbers Point, Oahu, have produced--in addition to evidence of prehistoric human occupation--a large quantity of fossil bones representing several new genera and species of endemic birds (Sinoto Ms.). These bird bones, from sinkholes in the upraised reefal limestone terrain, are also associated with recent and subfossil land mollusca. Three samples of these snails, all from Site OA-B6-78 (overburden, Layer I, and Layer II) were given to me by A. Sinoto, Field Director, for identification. Land snails are excellent indicators of ancient environmental conditions (Evans 1972) and might serve such a purpose in the Barbers Point situation. For the present, however, the limited nature of the available samples (which must be considered non-quantitative) necessitates a cautious approach.

The specimens from the "overburden" sample are obviously recent. A few of the endodontids, for example, retain traces of their periostracum. In contrast, specimens from Layers I and II appear increasingly to be subfossilized, suggestive of a potentially greater age.

All specimens were identified by comparison with the type and synoptic collections of the Malacology Division, B. P. Bishop Museum. In some cases an exact determination was not possible, and the specimens are referred (cf.) to the closest species. Type specimens used for comparison are cited by catalog number. I thank Dr. Yoshio Kondo for graciously allowing me access to the Malacology Division's collection and for his succinct advice.

SYNOPSIS OF THE TAXA

PULMONATA (:STYLOMMATOPHORA)

Family Zonitidae

Striatura (Pseudohyalina) meniscus (Ancey)

Compared to holotype (BBM # 18876). The Barbers Point specimens are more strongly ribbed. A species endemic to the Hawaiian Island, both recent and subfossil; living under stones, in forest litter, on moss (Baker 1941:325).

Family Endodontidae

Endodonta frickii (Pfeiffer)

Compared to ideotype (BBM # 10351). This endemic species is widely distributed in the Waianae Mountains, Oahu (Solem 1976:382).

Family Subulinidae

cf. *Opeas javanicum*

Compared to BBM # 14991. The Barbers Point specimens probably belong to this, or to a closely related, species of this widespread genus.

Family Succineidae

cf. *Succinea caduca* Mighels

Compared to BBM # 10955. The *Succinea* are difficult to identify solely on their shells, but the Barbers Point specimens seem to belong to this common lowland species.

Family Achatinellidae-Tornatellinidae

Lamellidea oblonga (Pease)

There is no doubt as to the assignment of the Barbers Point specimens to this extremely widespread, apparently synanthropic, species (see Cooke and Kondo 1960:196-209).

cf. *Tornatellides serrarius* Pilsbry and Cooke

Compared to BBM # 38422. Three specimens from Barbers Point may belong to this species, or to a closely related tornatellinid species.

Family Amastridae

Leptachatina cookei Pilsbry

Compared to paratype (BBM # 35653). The species apparently is endemic to the Waianae Mountains (Pilsbry and Cooke 1915-16:9-10).

Leptachatina subcylindracea Cooke

Compared to BBM # 33466. This species is known from Pleistocene and Holocene fossil deposits on Oahu, Molokai, and Kahoolawe, and is presumably extinct (Pilsbry and Cooke 1915-16:11-12).

Family Pupillidae

Gastrocopta lyonsiana (Ancey)

Compared to BBM # 18772. This species was represented only in the overburden sample at OA-B6-78.

cf. *Lyropupa lyrata fossilis* Cooke and Pilsbry

Compared to BBM # 41001. The specimens from Barbers Point were provided by M. Morgenstein, who recovered them from a "deep" sample during his geological investigations. *Lyropupae* are ground- or litter-dwelling species abundant in Pleistocene and later deposits (Pilsbry and Cooke 1918-20:227). (The Barbers Point specimens also compared closely with BBM # 15216, *Lyropupa cylindrata*).

PROSOBRANCHIA (:ARCHAEOGASTROPODA)

Family Helicinidae

Pleuropoma laciniosa (Mighels)

Compared to BBM # 35362 (variety *laula*) and to BBM # 93329 (variety *ferruginea*). *P. Laciniosa* is a ground- or litter-dwelling species, represented by nine named varieties on Oahu, and 14 additional varieties from other Hawaiian Islands (Neal 1934).

