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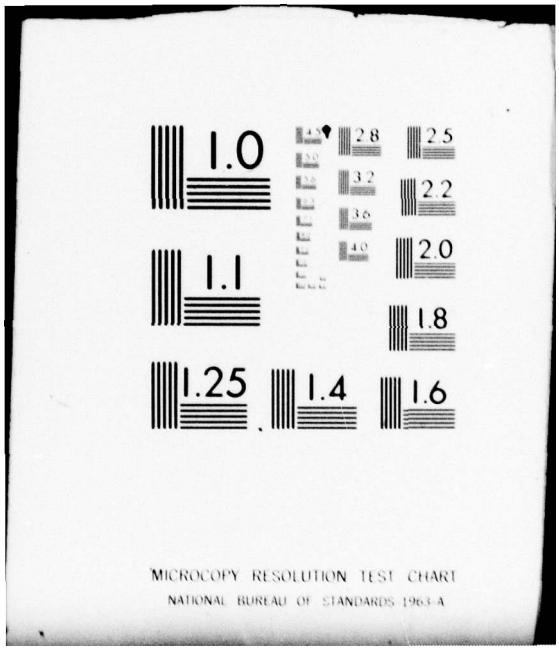
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HENDERSON SEAMOUNT GEOLOGICAL DATA

PATRICK T. TAYLOR, CODE 362

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Sea Floor Division
Naval Oceanographic Laboratory

January 1978

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NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY
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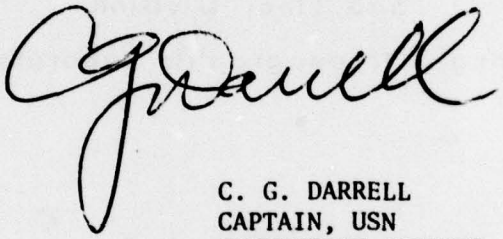
NSTL Station, Mississippi 39529

FOREWORD

This report describes in detail the morphology and micro-topography of the Henderson Seamount. A comparison is made between the surficial characteristics of this seamount and other typical seamounts of the Pacific Ocean region. NORDA Code 351 was evaluating the Naval Underwater Systems Center (NUSC) towed parametric sonar source proposed for detecting bathymetric shoals. The NUSC sensor was tested in the vicinity of the Henderson Seamount, therefore, these data represent "ground truth" which can be used by Code 351 in their interpretation and evaluation of the parametric sonar data.



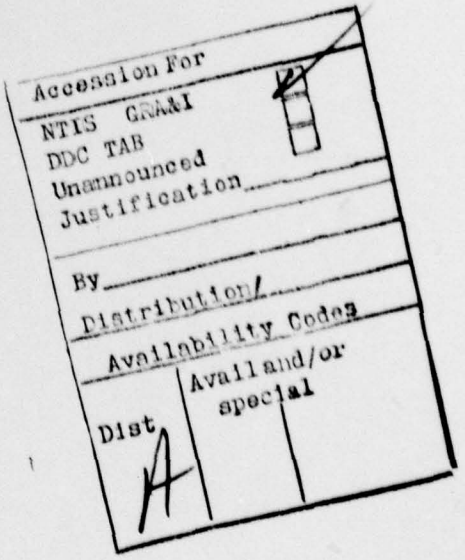
C. G. DARRELL
CAPTAIN, USN
COMMANDING OFFICER

EXECUTIVE SUMMARY

During February 1976, Naval Ocean Research and Development Activity (NORDA) Code 360 conducted geological operations over the Henderson Seamount in support of the Naval Underwater Systems Center TOPS test (Carlton and Crooks, 1976). Geologic data were obtained.

An interim report on the analyses of these geologic data was prepared on 21 October 1976 (Code 360:PTT:1t). This report discussed bathymetric "total slope" analysis of the Henderson Seamount.

In this final report, microtopography, sediment cover, and bottom roughness are discussed for the Henderson Seamount as well as other selected Pacific Ocean seamounts.



CONTENTS

ILLUSTRATIONS

HENDERSON SEAMOUNT GEOLOGICAL DATA

I. INTRODUCTION

This report presents an analysis of geologic data (bottom photographs, sediment cores, seismic profiler records, and dredged samples) from the Henderson Seamount, Eastern Pacific Ocean (Fig. 1). These data were gathered in support of the acoustic backscattering measurements made by the Naval Underwater Systems Center (NUSC) (Carlton and Crooks, 1976). Discussion of these geologic measurements, therefore, will be made with respect to the acoustic results, i.e., an interpretation of microtopography, sediment distribution, and small-scale slopes will be emphasized.

In order to compare Henderson Seamount with other Pacific Ocean Seamounts, bottom photographs were obtained from Lamont-Doherty Geological Observatory. The location of these Lamont photographs relative to Henderson Seamount is given in Figure 2.

A discussion of the bathymetric slopes of the entire Henderson Seamount (i.e., from the abyssal plain to the peak) was given in the interim report (Code 360:PTT:1t dated 21 October 1976). Analyses of three sediment cores obtained from the abyssal plain surrounding Henderson (Fig. 1) were made by Ross et al. (1976).

In this final report, we will discuss in detail the results from the photographic coverage of the Henderson Seamount, and how our data compare with the photos obtained by ships of Lamont-Doherty Geological Observatory on various Pacific Ocean seamounts.

II. MICROTOPOGRAPHY

A morphologic description of the ocean bottom, as revealed by the bottom photographs, is defined as microtopography. All the photographs obtained on the Henderson Seamount were taken with the same camera configuration. These data, therefore, are uniform with respect to inclination of camera with the horizontal and len's depth of focus. A strict comparison of our data with the Lamont photographs is not justifiable, since the latter employed various camera configurations, some even in a perpendicular mode. Nevertheless, since it is essential to determine how "typical" the Henderson Seamount is, a comparison of the two data sets will be made.

Microtopography has been divided into several aspects. Major slope is defined as the angle at which the largest percentage of surface area, as depicted in the field of the photograph, deviates from the horiziontal, whereas the minor slope refers to the next largest, in areal extent, sloping surface. Usually, the latter is numerically greater than the former, since small ledges and rock outcrops can maintain nearly vertical surfaces. The angular trend of the entire area revealed by the photograph is used to

determine the major slope, whereas the minor slope may represent a region of a few centimeters or up to one meter. Histograms of the major and minor slopes for both the Henderson and the Lamont data sets are given in Figures 3-6.

For the Henderson Seamount, we find a bimodal distribution of major slopes: (1) the abyssal plains are approximately horizontal, (2) the upper slopes display a normal distinction with a 26-30° mode (Fig. 3). Due to the differing camera configurations used by Lamont, all but 2% of the major slope displayed in their photographs appear to be horizontal (Fig. 5). This difference between the Henderson and Lamont data is not considered significant.

Distribution of minor slopes is nearly identical for both data sets. Horizontal slopes make up 73% of the Lamont data (Fig. 6) and 64% of the Henderson (Fig. 4). There are steeper (>76°) minor slopes (14% of the photos) for the Henderson data (Fig. 4) than in the Lamont photos (<7% of these data) (Fig. 6). Steeper slopes would tend to increase the back-scatter for acoustic signals impinging on the surface of the seamount. This variation in minor slopes, between the two sets of data, is considered significant. Since the minor slopes have much smaller dimensions than the major slopes, they are not as biased by the variation in camera configuration between the two sets of photographs. The most frequently occurring vertical dimension for the minor slopes in the Lamont data was 10 cm, and 15 cm for the Henderson photographs.

Another parameter under the general description of microtopography is the surface roughness. This factor is a measure of the uneven bottom microtopography. All the photographs were placed in one of six categories of surface roughness. These categories represent an increasing progression in bottom roughness from types 1 (least rough) to 6 (roughest); these types were drawn from the Henderson photographs (Fig. 7). Corresponding roughness types from the Lamont data set are shown in Figure 8. A comparison of Figures 7 and 8 suggests that the surface types on and around the Henderson Seamount are similar to those of the other Pacific seamounts. Histograms of the surface roughness from the entire set of Henderson and Lamont photographs are presented in Figures 9 and 10.

These two histograms depict two similar bottom roughnesses. For the Henderson Seamount, 73% of the photographs (Fig. 9) show roughness textures of type 1 through type 3 (Fig. 7), while 27% indicate types 4 through 6 (Fig. 9). Identical percentages were found for the Lamont data set (Fig. 10). Sixty-one percent of the Henderson photographs, however, indicate a bottom roughness of type 2 (Figs. 7 and 9), while the Lamont data show 29% to have this type of roughness (Figs. 8 and 10). Certainly, this differing percentage of type 2 bottom roughness is significant with respect to microtopography, however, its effect on incident acoustic waves is problematical.

Percentage of surface area covered by rocks and boulder size are illustrated by histograms (Figs. 11-14). These data indicate that in 19% of the Lamont photographs, there is greater than 50% of the surface covered

by rock outcroppings (Fig. 12). However, the Henderson photographs show that only 10% of the surfaces have a 50% rock covering (Fig. 11). This difference in percentages (9%) may or may not be significant, since there is a great deal of variation in how the photographs were made.

In comparing the size distribution of boulders on the Henderson Seamount with the Lamont data set, we find that 52% of the former and 7% of the latter are greater than 3 inches (7.6 cm) in diameter (Figs. 13 and 14). This is a significant variation. The mode of boulder size for Henderson is 4-5 inches (10.1—12.6 cm) (Fig. 13), while the mode for the Lamont sizes is less than one inch (2.5 cm) (Fig. 14). For the larger size boulders on the Henderson Seamount, we find that 8-1/2% are greater than 10 inches (25.4 cm) in diameter (Fig. 13), while for the Lamont data, this value is only 2-1/2% (Fig. 14). The variation between these two percentages is so large that this must represent a significant difference.

Differing boulder sizes between these two data sets may result from unequal initial conditions (chemical composition, pressure, or temperature) of the molten rock during the formation of the seamount. Increased lava acidity resulting from higher silica content would produce greater explosivity at the time of seamount formation, and therefore larger ejecta fragments.

