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NORTH PACIFIC GUYOTS

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Commander,
Naval Oceanography Command

This technical note has been prepared to document known guyots in the North Pacific Ocean that have been surveyed with the Sonar Array Survey Subsystem multibeam sonar system to give total coverage. It is intended to show the features, the derivation of the names, and to correct misconceptions about the geomorphology and history of guyots.

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A bathymetric atlas of North Pacific guyots is presented as a series of chartlets along with a description, the derivation of names, and a history of guyots and associated geomorphology. The features were surveyed by swath bathymetric systems that provide total coverage and permit a comprehensive study of guyot geomorphology. A description of sonar and navigation equipment is included.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CON.)

LIST OF TABLES

I. INTRODUCTION

During World War II sonar had progressed enough for Hess (1946) to notice flat tops on some Pacific Ocean seamounts. A study revealed that these features varied in size, had flat or gently sloping tops of 2^{o} or less, and that they were circular or oval in plan. These seamounts were named guyots after a 19th century geographer, Arnold Guyot. The observed top depths of the flat surfaces ranged from 520 to 960 fm, and the bottom from 2600 to 3100 fm. The guyots as described by Hess exhibited very little terracing and were thought to be relics of Pre-Cambrian volcanic islands with no reef growth. The sonar was a minimum 65^{o} beam width and navigation was poor by today's standards.

Hamilton (1956) showed several guyots in the Mid-Pacific Mountains to be submerged between 700 to 900 fm. These features displayed symmetry and concave sides upward to 20^{o} slopes near the tops. Conclusions from the study were: guyots of the Mid-Pacific Mountains were truncated volcanoes with flat, wave-eroded platforms; reefs tried to become established during the Cretaceous, but were killed by rapid submergence; and the guyots continued to subside to a 900-fm top. The evidence then available did not support theories of sediment-filled calderas and atoll lagoons, or upfaulted blocks. Here again the sonar beam width was 65^{o}, and the navigation was marginal to poor by today's standards.

Menard and Ladd (1963) summarized the "state of the art" and restricted the definition of a guyot to a flat-topped seamount deeper than 100 fm (200 m) and stated that guyots were definitely drowned atolls. The topography was the same as that of an insular shelf except for island erosion. None of the dredged guyots displayed anything older than Cretaceous on them. The depths ranged from 200 to 2500 m with most falling between 1000 to 2000 m. Guyots were thought to be located worldwide, with half of the estimated total of a few hundred lying in the West Central Pacific. One important note was that the depth should be considered as the break in slope between the sides and the summit plateau because this represents sea level when truncation began. Furthermore, the present guyot depth represents the sum of sea level change and subsidence since formation (Kaneoka, 1972). Guyots have also been shown (Heezen and Hollister, 1971) to be dipsticks to record ancient ocean depths. The subsidence implied by guyots is related to the subsidence of the oceanic crust itself (Vogt and Ostenso, 1967).

Comparative geomorphology then loomed ominously over the new science. Not only were wave truncation and subsidence responsible for guyot formation, but other means of producing a flat top were discovered in the Galapagos (Simkin, 1972). Flat-topped morphology will be expected any time circumferential feeder vents build heights to one tenth the summit diameter. Sediment capping of multiple tops and atolls (Karig et al., 1970) would also produce guyot morphology, which was shown on a seismic track (Tamaki, 1976). At this stage, the marine geology community realized that it did not have enough data to determine anything about guyots other than the possible existence of some flat-topped seamounts and some of the dredged age data which are also hit-or-miss depending on many variables.

While the ages of many guyots are unknown, the age of the floor on which they sit is now known for most cases (figure 1). The oldest floor is 150 MYBP in the West Central Pacific (Heezen and Hollister, 1971) and should hold the oldest guyots. The youngest crust, and probably guyots, presented is in the Gulf of Alaska.