COMMENTS

The presence of 11 species of land mollusca (in 8 families) at Barbers point, an assemblage almost as varied as that from recent deposits at Halawa Valley, Molokai (Kirch 1972, 1975), is suggestive of some potential for environmental reconstruction. The possibilities are made especially

intriguing by the association of these subfossil snails with several new taxa of extinct Hawaiian birds. Interestingly, the Barbers Point species include both local endemics and widespread--aparently synanthropic--species.

For the present, however, restrictions in the available samples dictate a cautious approach. Thus I conclude solely with some suggestions for further field investigations: 1) a wider range of sites and sinkholes should be sampled for land mollusca, at all stratigraphic levels; 2) carefully controlled column samples, at 5 to 10 cm intervals, need to be obtained; 3) samples should be fine-screened to ensure complete representation of all species, including minutiae; and 4) a survey should be made of the contemporary, living land molluscan fauna of Barbers Point, to serve as a control for interpretation of the subfossil assemblages.

Table 1

Stratigraphic Distribution of Land Snails From Site OA-B6-78

	Overburden	Layer I	Layer II
PULMONATA (STYLOMMATOPHORA)			
Zonitidae			
Striatura meniscus	X	X	X
Endodontidae			
Endodonta frickii	X	X	X
Subulinidae			
cf. *Opeas javanicum*	X	X	X (1)
Succineidae			
cf. *Succinea caduca*	X	X	X (1)
Achatinellidae-Tornatellinidae			
Lamellidea oblonga	X	X	X
cf. *Tornatellides serrarius*	X		
Amastridae			
Leptachatina cookei	X	X	X
Leptachatina subcylindracea	X	X	X
Pupillidae			
Gastrocopta lyonsiana	X		
cf. *Lyropupa lyrata fossilis*			(X)
PROSOBRANCHIA (ARCHAEOGASTROPODA)			
Helicinidae			
Pleuropoma laciniosa	X	X	X

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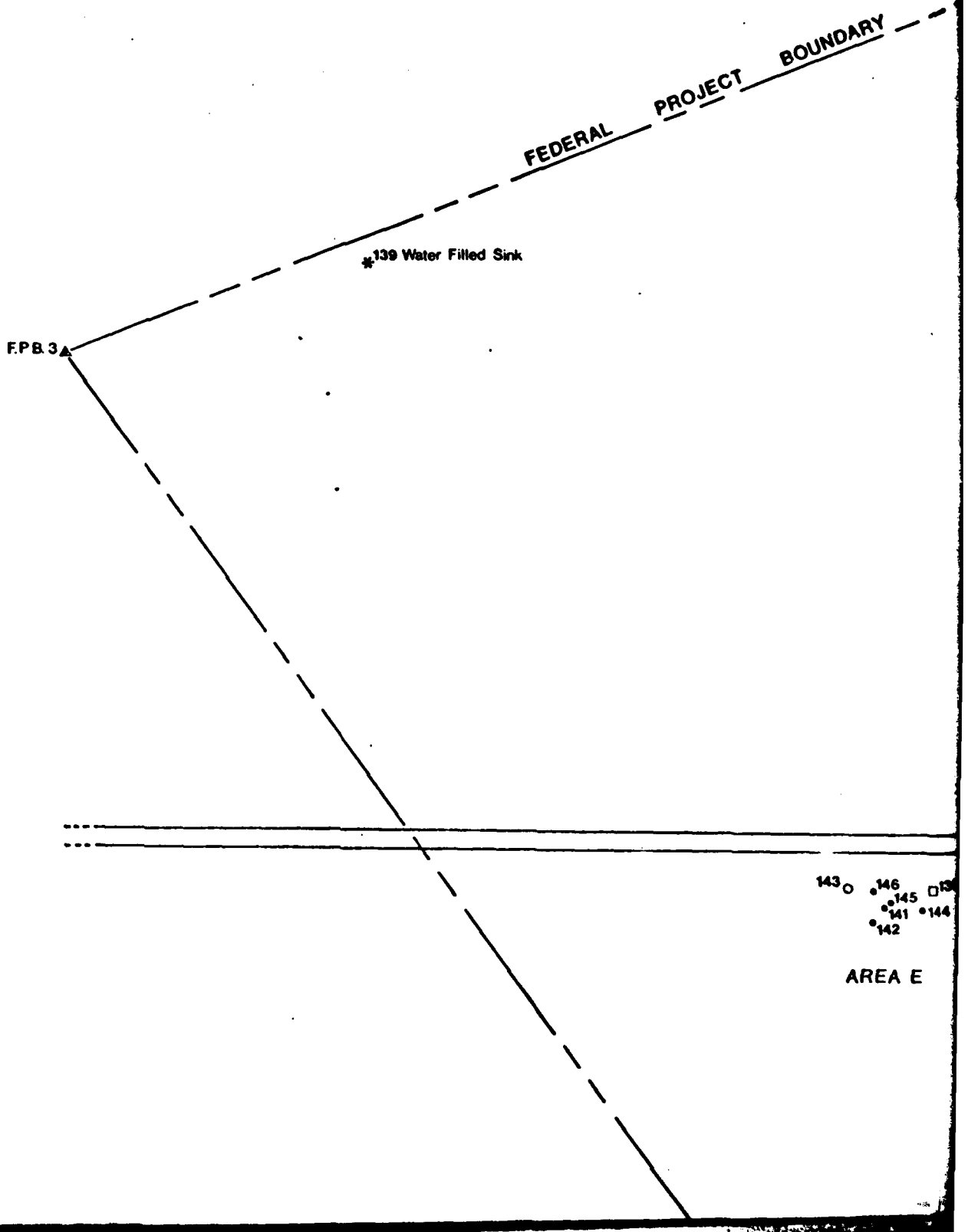