III. SEDIMENT COVER

Percentages of areal distribution of sediment from both Henderson and Lamont data, revealed by bottom photographs, are given in Figures 15 and 16. These histograms indicate a similar pattern between these two data sets. Greater than 80% sediment cover is shown for 60% of the Henderson (Fig. 15) and 62% of the Lamont photographs (Fig. 16), while less than 10% sediment cover is found in 9% of the former and 16% of the latter. No geologic significance is apparent in these differing percentages.

Three sediment cores obtained on the abyssal plain surrounding Henderson Seamount reveal a predominantly clay-silt sedimentary environment. Terrigeneous material, having come from the nearby North American land mass, is the source of this sediment. Detailed descriptions of these sediment cores are found in Ross et al. (1976).

It is not possible to determine the sediment thickness from the bottom photographs. During the DESTEIGUER operation, over 500 nm of seismic profiler data were recorded. Sediment thickness varied from over 300 m down to the resolving limit of this seismic system. Thickest accumulations occur to the east and west of Henderson's peak, with a maximum thickness of 305 m to the west and 253 m to the east. There are no resolvable sediments on the steep sides of the mount, however, there are accumulations of up to 15 m on the area of the peak. Pelagic deposition (e.g., particulate matter falling through the water column) is doubtlessly responsible for the sediment on the upper slopes of this seamount.

Sediment accumulations around the base of this seamount are not uniform; there is a tendency for the sediment to occur in mounds or drifts. Slowly

moving bottom water or sediment slumping is most likely responsible for these accumulations. If bottom water is moving around this seamount, it must be at a very slow speed, since the photographs fail to indicate higher speed motion.

IV. LOCATION OF THE GEOLOGIC DATA RELATIVE TO THE ACOUSTIC AND OTHER STATIONS

During the DESTEIGUER operation of February 1976, in addition to the geologic sampling, there were towed acoustic parametric source measurements (TOPS) made together with bottom reverberation recordings and sound velocity/salinity, temperature, and depth profiles (SV/STD). The geographic relationship between all of these data stations is given in Figure 17. From this figure, we can see that the TOPS Day 1 track came near reverberation stations 6 and 11 and the second SV/STD profile, while the Day 2 track was close to reverberation stations 5 and 10 and dredge and camera stations number 3. However, tracks for Days 3 and 4 were not proximate to any of the geologic stations. Track for Day 5 was close to camera station 3 and SV/STD profile 2.

V. CONCLUSIONS

Minor slopes and boulder size are the only two parameters showing significant difference between Henderson Seamount and the selected seamount photographed by Lamont-Doherty Geological Observatory. Minor slopes (Figs. 4 and 6) generally represent small (<1 m) topographic surfaces which lie at angles differing from the main trend of the surrounding sea floor. Fourteen percent of the Henderson Seamount photographs display minor slopes with angles greater than 75°, while 7% of the Lamont data have this value.

Ninety-three percent of the boulders in the Lamont data are less than 7.6 cm in diameter (Fig. 14), however, only 48% of the boulders shown on Henderson Seamount are smaller than this value (7.6 cm) (Fig. 13).

In every other aspect, the Henderson Seamount is similar to the other Pacific Ocean seamounts. Major slopes, bottom roughness of microtopography, and percent sediment cover all indicate that Henderson is a "typical" Pacific Ocean seamount.

Proximity of the acoustic and geologic data stations are presented in Figure 17. Some of the towed-parametric source (TOPS) tracks are close to the acoustic reverberation, SV/STD, or geological stations. To evaluate the acoustic data with respect to geological observations, TOPS tracks for Days 1, 2, and 5 (Fig. 17) should be examined.

Henderson Seamount is located in a region of relatively high organic productivity. Significant accumulations of sediment on the seamount's peak no doubt reflect this fact. In order to estimate the relative sediment accumulation around any Pacific Ocean Seamount, it is necessary to note: (1) the location of the submarine feature with reference to regions of high organic productivity; and (2) the proximity of continental sediment sources. Sedimentary accumulations around Pacific Ocean seamounts are, therefore, largely a function of geography.

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Carlton, Lynn F. and Robert Crooks (1976). Measurement of Acoustic Backscattering from the Henderson Seamount using the TOPS Parametric Source. TMNo. 316-366-76, Naval Underwater Systems Center, New London, CT, 22 p.

Ross, C., L. Reynolds, and J. Bowman (1976). A Summary of Sediment Size, Chemistry, X-radiography, Sound Velocity, and Mass Physical Properties of Three Cores from the Pacific. USNS DESTEIGUER, Laboratory Item 495, U. S. Naval Oceanographic Office, Washington, DC, 23 p.

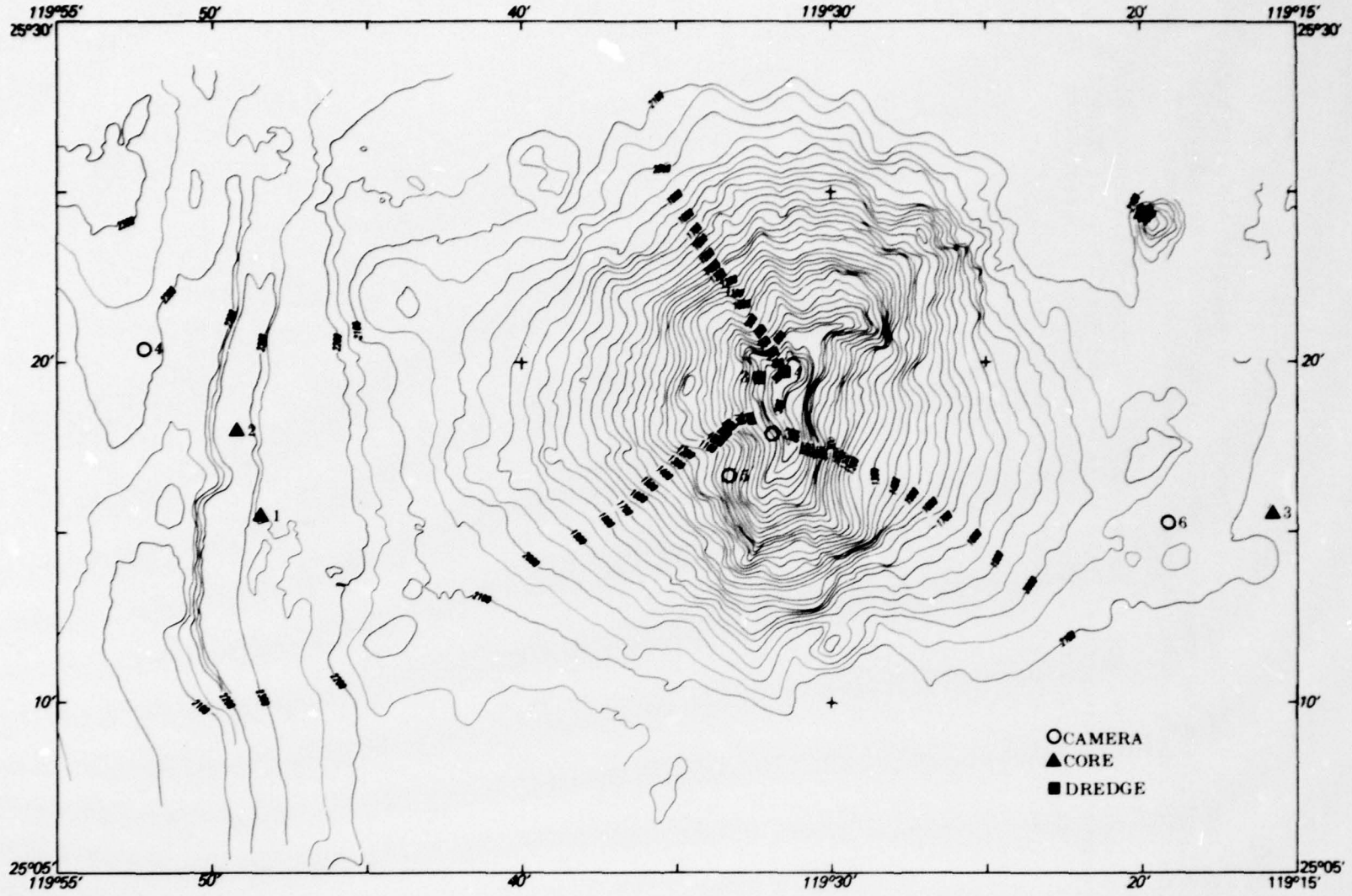


Figure 1. Bathymetric map (corrected fathoms, contour interval equals 50 fathoms) of Henderson Seamount. Location of geologic data is indicated. Latitude is north and longitude is west.

