THE SURFACE MORPHOLOGY OF THE TUSCALOOSA SEAMOUNT

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE
UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN GEOSCIENCES--GEOLOGY

DECEMBER 1969

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We certify that we have read this thesis and that in our opinion it is satisfactory in scope and quality as a thesis for the degree of Master of Science in Geosciences--Geology.

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ABSTRACT

A bathymetric chart of the Tuscaloosa Seamount based on new data is presented here. Interpretation favors an origin due to constructional volcanism rather than to landsliding. The broad, relatively flat summit suggests a guyot whose present depth is probably due to regional subsidence.

INTRODUCTION

Location of Tuscaloosa Seamount.

The Tuscaloosa Seamount (Figure 1) is 100 kilometers northeast of Kaneohe Bay, Oahu, Hawaii. It is the principal feature of the area of rough topography that interrupts the trend of the Hawaiian Deep northeast of Oahu (Figure 2).

Statement of Problem.

The Tuscaloosa Seamount and the irregular topography around it have been interpreted as volcanic in origin by Hamilton (1957). However, Moore (1964) interpreted the contours of the preliminary United States Navy Oceanographic Office chart BC1604N (which has not been published as of this writing) to indicate two large landslides north from Molokai and northeast from Oahu. These two interpretations imply different structures and perhaps different petrologies. New data have been needed to improve details of the region's bathymetry so that some judgement between the two theories might be made. Constructional volcanism is a geologic concept which should require no treatment here.

Summary of Landslide Hypothesis.

In Figure 3 Moore's inferred outlines of landslide boundaries are shown by dotted lines on the plan view provided by a portion of BC1604N. He has also presented an unexaggerated profile and a structural section with vertical exaggeration. He lists overall slide slopes of two degrees, concave-upward escarpments at the head of each slide, flat-top will be pointed out whose existences therefore remain in doubt.

Selection of Datum Points, Handling of Records, and Production of Charts.

PGR records, annotated each hour and at the discretion of personnel standing watch, were folded accordian-like for ready access to any time along the record. Datum points were listed at three-minute intervals and whenever the trace of the bottom passed through horizontality, assuring the recording of all peaks and troughs. Depths were corrected for sound velocity (Belshé, 1967) and plotted along smoothed ship tracks. Adjustments by bathymetry as described above were followed by contouring and interpretation.

RESULTS AND DISCUSSION

Presentation of Plates.

Plate I presents track-adjusted data. Plate II presents contours based on Plate I. Plate III presents some of the possible alternate contours of Plate I and points to the fact that contouring and geologic interpretation are interrelated. Plate IV presents a vertically unexaggerated profile taken along ship track F to G on Plate I. Borders of Plates I and II match for overlay purposes.

Description of Surface Morphology.

The shallowest peak of the Tuscaloosa Seamount is its eastern peak which is 2765 meters below sea level. The western peak is at least 2841 meters below sea level. The base of the seamount is defined by a moat deeper than 4300 meters on its southwest side, by sediment basins deeper than 4800 meters on its eastern and western ends, and by a deep exceeding 4700 meters along most of its northeast side. It measures about 35 by 21 kilometers at its base, slopes at about 30° to a rather flat summit measuring about 20 by 10 kilometers, and has summit relief of less than 500 meters. Summit relief is due to round and oblong hills and depressions. One depression is confirmed by data from three lines, and it slopes toward the center of the summit from the northeast part of the western peak. A second depression is inferred on the basis of nearby soundings and awaits confirmation. A third depression is shown in Plate III but not in Plate II. Plate III also shows that the summit region in excess of 3100 meters may be broader than has been shown in Plate II. The data can be validly interpreted in various ways and give rise to contours which may differ according to geologic interpretation; for instance, Plate II shows a canyon where Plate III shows a summit depression. Two spurs are located on the north slope of the east peak. One trends parallel to a steep escarpment on the southwest of the east peak, the other trends parallel to a ridge at the summit of the east peak.

Structural Interpretations.

The profile shown on Plate IV strongly suggests that the Tuscaloosa Seamount is a guyot. The hills on the summit are interpreted as constructional volcanic cones. The depressions are suggestive of grabens formed during magma subsidence. The alignment of spurs with a ridge and a scarp is interpreted as a surface expression of two dike complexes crossing within the eastern peak.

The only feature which might be interpreted in support of the landslide hypothesis is the moat at the base of the seamount's southwest slope. If the moat defines a fault and if submarine erosion is hypothesized, the moat might be explained on the basis of differential erosion of a brecciated zone along the outcrop of the fault. However, moats at the base of the seamounts are features commonly explained by isostatic adjustment to load, and I favor this explanation for this moat.

The step-like features shown in Figure 4 are about one kilometer north of the eastern peak and are not well understood. They may confirm that the Tuscaloosa Seamount has been above water. Dr. Agatin T. Abbott (personal communication) has noted their general resemblance to features on the Hawaiian island of Kahoolawe (Figure 2) which he attributes to the superposition of lava flows over wave-cut cliffs. These step-like features may record successive stands at sea level relative to the seamount, and the possibility of drowned fringing reefs is to be noted. If so, the slight depression to the right of the first step in Figure 4 may indicate a former lagoon; the broad, lower areas of the summit may have been lagoons as well.