FEDERAL PROJECT BOUNDARY
*139 Water Filled Sink
F.P.B. 3
143
146
145
141
144
142
AREA E

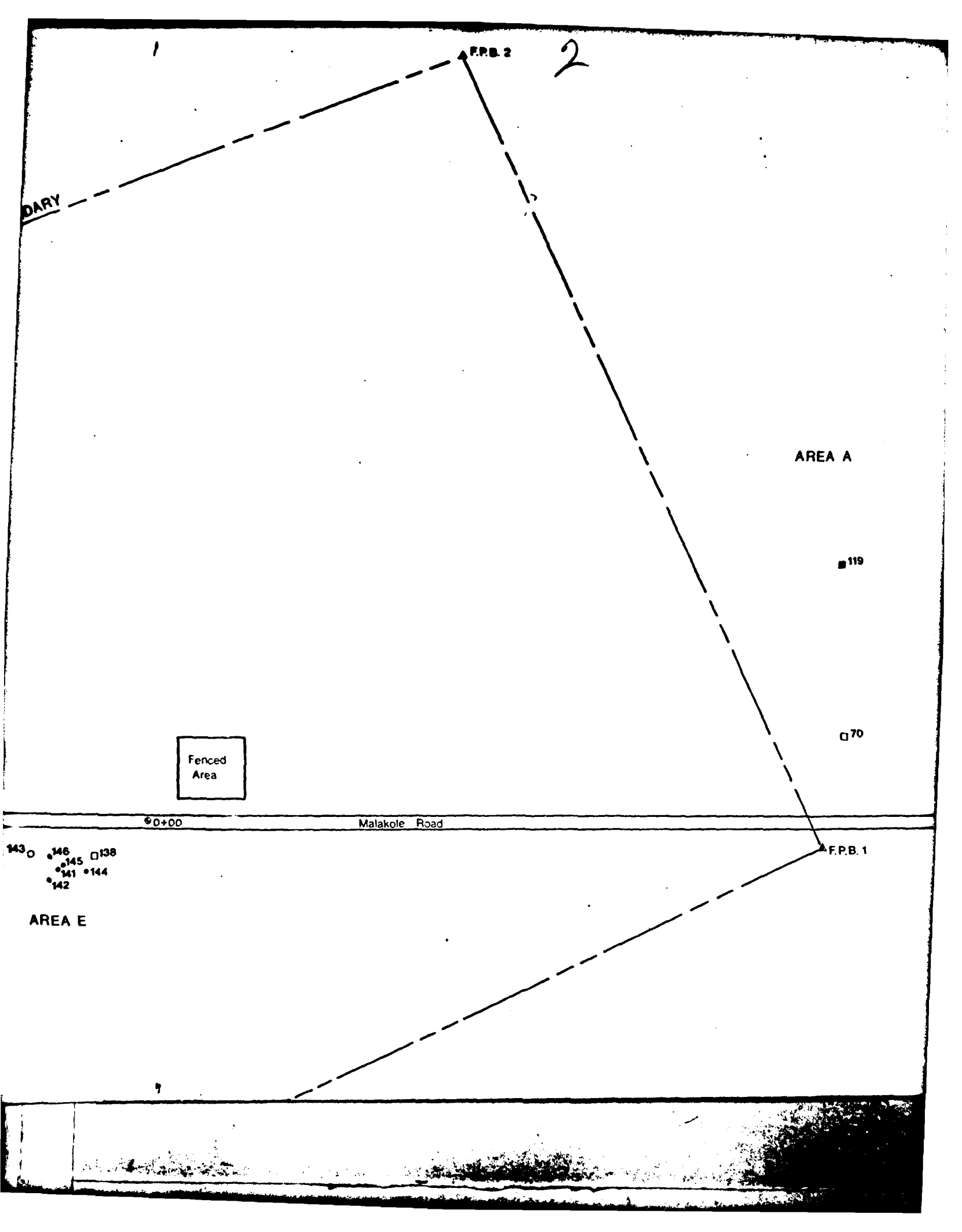