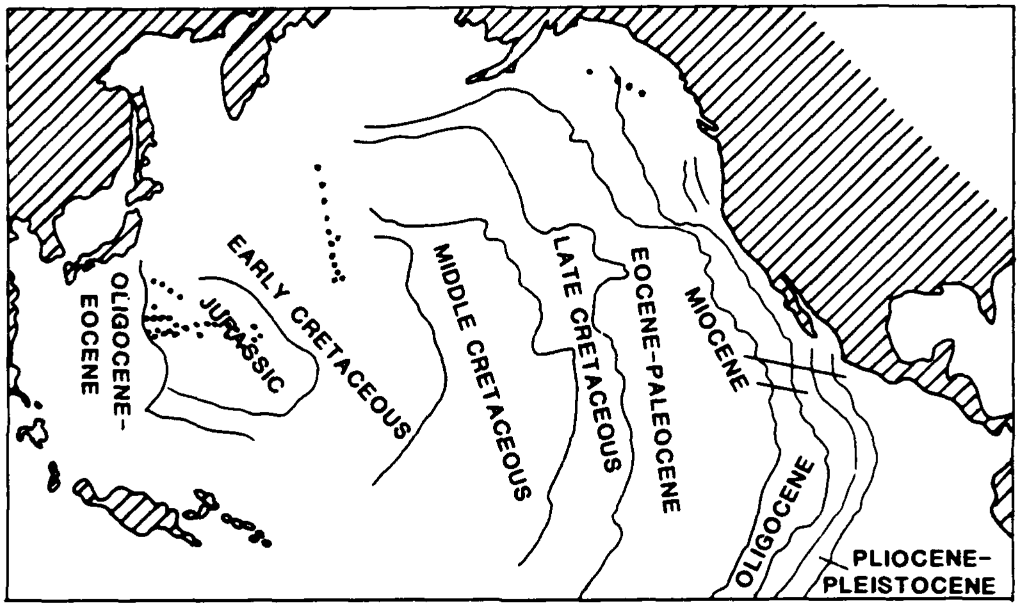

Figure 1. Pacific Crustal Ages with Approximate Guyot Locations (adapted from Heezen and Hollister, 1971).

A summary of the data acquisition methods shows that most navigation for nonmilitary ships has progressed to navigation satellites used to update "dead reckoning" or sunshot track lines. While these ships did not have LORAN-A or C for navigation, they also did not take the necessary time to explore fully the bathymetry to determine the true morphology of any intermediate features even with the primitive sonar. Also, many surveys were and are being conducted and features named that do not exist either in position or morphology because of these methods, which is especially true for guyots (Smoot, 1980).

In 1974, the director of the Ocean Survey Program at the U.S. Naval Oceanographic Office (NAVOCEANO) took an interest in the marine community and in releasing total coverage multibeam data. At that time, this was the only active multibeam sonar in the world. The director asked the author if he would like to begin releasing data on guyots. To that effect the author, having a background in cartography and marine surveying, began the study of guyots. Having access to a large data bank, the author decided to perform a systematic study of guyot morphology based on real bathymetry (sonar bottom) to determine the areal flat surface, slopes, and degree of roundness, flatness, and symmetry in the historical definition.

This report is the culmination of that effort so that by now there is no longer any reason to proliferate any misconceptions as to guyot morphology engendered in the definition. The purposes of this report are to: (1) describe the feature-naming process and provide a history of enclosed names where possible, (2) provide an atlas of multibeam-surveyed guyots, and (3) make alterations in the historical guyot definition based on this study.