Since the Moho is depressed by two and one-half kilometers under the Hawaiian Deep (Furumoto and Woollard, 1965) by the Hawaiian Ridge, and since the generally flat summit of the Tuscaloosa Seamount is within 500 meters of that depth below sea level, the possibility that the seamount is a very old feature predating the Hawaiian Ridge becomes worthy of consideration. However, the Moho dips toward the Hawaiian Ridge at the Hawaiian Deep while the top of the Tuscaloosa Seamount as well as the Waho Shelf (at 900-1090 meters depth) surrounding all the Hawaiian Islands (Stearns, 1966) dip to the north. This indicates that subsidence subsequent to the formation of these shelves has been greater to the north of the Hawaiian Ridge than along the Ridge itself.

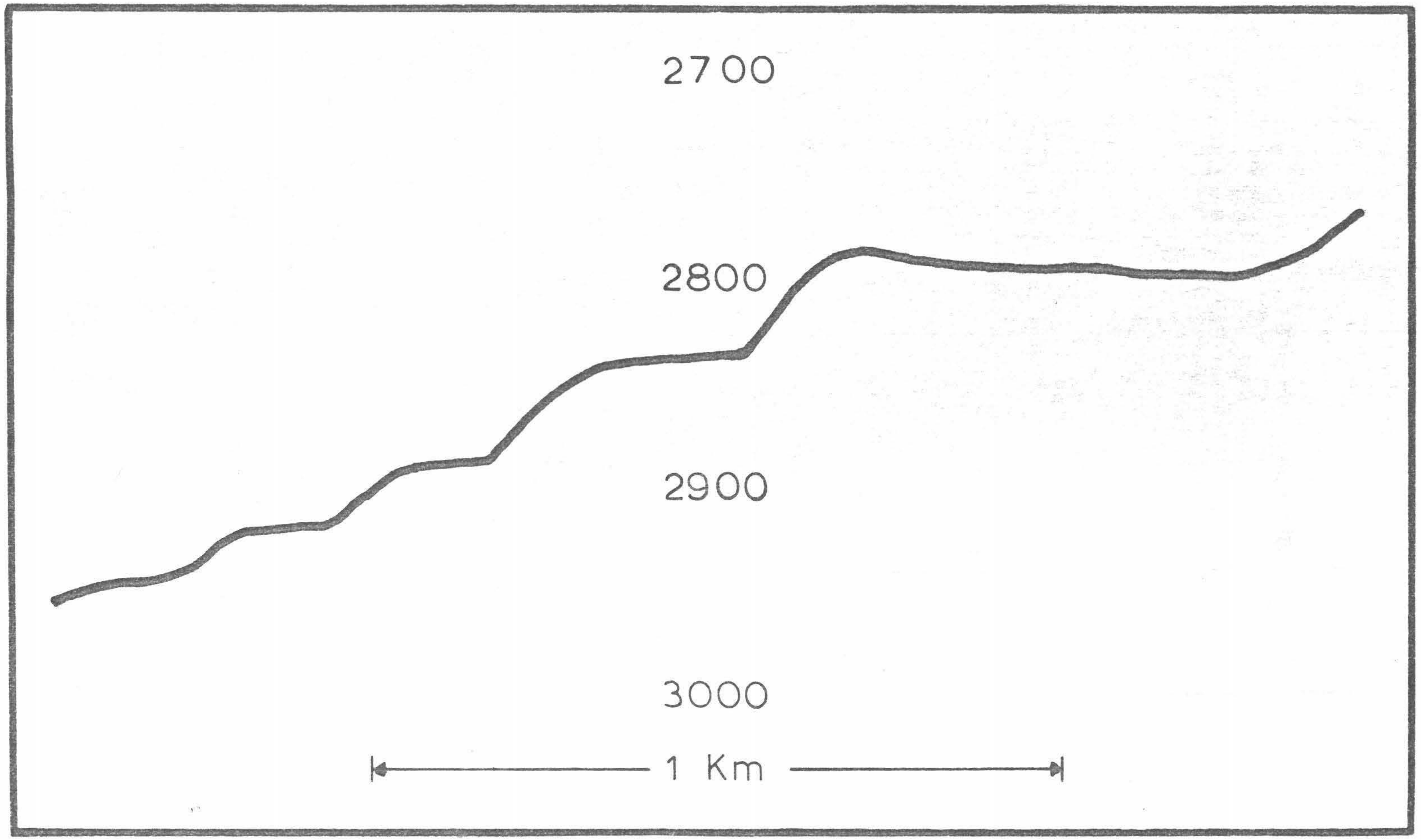

Figure 4. Steps near east peak of Tuscaloosa Seamount. Depths in meters not corrected for sound velocity.

Supporting Geophysical Data.

No detailed work with sparker, gravity, or magnetic instruments relating to the area has been published. Aerial magnetic studies (Malahoff and Woollard, 1968) in the vicinity yield far too broad a picture to help pinpoint vents or dike complexes within the seamount. However, a regional high indicates intrusion, and this lends support to the hypothesized origin by constructional volcanism.

Petrologic Evidence.