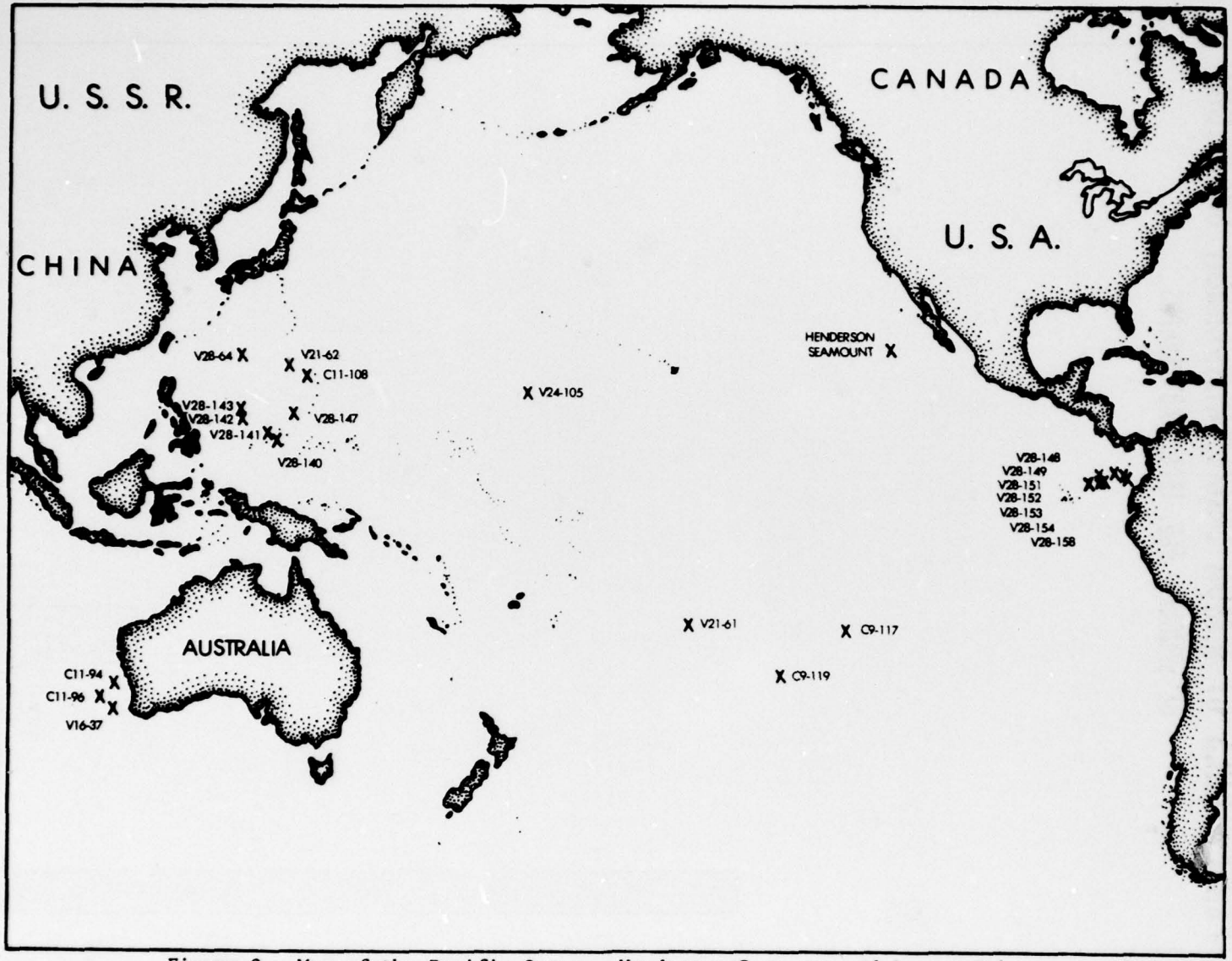


Figure 2. Map of the Pacific Ocean. Henderson Seamount and Lamont-Doherty camera stations are shown.

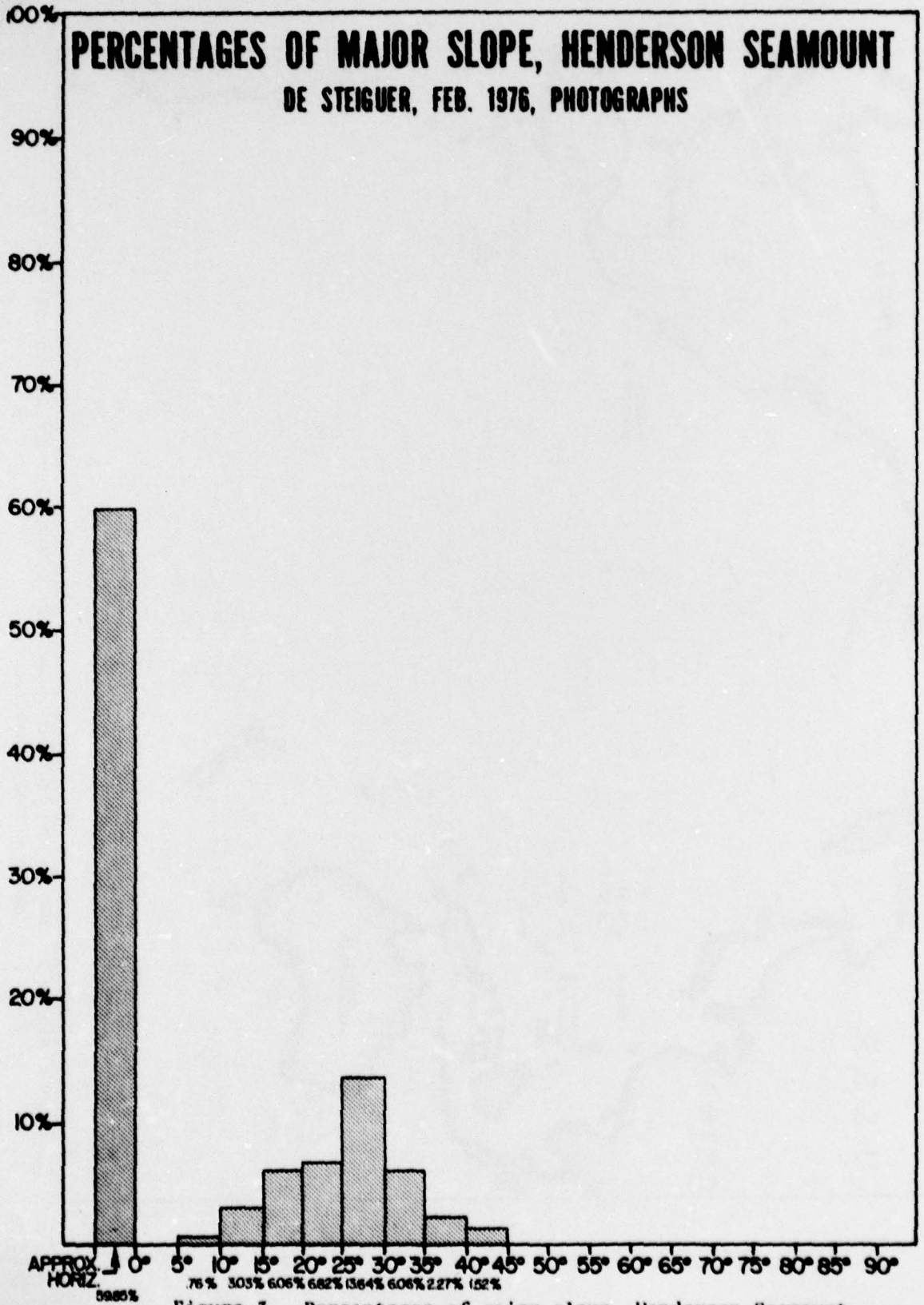


Figure 3. Percentages of major slope, Henderson Seamount.

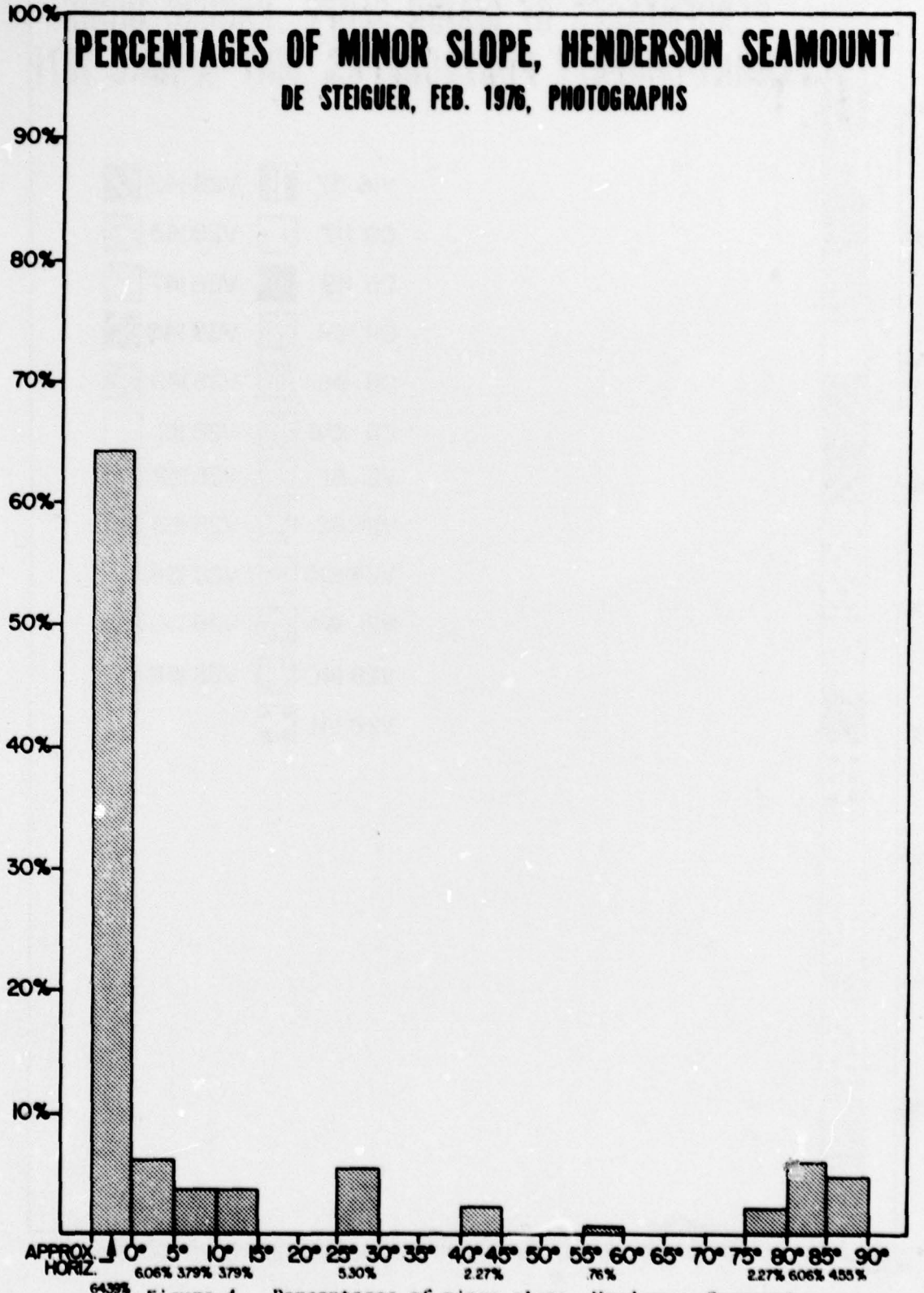


Figure 4. Percentages of minor slope, Henderson Seamount.