II. METHODS AND MATERIALS

The guyot charts have been constructed with multibeam array sonar using sound velocity-corrected, real-time depths for vertical control. The 1° beam width, 61 to 90 beam swath Sonar Array Survey Subsystem gives up to twice the ocean depth coverage and is the best sonar survey system. A closer look at the multibeam array survey system (Glenn, 1970; Glenn, 1976) shows that thirty to sixty depths are collected from a plane wave of sound. These depths cover a wide area perpendicular to the ship's track (figure 2). Essentially, the subsystem transmits a 90° plane wave, receives individual bottom depths for the selected returning beams, correlates the sonar and navigation data, and computes and processes the sonar bottom. Roll and pitch compensators keep the plane wave perpendicular to the sea floor. Constant updating of the sound velocity profile through water, aided by a change of surface velocity with every ping, assures that the outer beams are not distorted by "ray-bending." The ping rate of every 12 to 15 seconds assures a rather large matrix of depths for the computer to interpret the desired contour interval. A high-speed digital X-Y plotter then produces a real-time strip chartlet while the ship is underway. The width of this chartlet is dependent on sea floor depth. At 2500 fm, a three-mile survey line spacing would then produce total coverage of the bottom. A newer, not quite as accurate, relative to this system is SeaBeam. SeaBeam is commercially available and generally suits the needs of the marine community (Allenou and Renard, 1978; Adams, 1983).

Horizontal control is provided by LORAN-C and, where applicable, dampened by an inertial navigation system updated by navigational satellites, electromagnetic and doppler logs, and an advanced time standard. This system gives accuracy of less than 1 nautical mile so the survey information is highly repeatable (Dunham and Shostack, 1980). Near-total to total coverage depth