A small manganese-coated cobble recovered in a core at the Tuscaloosa Seamount is an olivine basalt with abundant glass and palagonite which is believed to be either a fragment of hyaloclastite or a fragment of palagonitized tuff. Abundant in the sediment fraction of the core is glass with microlites of pyroxene and olivine. Detailed petrology of the seamount remains to be done.

CONCLUSION

Though petrologic evidence is scant, on the basis of seismic and bathymetric evidence, I believe the Tuscaloosa Seamount to be a guyot. Hills at its summit appear to be cones; depressions there appear to be craters. Two rift zones seem to be topographically expressed on the east peak. The moat appears to be due to isostatic adjustment to load. Therefore, I believe the Tuscaloosa Seamount to have been formed by constructional volcanism rather than by landsliding.

In addition to geophysical work supported by deep-towed, narrow-beam, or side-scanning sonar to improve bathymetric details, the need for petrologic data demands dredging. It will be of interest to know whether the nephelinites of the Honolulu Volcanic Series (Stearns and Vaksvik, 1935) erupted as far from Oahu as the Tuscaloosa Seamount, though their presence alone will not disprove that the Tuscaloosa Seamount predates the Hawaiian Ridge.

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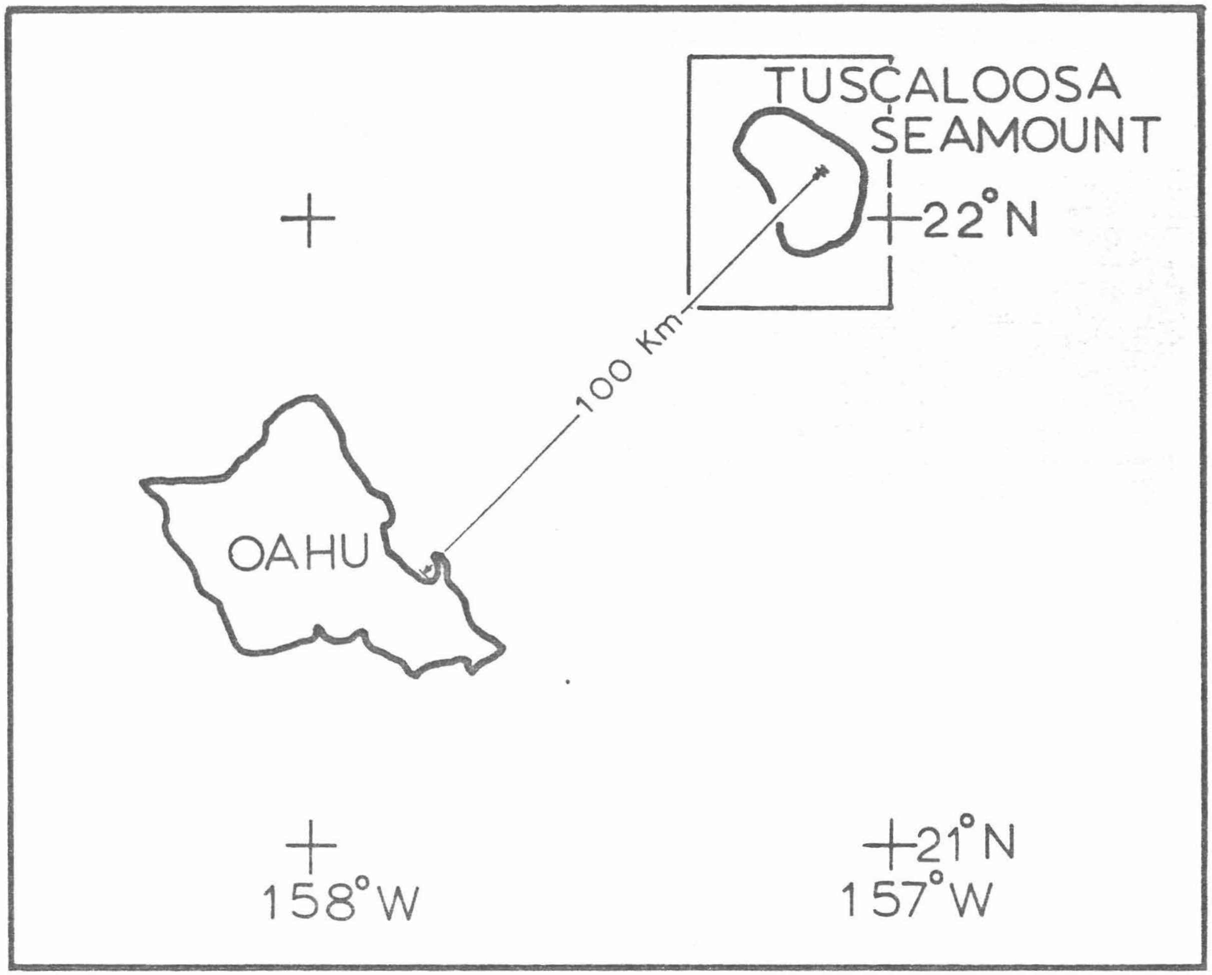

Figure 1. Position of Tuscaloosa Seamount relative to Oahu, Hawaii; survey area outlined.