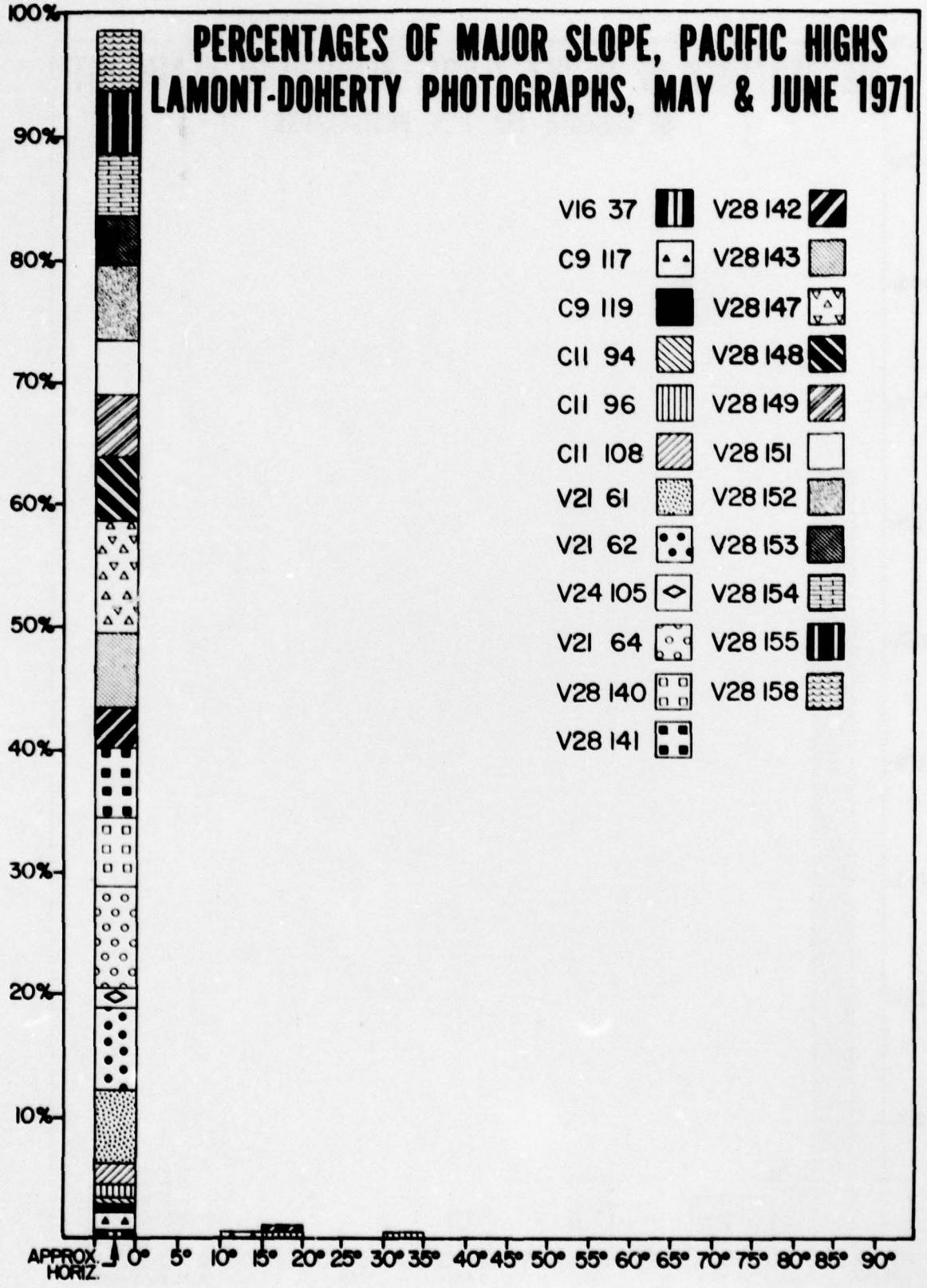


Figure 5. Percentages of major slope, Lamont-Doherty photographs.

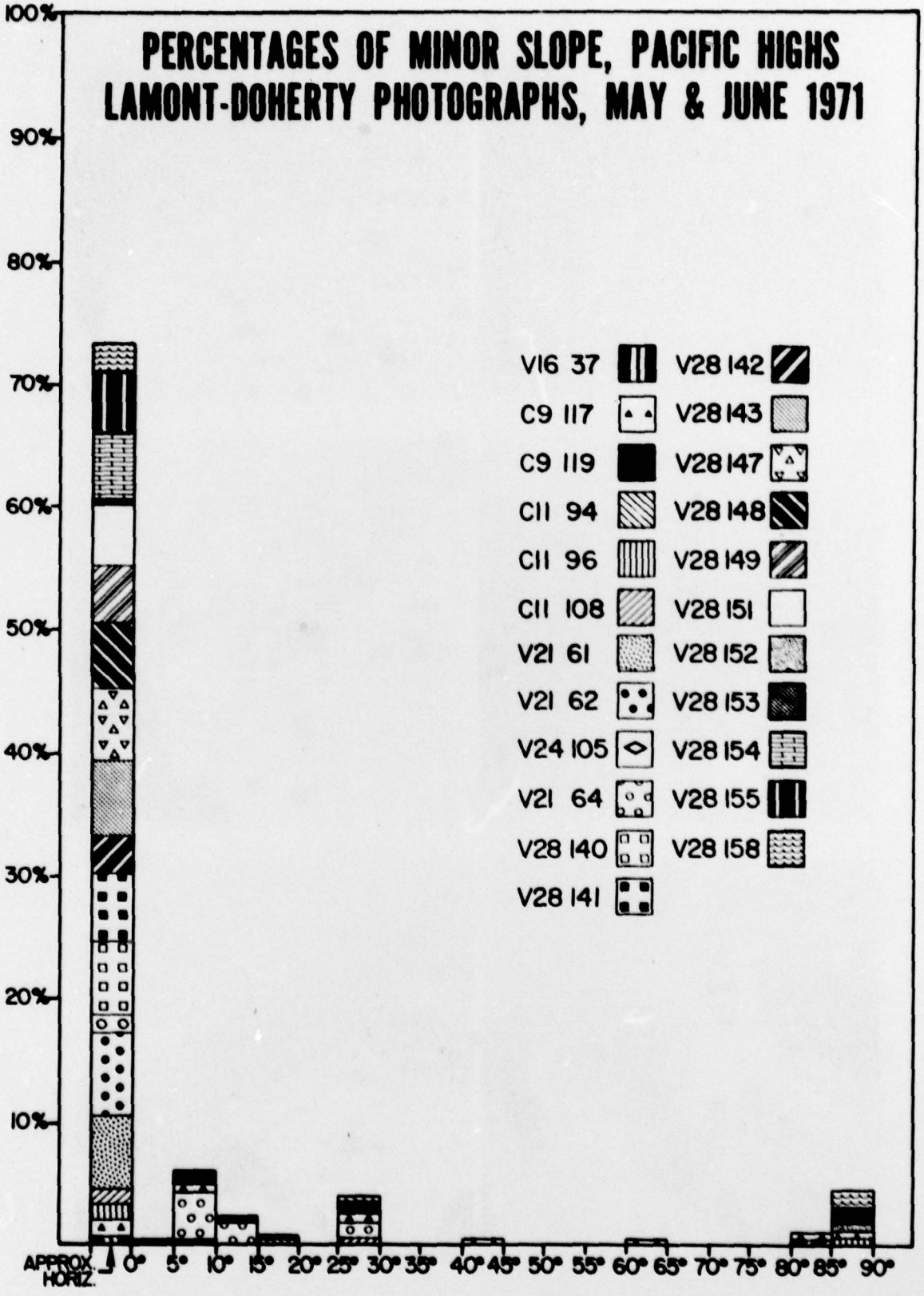


Figure 6. Percentages of minor slope, Lamont-Doherty photographs.