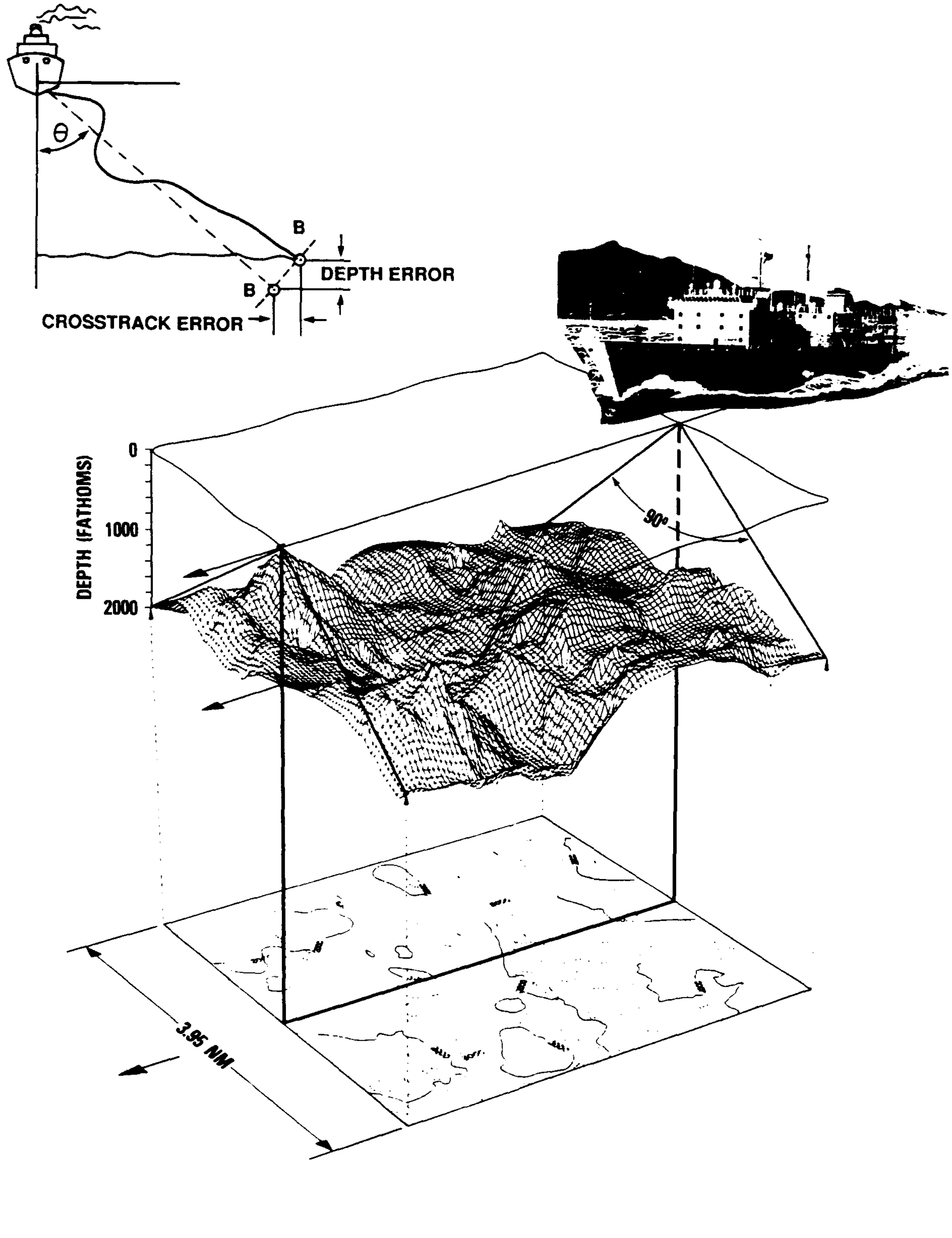

Figure 2. Transmitted Sonar Beam Pattern and Contour Strip Chart Header.

charts provide an excellent look at the sonar bottom of some North Pacific guyots on Mercator projections.

The guyots in this atlas are presented from east to west across the North Pacific between the Pacific Plate subduction zones and 20°N latitude. The guyots are shown regionally or by chains in the Gulf of Alaska, the Emperors, the Japanese, the Michelson Ridge, the Dutton Ridge, and the Marcus-Wake Seamounts. All of the parameters are provided by direct measurements of the features themselves excepting any available age data (Ozima et al., 1977; Heezen et al., 1973; Jackson et al., 1980; Turner et al., 1973). The guyot diameters were not considered because there are presently no available seismic traces that penetrate the flank slopes. Because of sedimentation, the outer flank slopes are asymptotic to the surrounding sea floor and a true outer diameter cannot be determined. Also, the upper flanks cannot be extended through the lower flanks to remove the overload effects because the actual basement depth is undetermined, especially where any thermal rejuvenation may have occurred. Otherwise, the name, latitude, longitude, and age are of atlas interest. The other parameters are needed to explain the gross morphology.

First, by definition a guyot has an eroded flat top. The minimum guyot depth is measured from sea level to the shoalest point on that flat top (or plateau). The summit plateau break depth is the point at which the eroded portion stops and the original side slopes begin (figure 3). This point is readily observable on most cases except where there are wave-cut terraces. The summit plateau area is then merely a measurement of that area inside the summit plateau break depth. This essentially shows the surface area of the paleo-island.

The sides and flanks are next. The flank break depth is more difficult to ascertain. Essentially, it is an eyeball measurement of the point where sedimentation begins around the original edifice between the larger upper slope angle and the gentler lower slope (apron) angle and is extremely variable between features. This point was unknown before the advent of close order surveying. The regional base depth discounts moating and is the depth of the surrounding environment. The minimum guyot depth subtracted from this figure gives the guyot height.

Figure 4 depicts the Hawaiian Island chain from the northeast. Essentially, it shows how tholeiitic basaltic guyots are formed. The hot spot now located below Loihi and Kilauea has produced this chain of features, and Loihi is believed to be the next island to be forming. To understand the 3-D graphics, one has to know that subaerial slopes can not attain the steep angles that submarine slopes can. This does not cause any confusion and will be seen to be a good indicator of sea level. Also, for the purposes of this discussion the term guyot will be used even though it is represented by volcano, seamount, island, bank, and