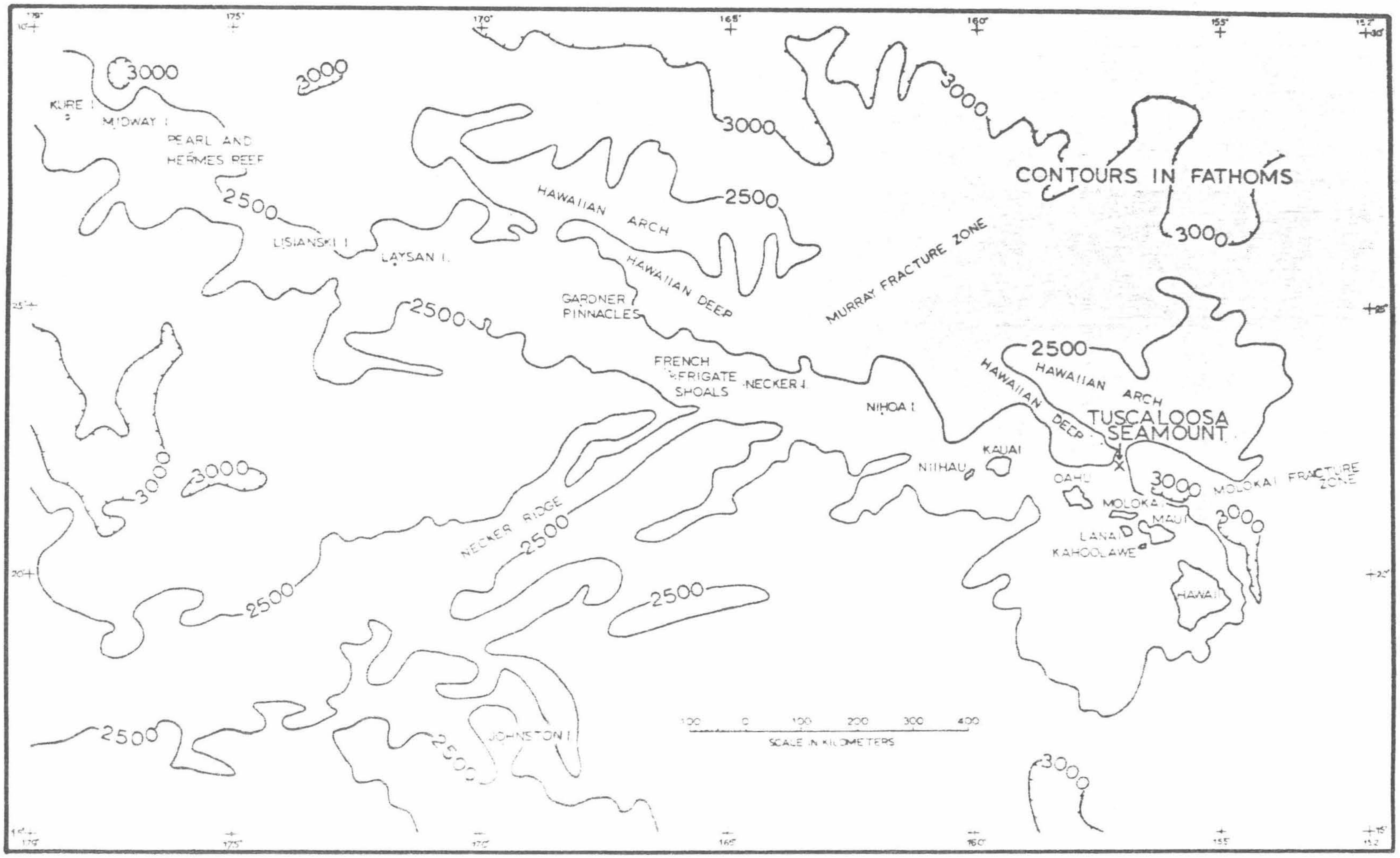

Figure 2. Relation of Tuscaloosa Seamount to structure of Hawaiian Archipelago. (After Woollard, 1966).