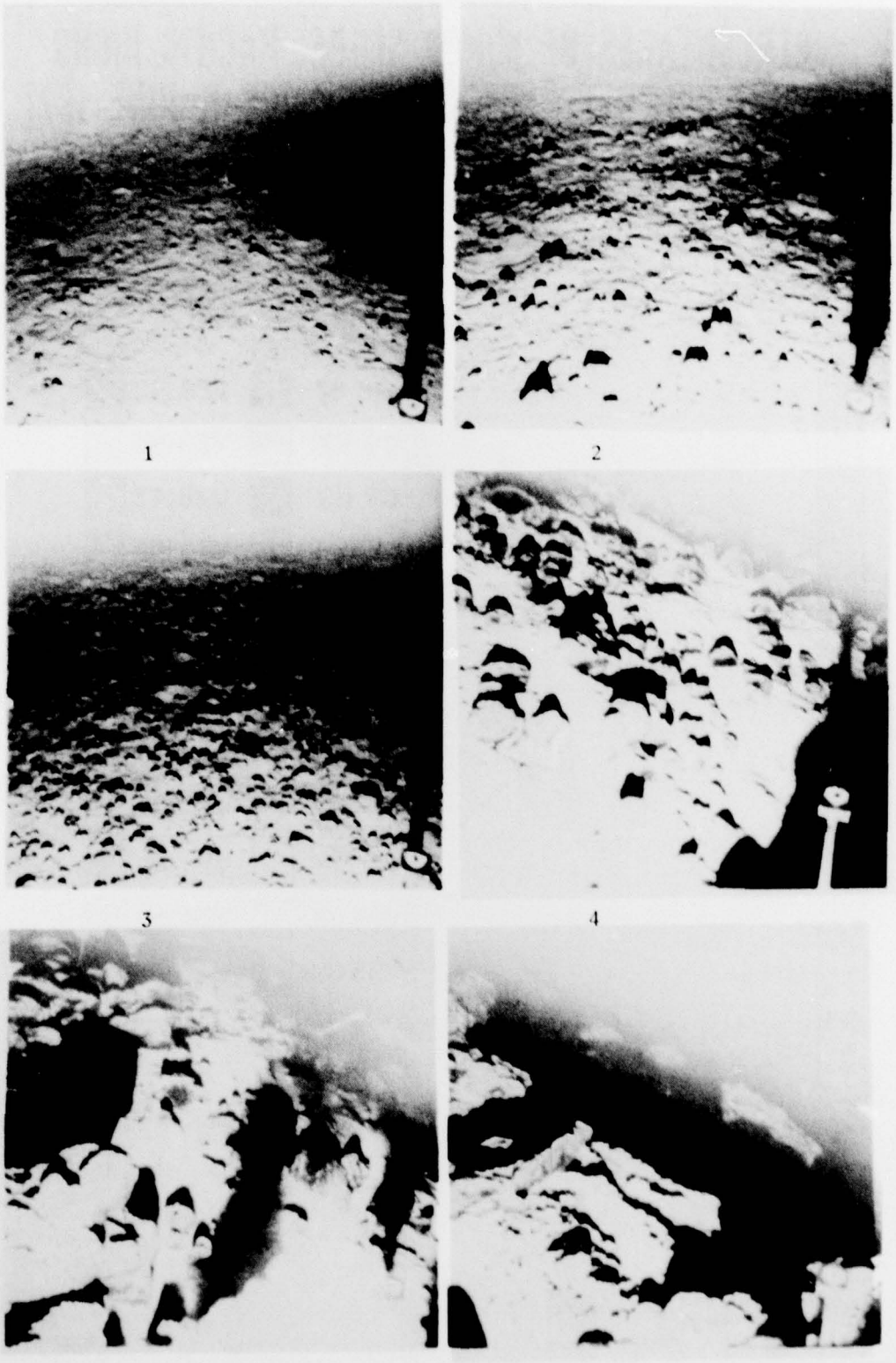
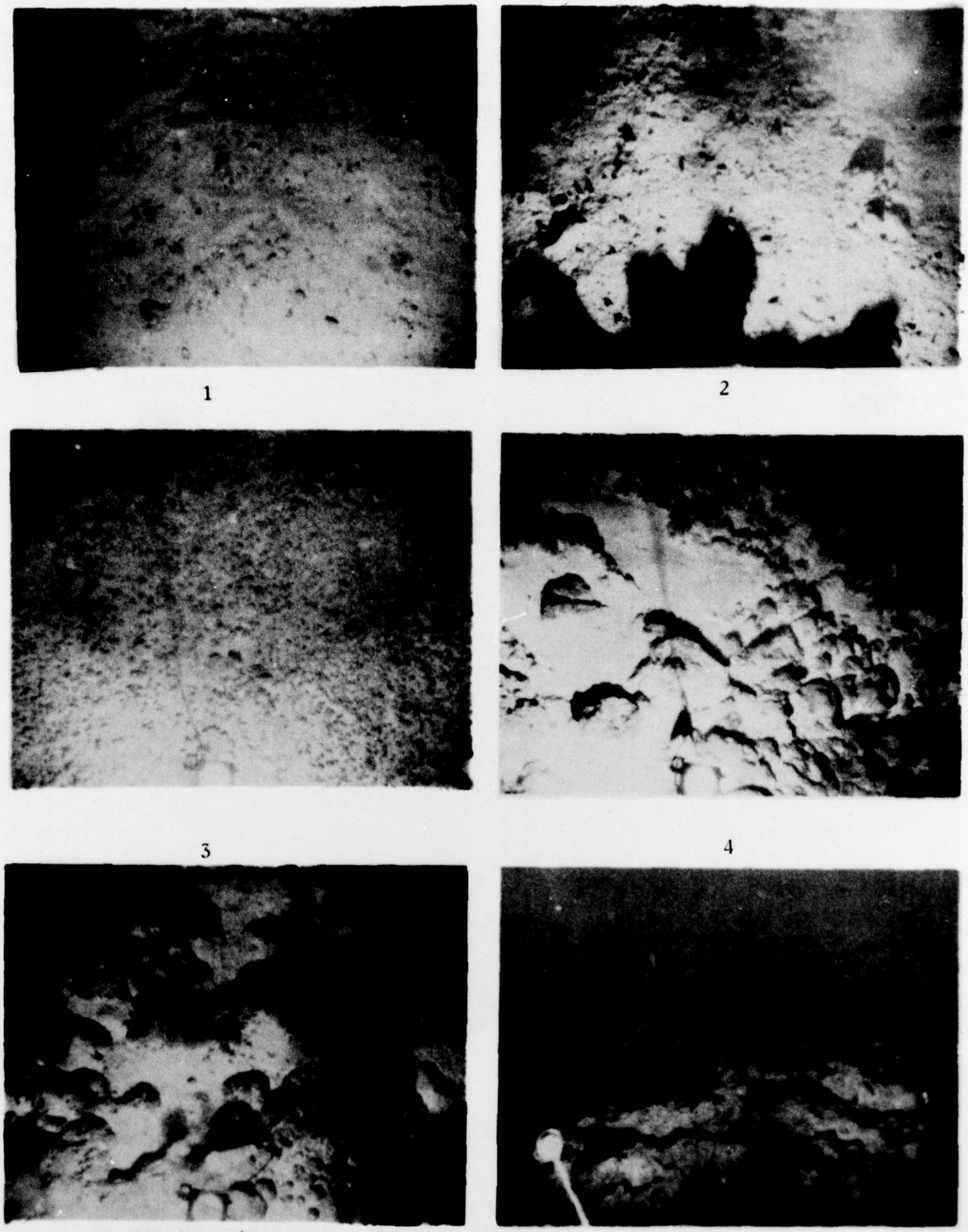


Figure 7. Surface roughness types from Henderson Seamount.



1 2

3 4

5 6

Figure 8. Surface roughness types from Lamont-Doherty data

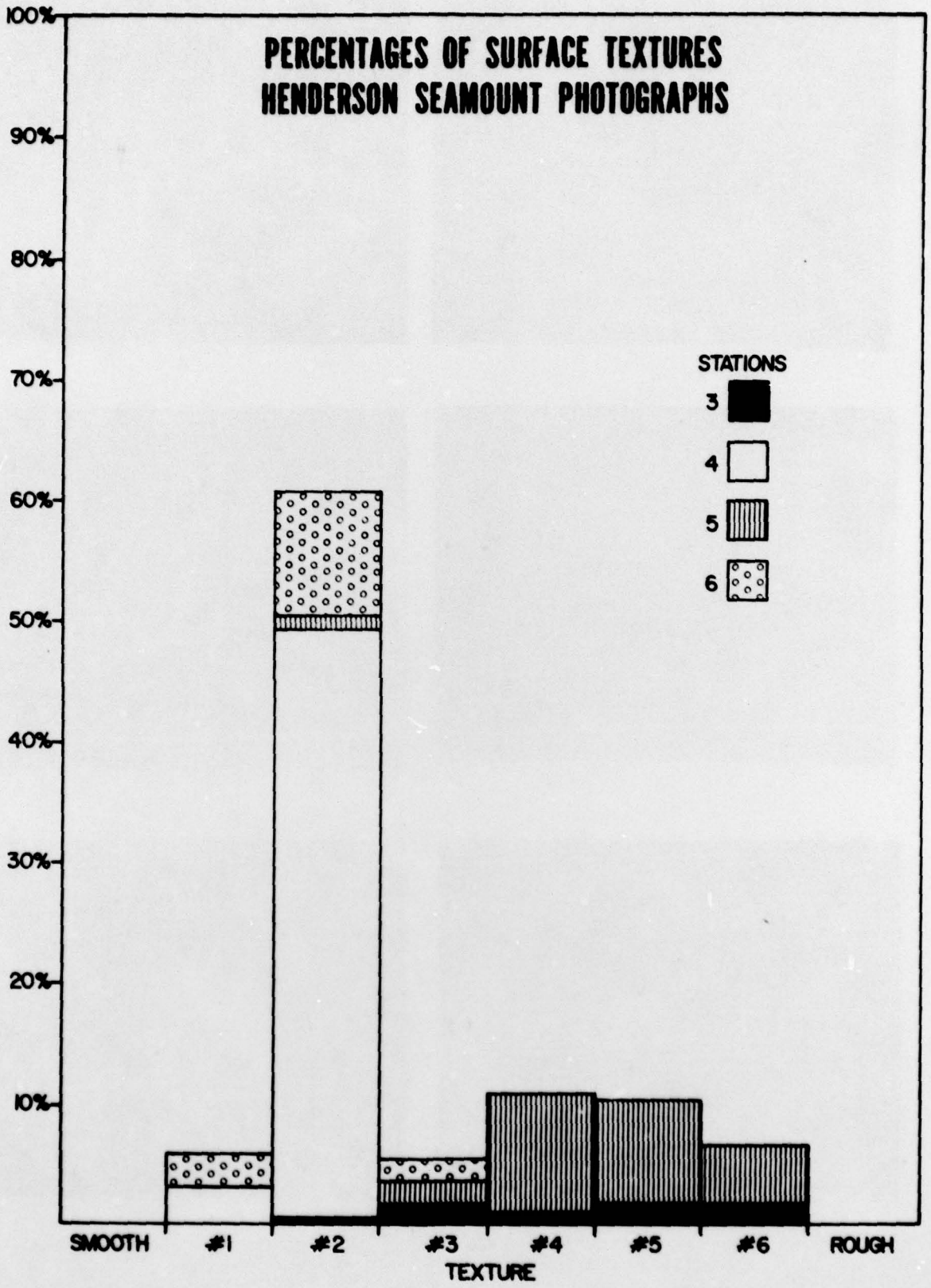


Figure 9. Percentages of surface textures, Henderson Seamount.