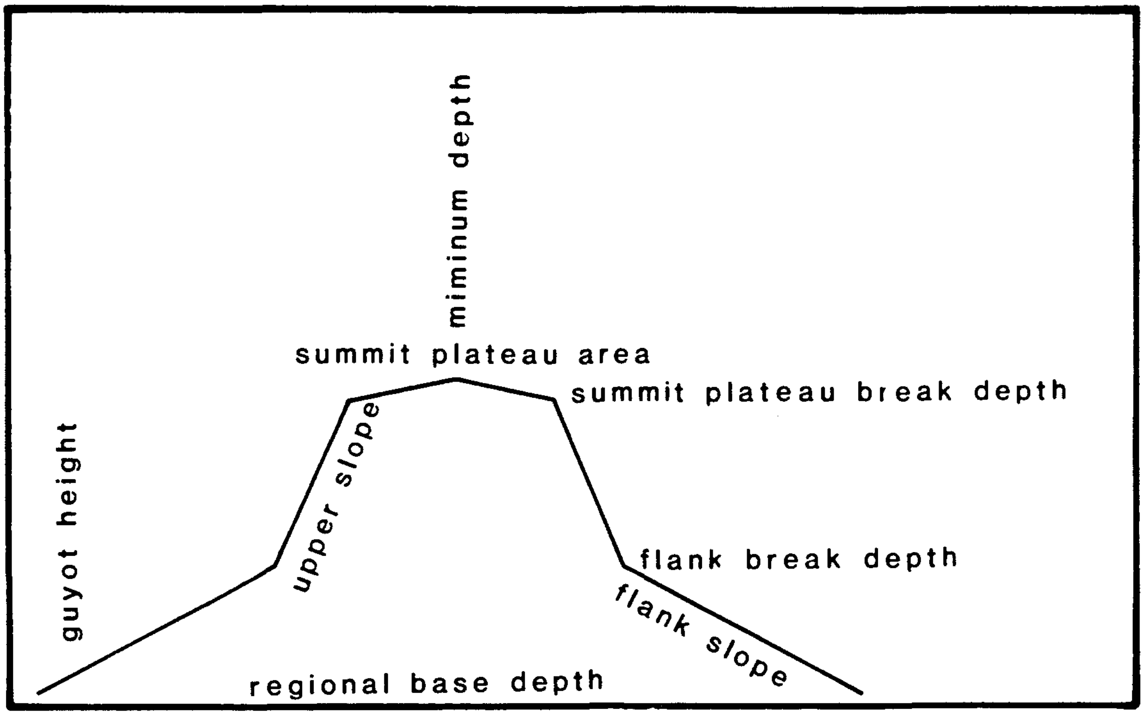

Figure 3. Location of Guyot Parameters.

finally guyot. One can readily see the onset of subaerial erosion on the eastern side of Hawaii at a very young age. By 0.8 to 1.8 MY later the platform has subsided and erosion is almost complete at Oahu. The last big island, Kauai, could have been built of material more resistant to erosion because its exposed surface appears to be undergoing an exfoliation process. The large, subaerial plain is significant because it uses about 100 fathoms or more above sea level, higher than any sea level stands in the 2.7 MY of Kauai's existence. For this guyot chain. wave action has not been a significant contributor to the erosion process. It would appear that the average summit plateau break depth based on this is definitely the figure to use in paleo sea level studies. Last, Niihau and Kaula are already essentially guyots, even though they are in the "bank" definition region now.

Skipping from Hawaii to the Japan Trench, a guyot can be found in its dotage. The total coverage SeaBeam data (Paytot et al., 1987, figure 5) is added to help show what probably happens to most sea floor features in the end. They break up at a subduction zone and are lost to the geologic record. Daiichi-Kashima is about to become that. It is apparently not large enough to abduct any material onto the landward trench slope. The feature has undergone normal faulting parallel to the trench axis as it entered the subduction zone, and a large portion of the main guyot has downdropped into the trench to be "crunched for digestion." In a matter of a few thousand years, Daiichi-Kashima will be no more--the same fate Loichi can expect in about 70+ MY if all tectonic parameters remain the same.