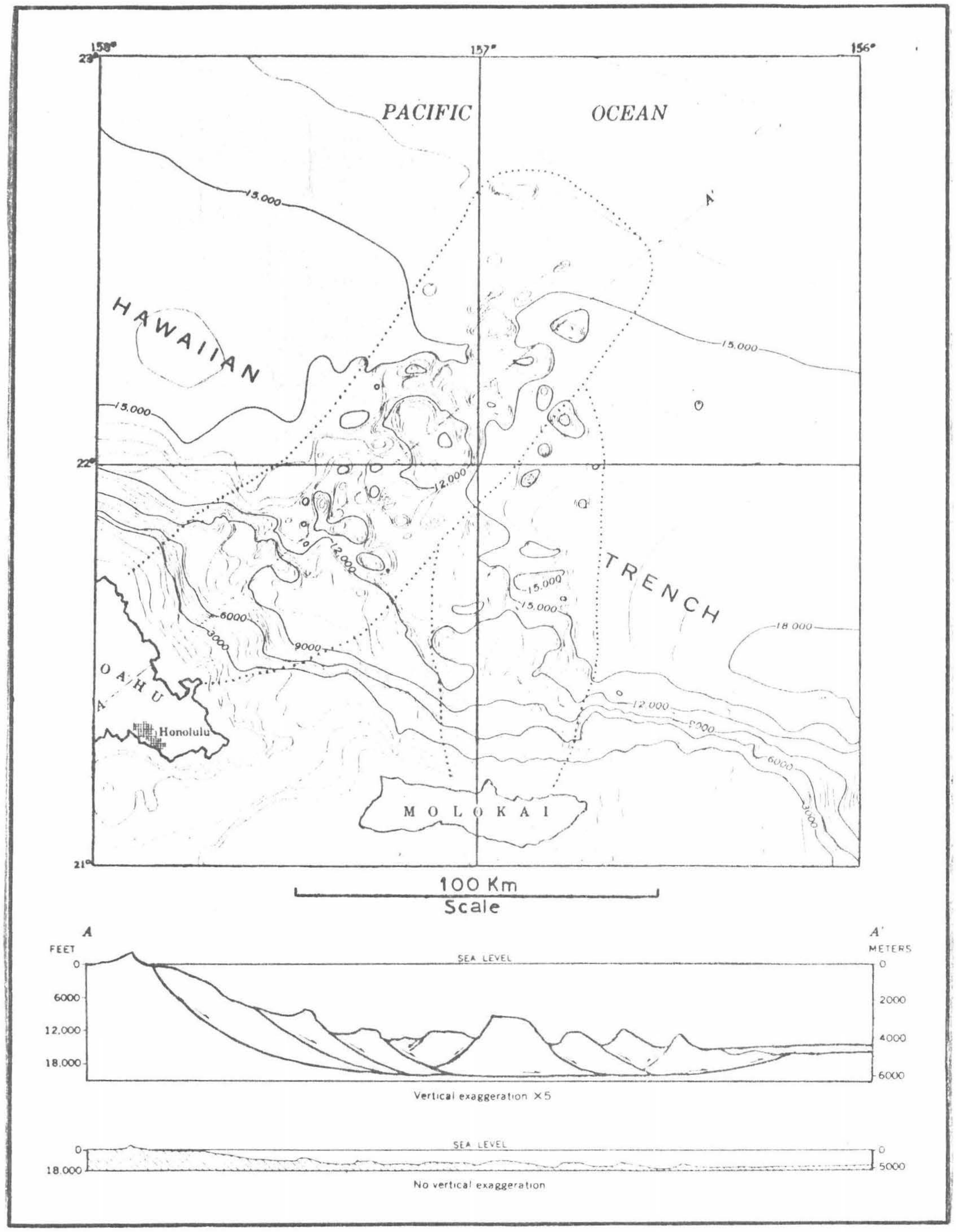

Figure 3. Moore's interpretation of U.S. Navy Oceanographic Office preliminary chart BC1604N showing landslide boundaries by dotted lines in plan view and interpretation of cross section A-A'. (From Moore, 1964).

mountains generally tilted seaward from Oahu and Molokai, and elongation of seamounts perpendicular to the inferred direction of movement. The structural section shows the sole of the slide at a depth of 6000 meters; faulting is a combination of gravity and thrust types.

Purpose of Thesis.

The purpose of this thesis is to prepare a new bathymetric chart of the Tuscaloosa Seamount and to interpret it in terms of geologic structure. The constructional volcanic and landslide hypotheses are evaluated in light of the new data.

Acknowledgements.

I would like to thank Dr. John C. Belshé for bringing the problem to my attention, for suggesting this work, for acting as chief scientist during two of the cruises, for standing watches, for performing by machine the corrections to soundings for sound velocity (Belshé, 1967), for critical discussions, and for making available the original records, which are now in his possession. Mr. Arthur G. Cropper deserves credit for standing watches and for keen interest during critical discussions. The crew of the R/V TERITU has at all times been helpful and conscientious and have my thanks. The Hawaii Army National Guard is thanked for extending the use of its tracking facilities at Makapuu Point, Oahu.

EQUIPMENT AND PROCEDURES

Equipment.

The platform for data collection was the R/V TERITU. It was equipped with 12 kilocycle wide-beam (30^{o}) transducer and Precision Graphic Recorder (PGR).

Navigation and Track Adjustment.

The survey consists of data taken during three cruises. Cruises one and three were controlled by Loran A, positions resulting from determinations of distance from two hyperbolic pulse-modulating shore-based transmitters. The second cruise was controlled by Nike-Zeus range and bearing tracking facilities from Air National Guard facilities at Makapuu Point, Oahu. All navigational fixes were at 15 minute intervals. Tracks were straight-line smooth-plotted and ship turns were later adjusted by bathymetry. The first cruise by Loran A navigation located the seamount three kilometers northeast of its position on BC1604N, but Nike-Zeus data for the second cruise plotted congruently with the expected position. The entire network of lines from the first cruise was therefore superimposed by inspection upon the network of lines from the second cruise. Thereafter adjustment of lines to minimize crosscheck errors in the bathymetry was performed within the limit of moving no point more than three-quarters of a kilometer from its smooth-plotted position. All data collected are presented in spite of the fact that perfect bathymetric crosschecks have not been attained by the above-outlined procedure. Two features