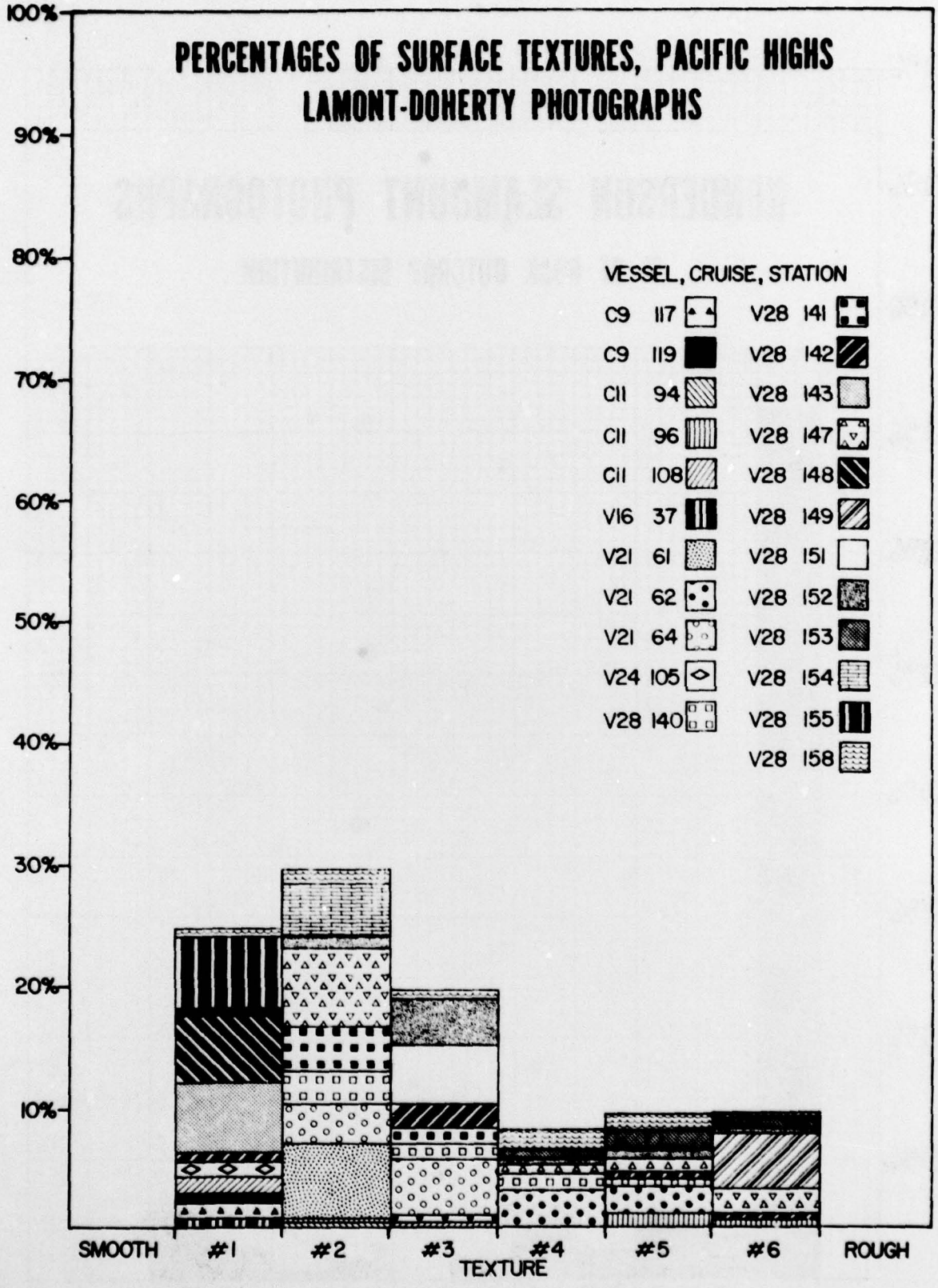


Figure 10: Percentages of surface textures, Lamont-Doherty Photographs.

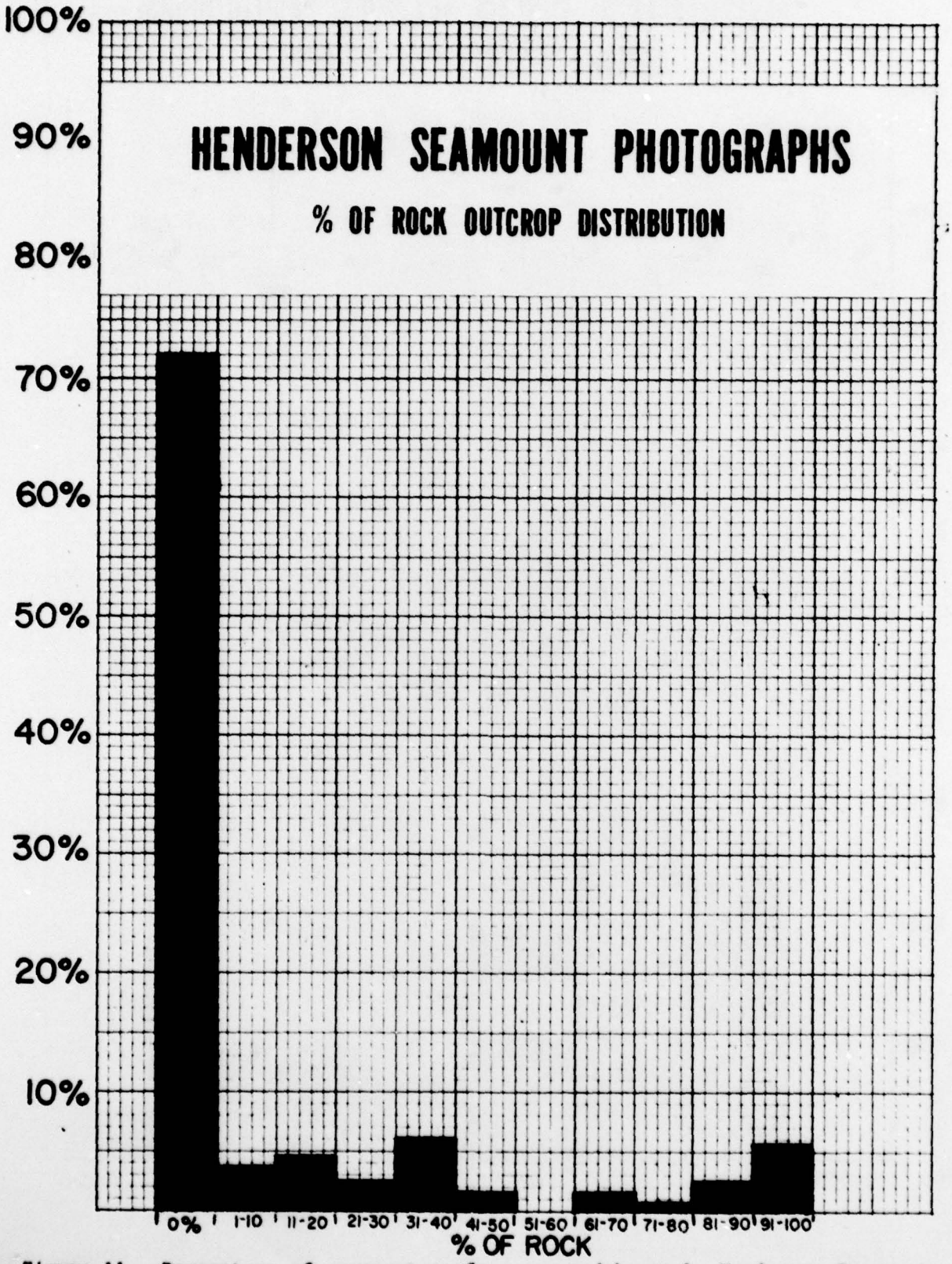


Figure 11. Percentage of seamount surface covered by rock, Henderson Seamount.

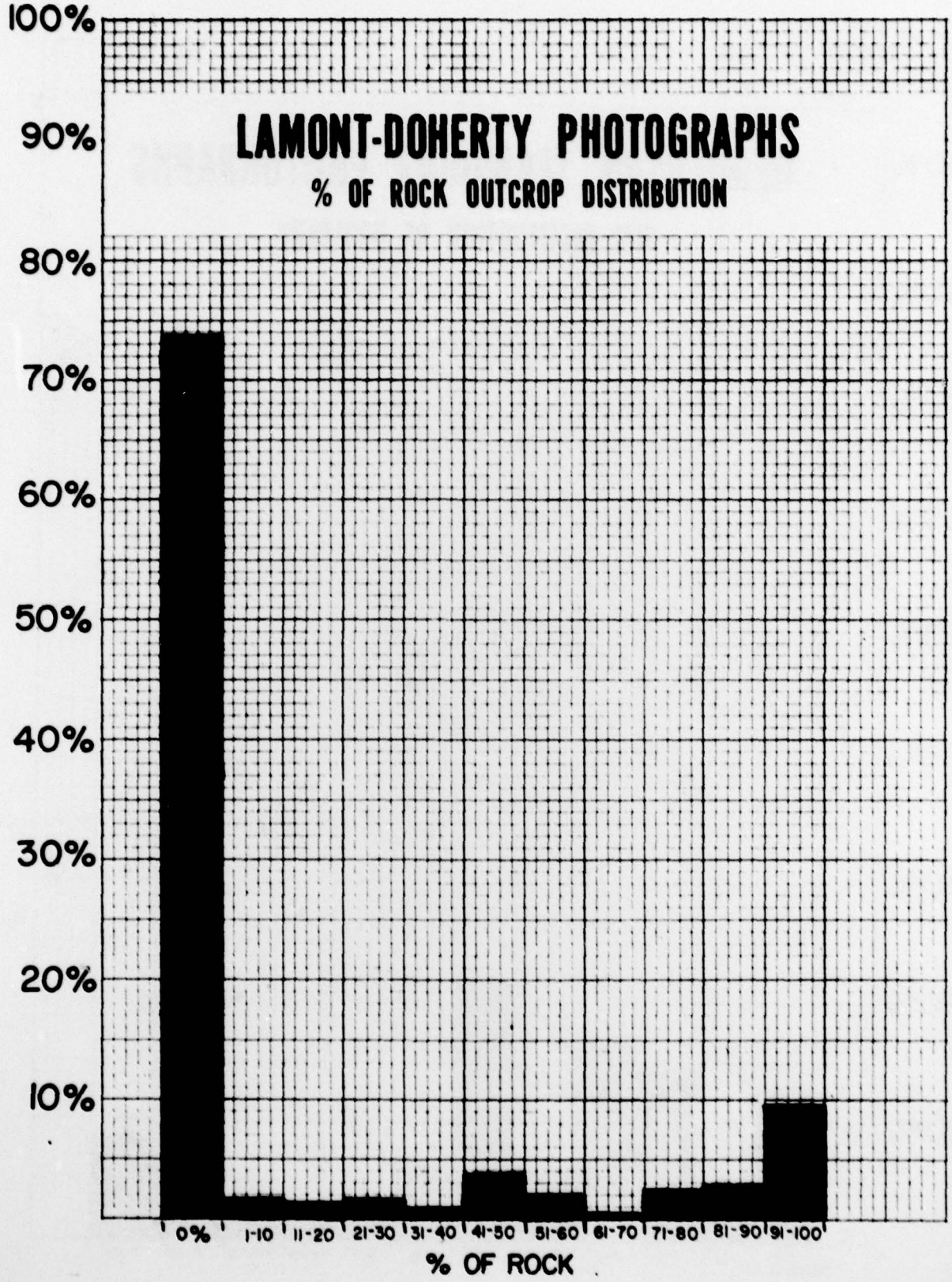


Figure 12. Percentage of seamount surface covered by rock, Lamont-Doherty data.