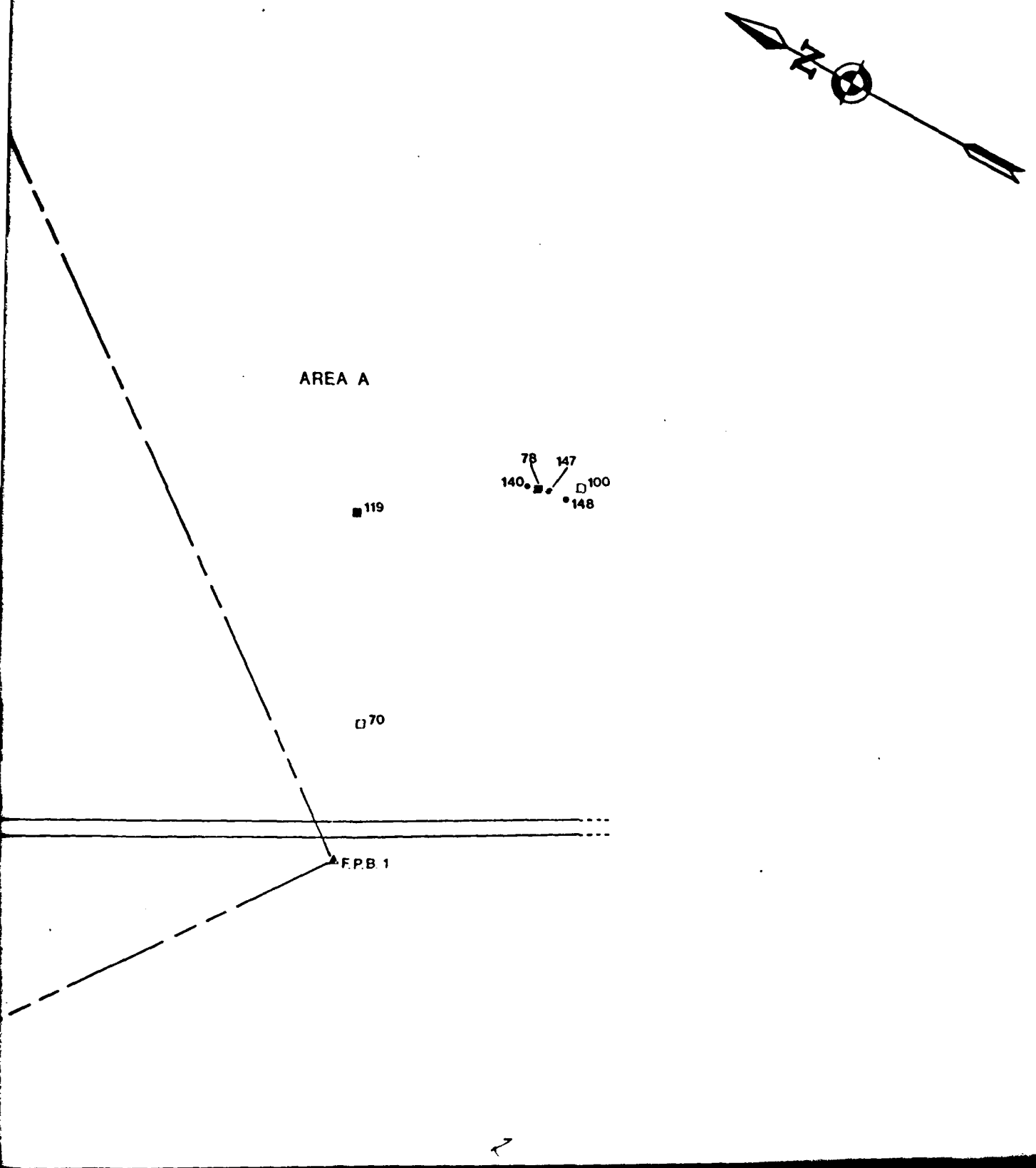
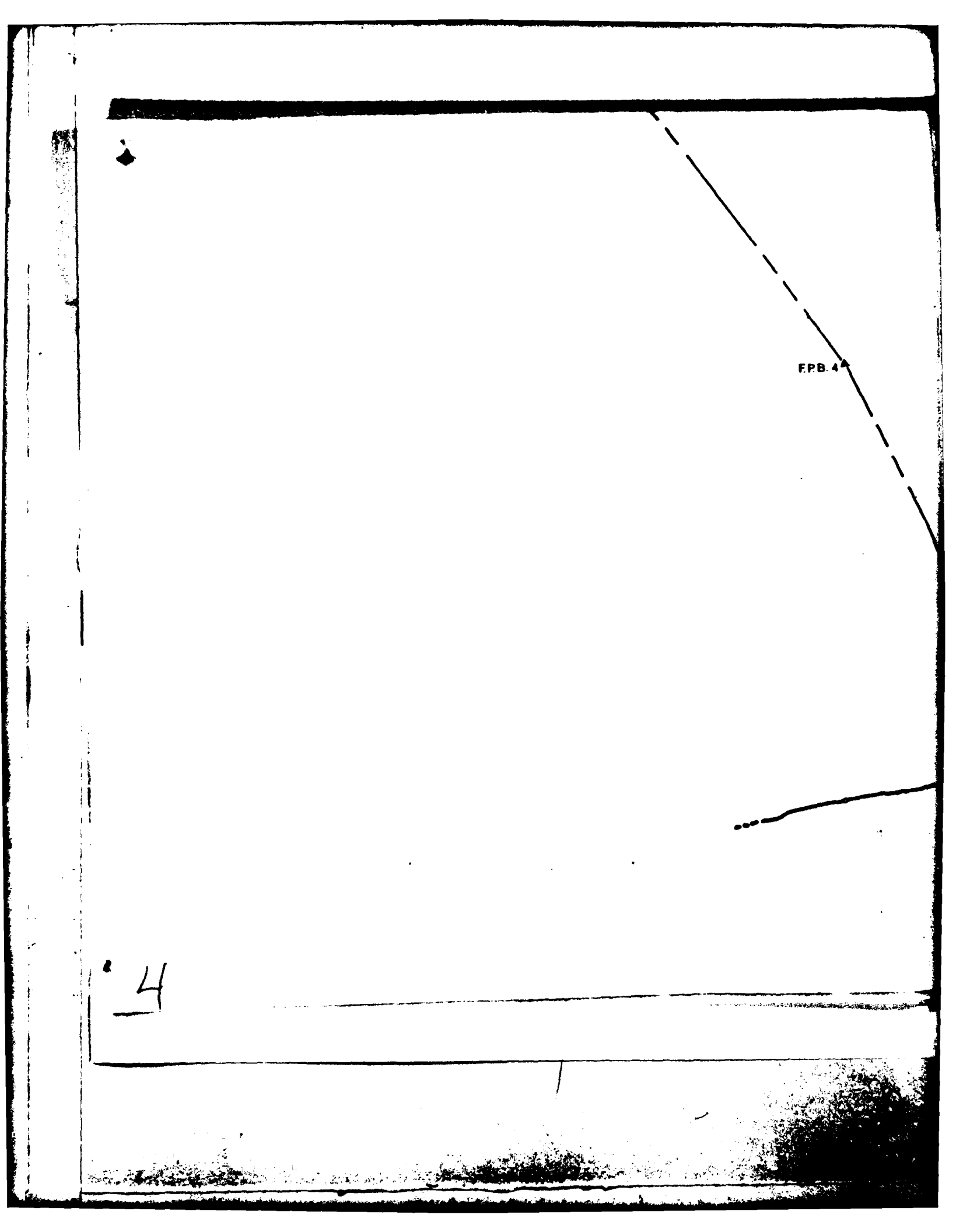