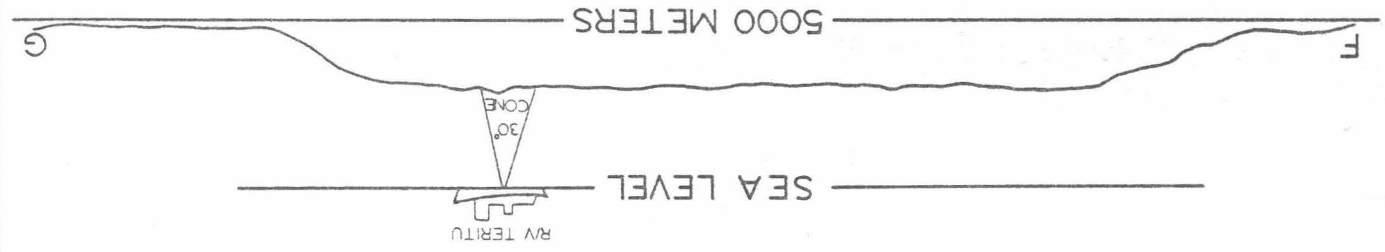

PLATE IV: TUSCALOOSA SEAMOUNT
PROFILE, no vertical exaggeration.

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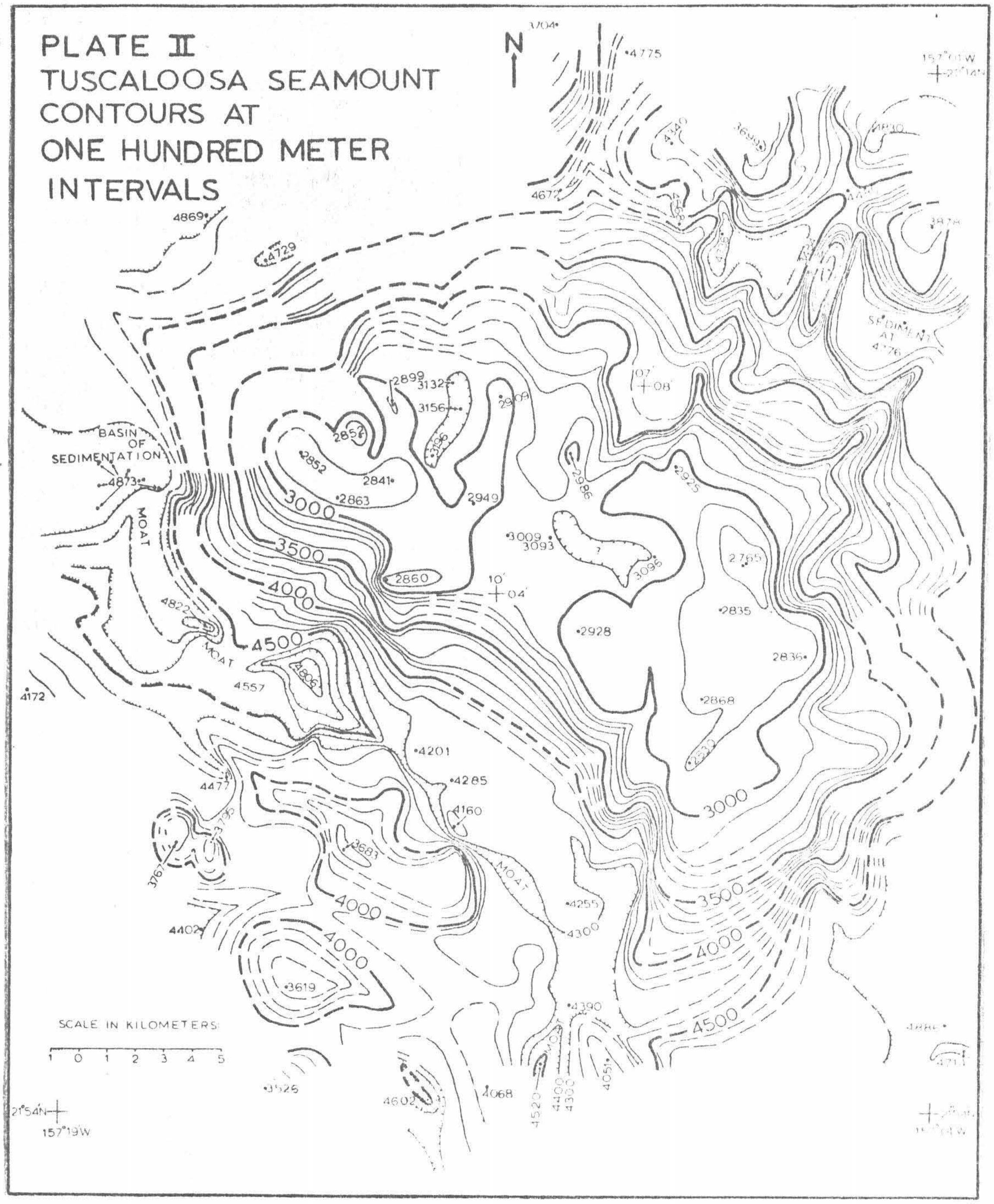

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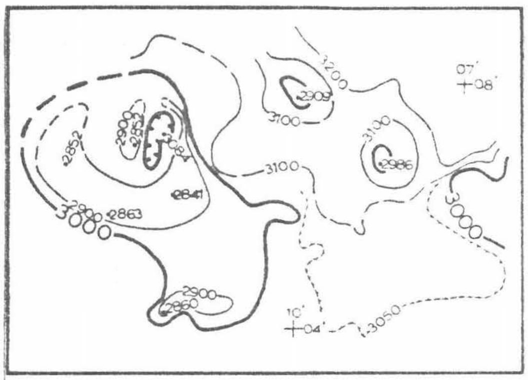