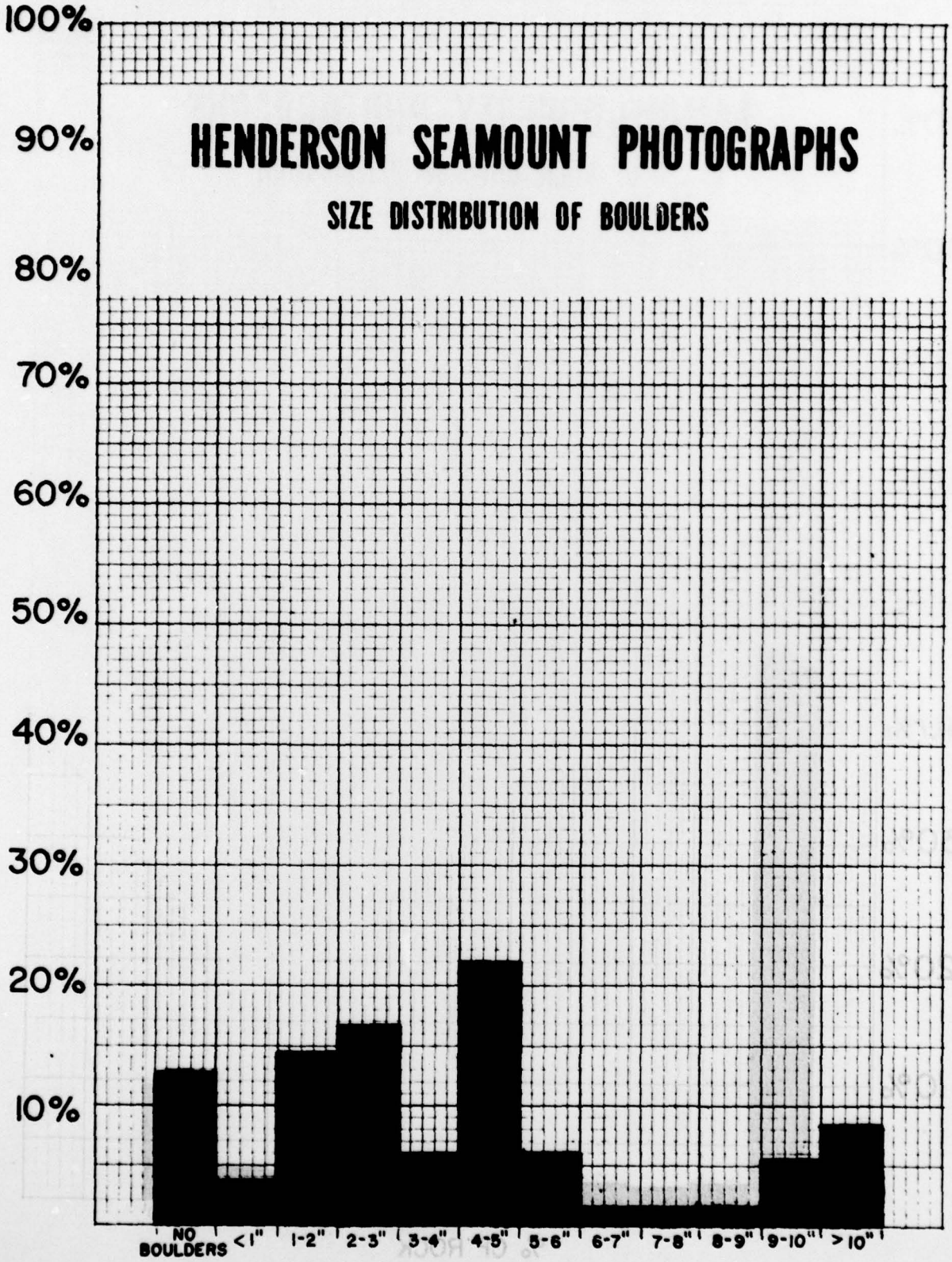


Figure 13. Size distribution of boulders, Henderson data.

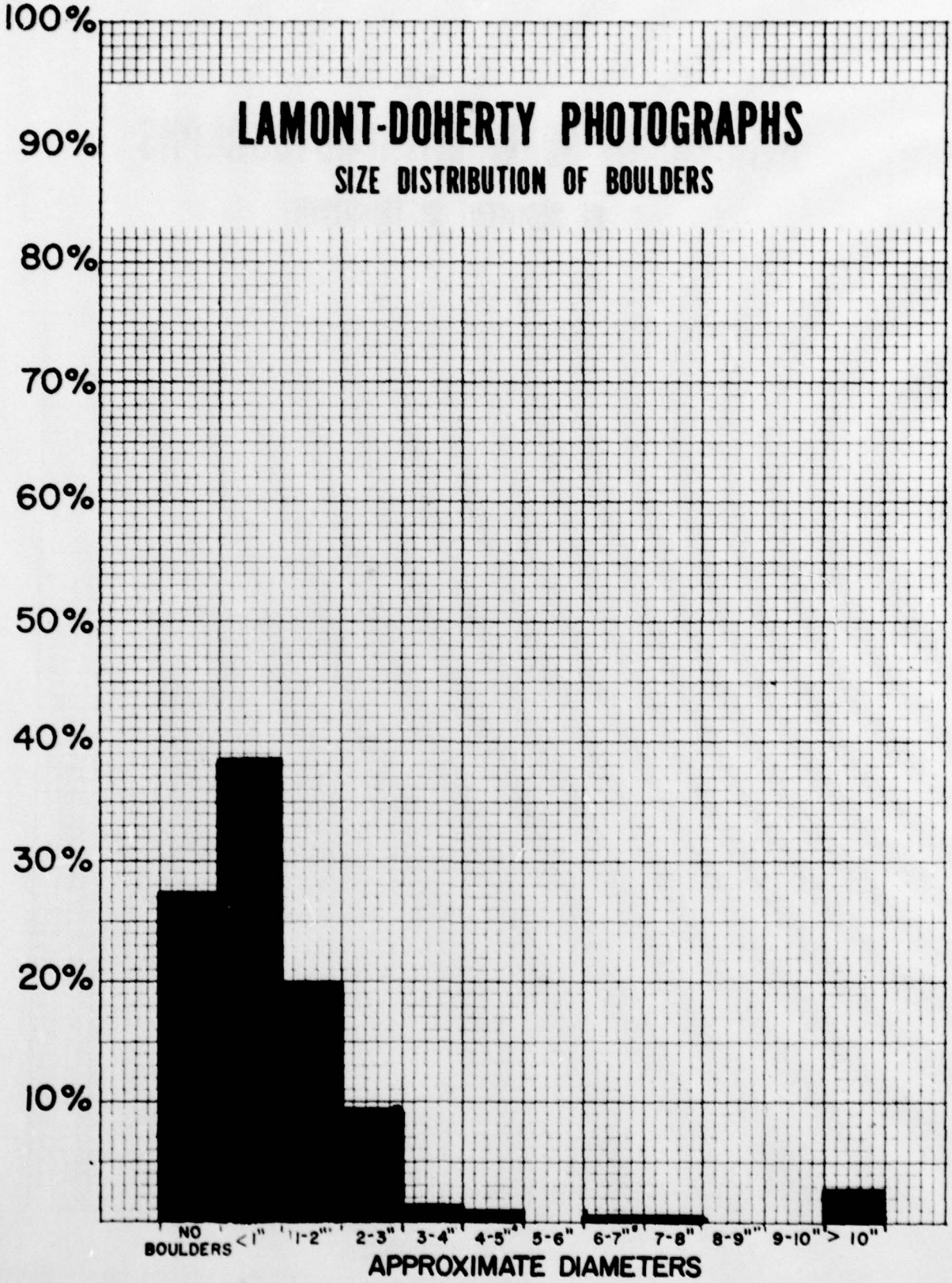


Figure 14. Size distribution of boulders, Lamont-Doherty photographs.