1
F.P.B. 2
2
DARY
AREA A
119
70
Fenced
Area
0+00
Malakole Road
F.P.B. 1
143
146
145
138
141
144
142
AREA E

Fig. 2. OVERALL SITE LOCATION MAP.

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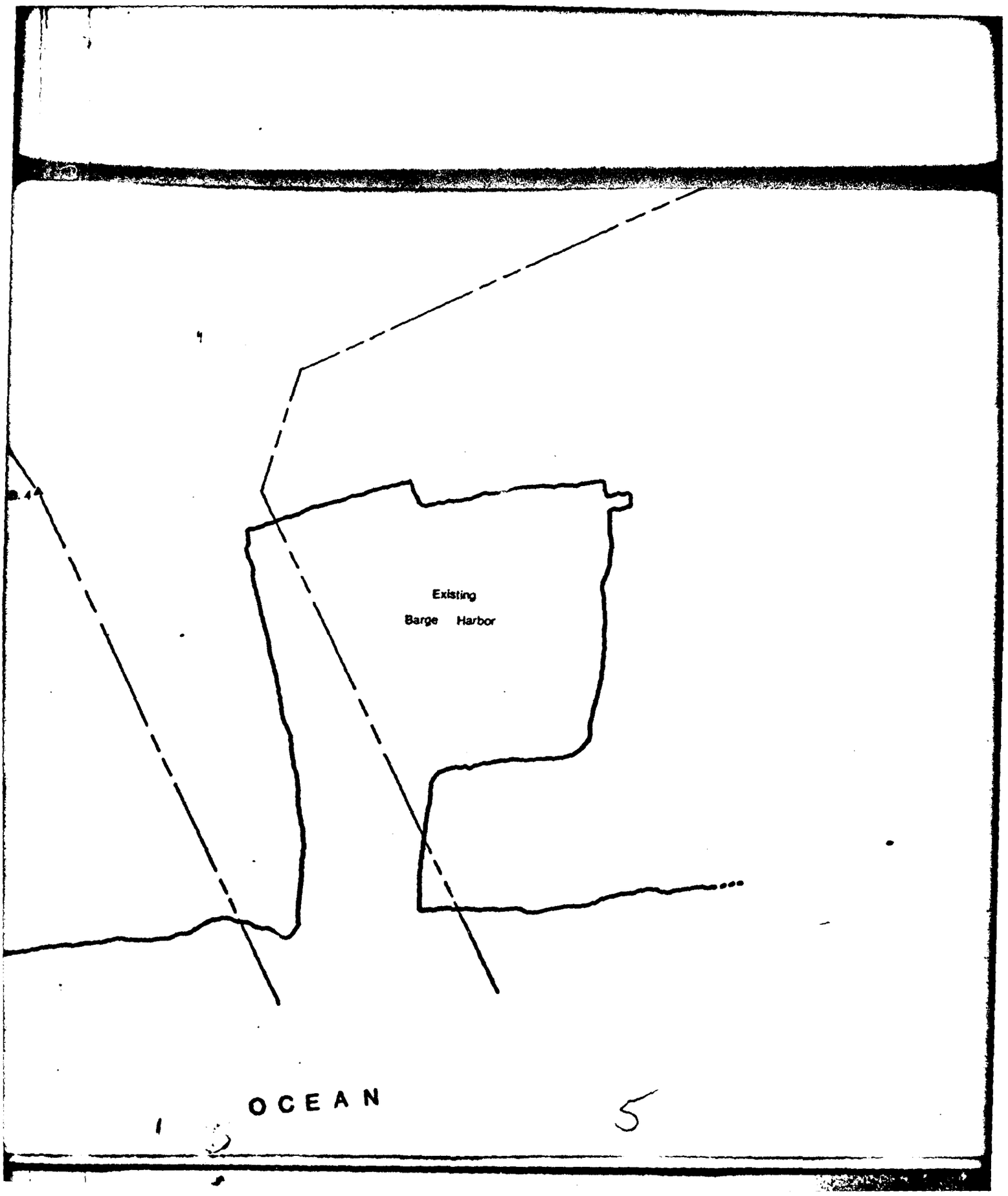
Existing
Barge Harbor
OCEAN

BARBERS POINT SALVAGE

SEPTEMBER, 1977

■ Archaeological Site
□ Archaeological Site Complex
• Paleontological Site
○ Paleontological Site Complex

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