PLATE III:

ALTERNATE CONTOURS OF WESTERN PEAK AND CENTRAL SUMMIT OF TUSCALOOSA SEAMOUNT, CANYON OF PLATE II HERE SHOWN AS CRATER, LARGER AREA BELOW 3100 METERS RENDERS A RIDGE FROM PLATE II AS A LOW REGION AND CONE HERE WHILE ELIMINATING A GRABEN OF PLATE II. THIS PLATE OVERLAYS PLATES I & II WITH AID OF TWO COORDINATE TICK MARKS.

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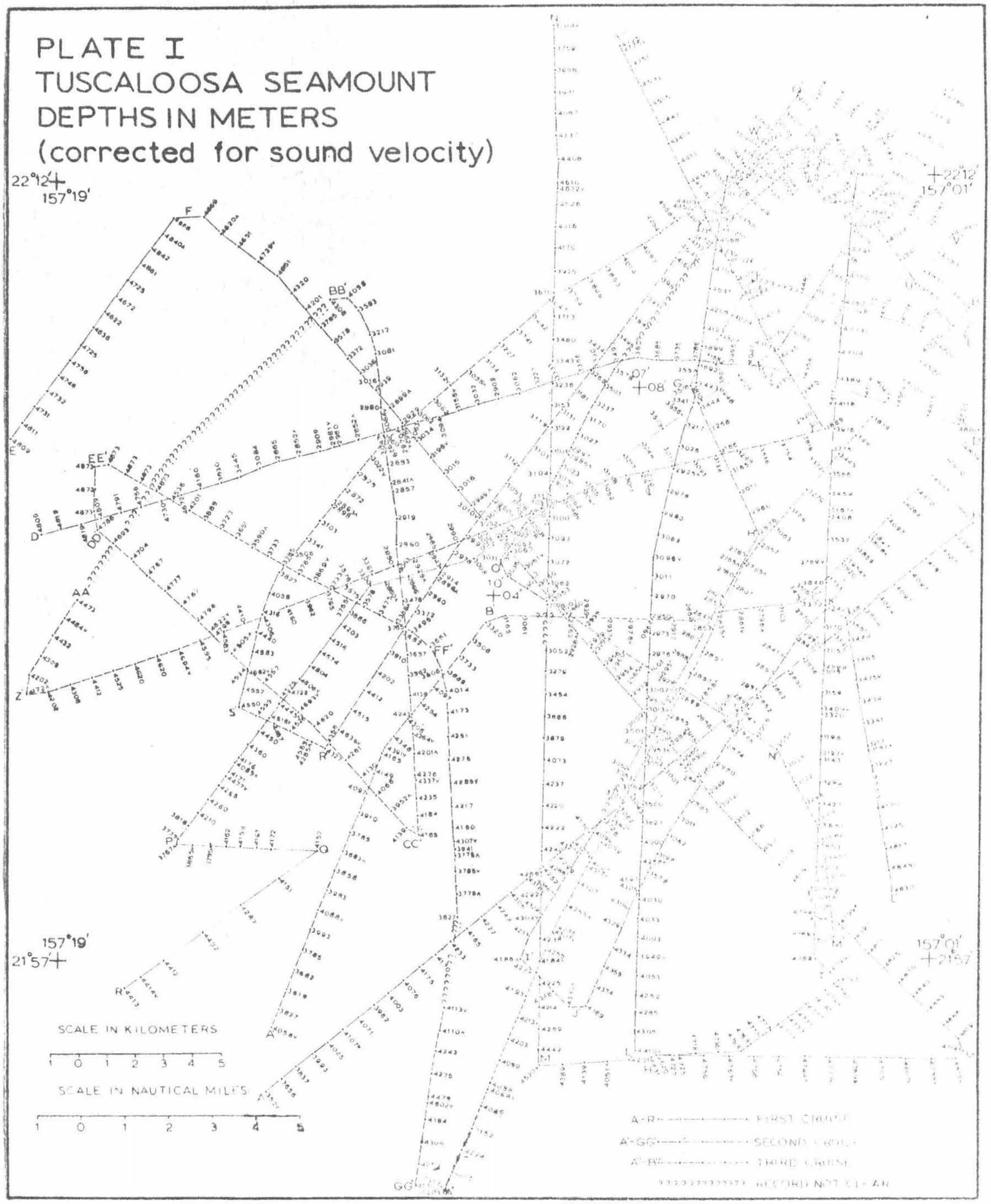