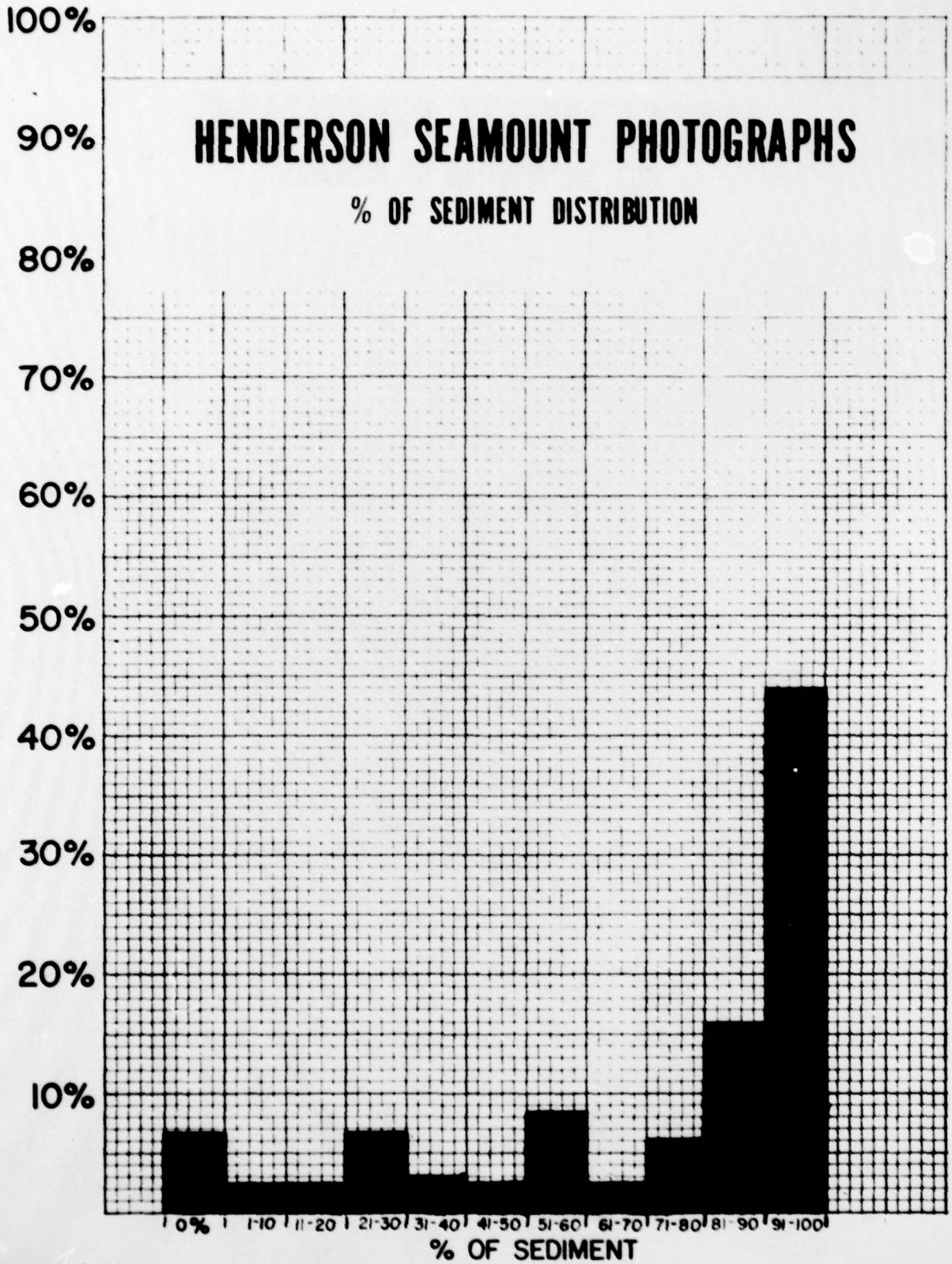


Figure 15. Percentage of seamount surface sediment covered, Henderson data.

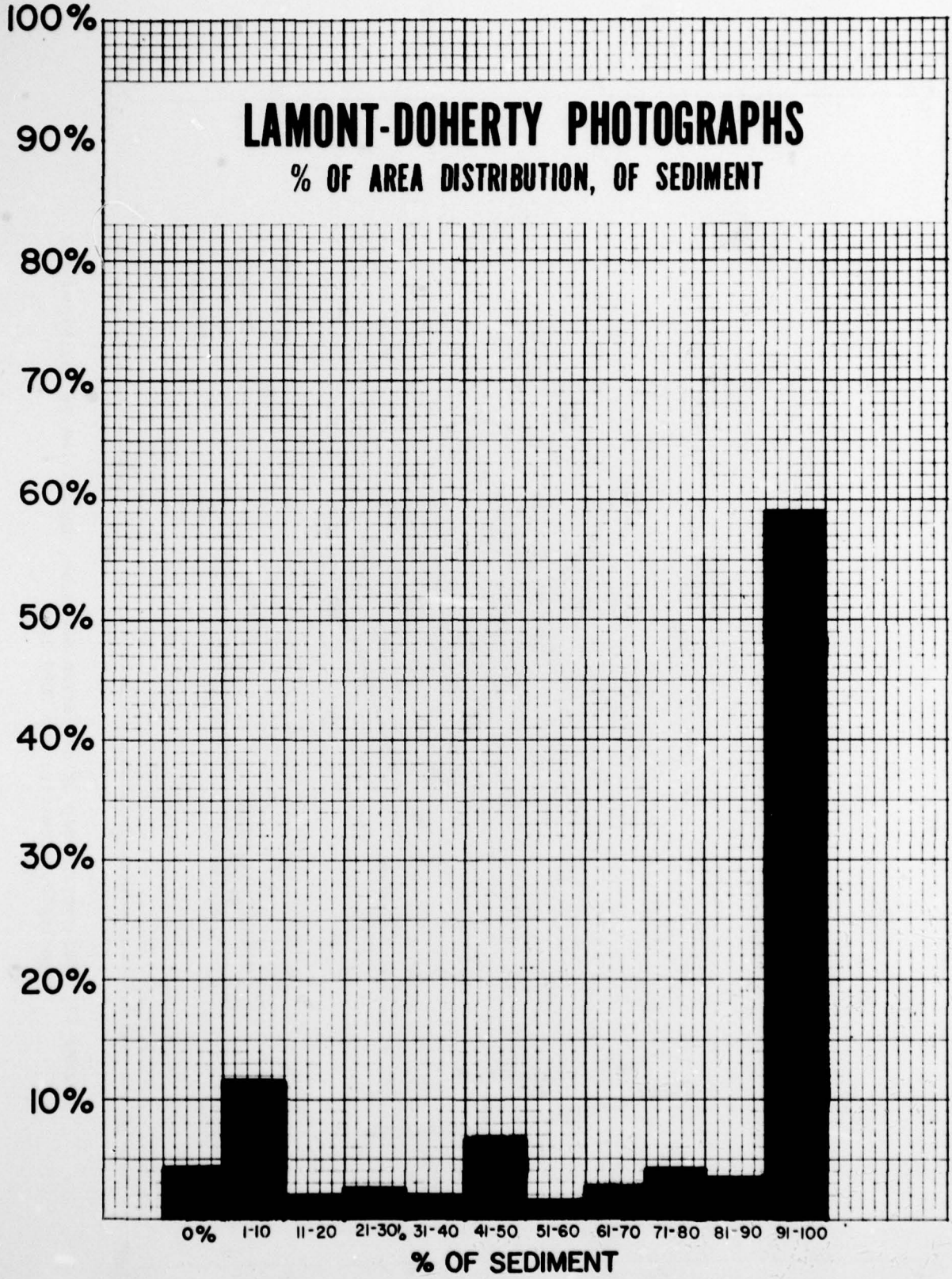


Figure 16. Percentage of seamount surface sediment covered, Lamont-Doherty photographs.

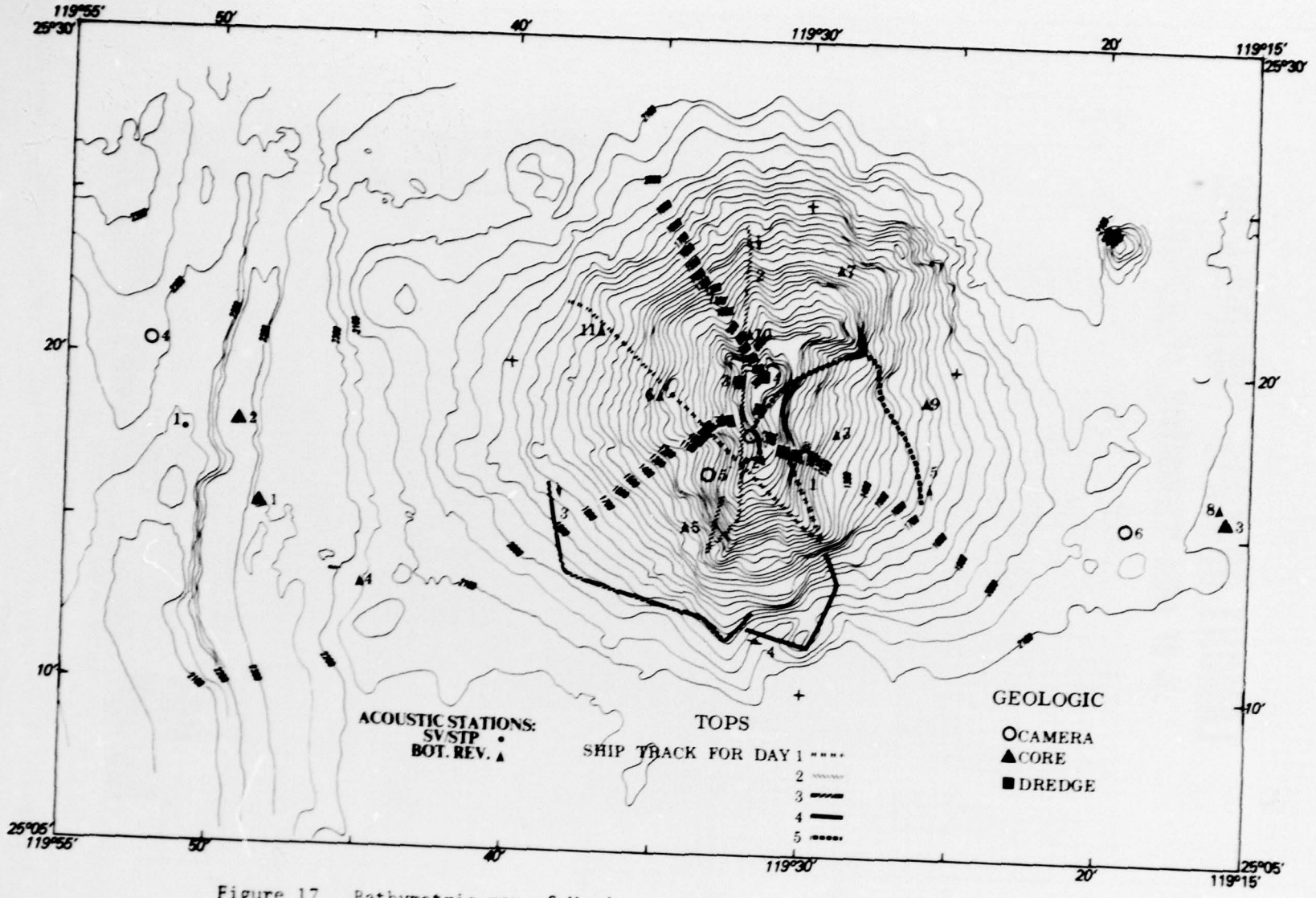


Figure 17. Bathymetric map of Henderson Seamount, indication of positions of geologic, acoustic, and TOPS data.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report presents an analysis of geologic data (bottom photographs, sediment cores, seismic profiler records, and dredged samples) from the Henderson Seamount, Eastern Pacific Ocean. These data were gathered in support of the acoustic backscattering measurements made by the Naval Underwater Systems Center (NUSC). Discussion of these geologic measurements, therefore, will be made with respect to the acoustic results, i.e., an interpretation of microtopography, sediment distribution, and small-scale slopes will be emphasized. CONT'

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