PLATES ONE THROUGH FOUR
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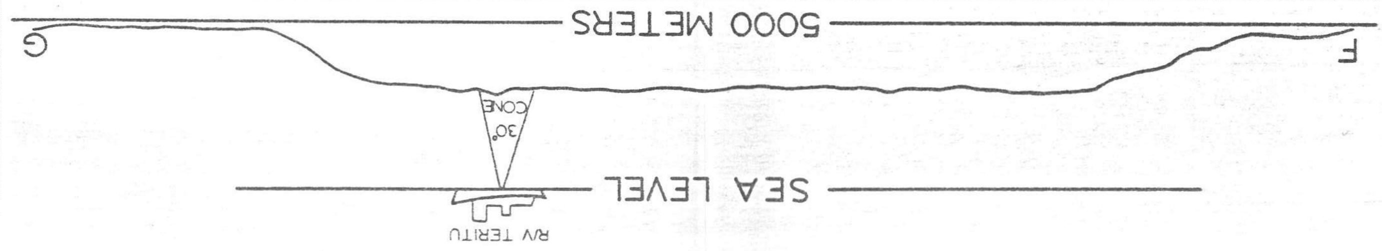

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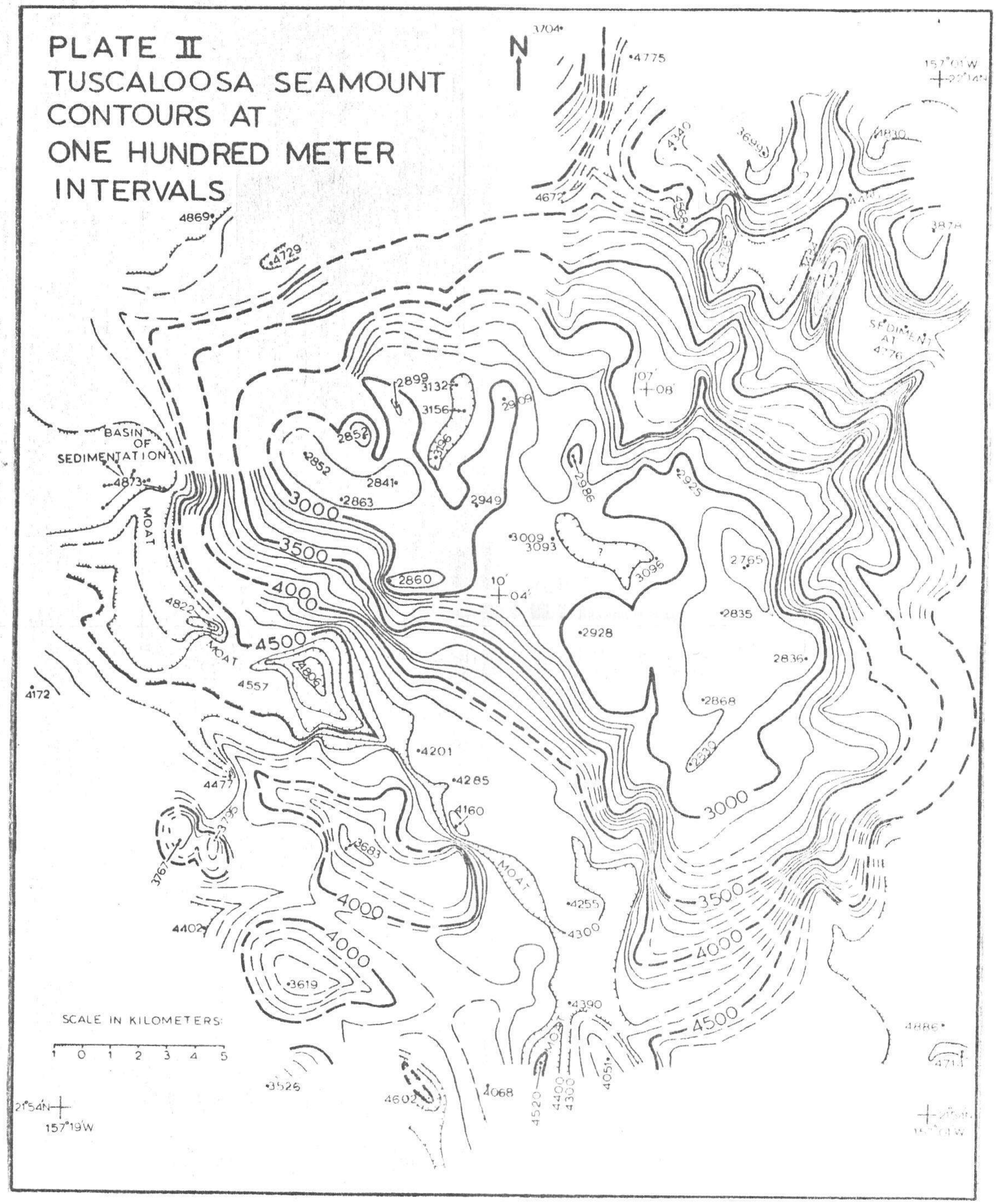

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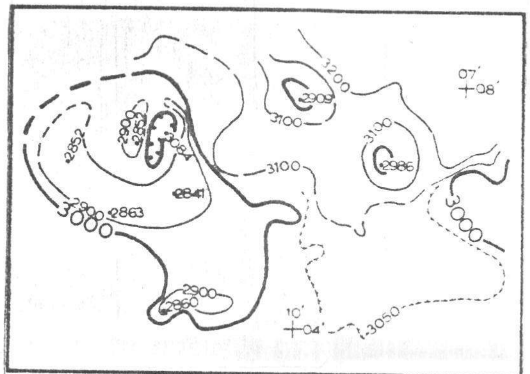

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