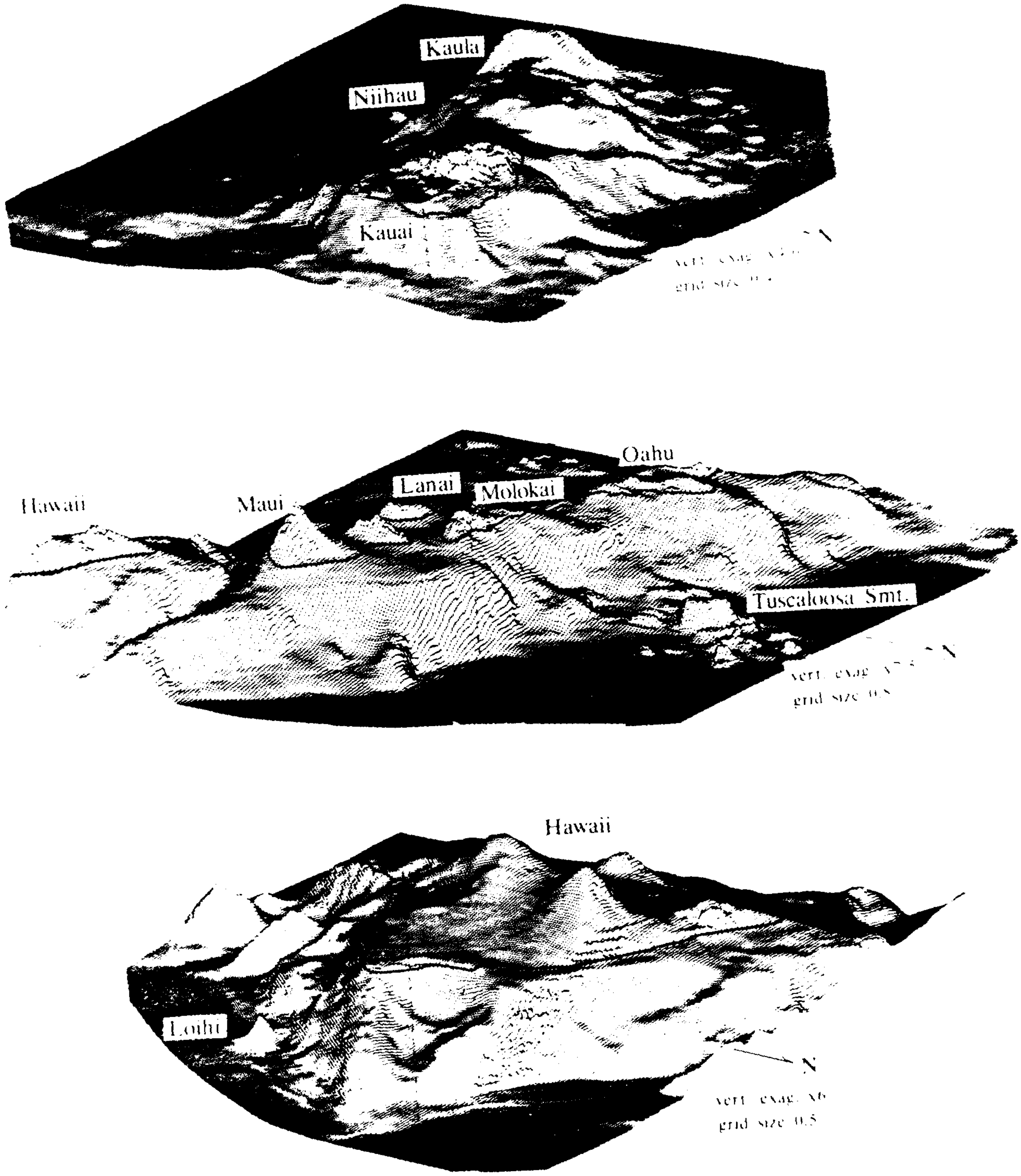

Figure 4. 3-D Figure of Hawaiian Chain.

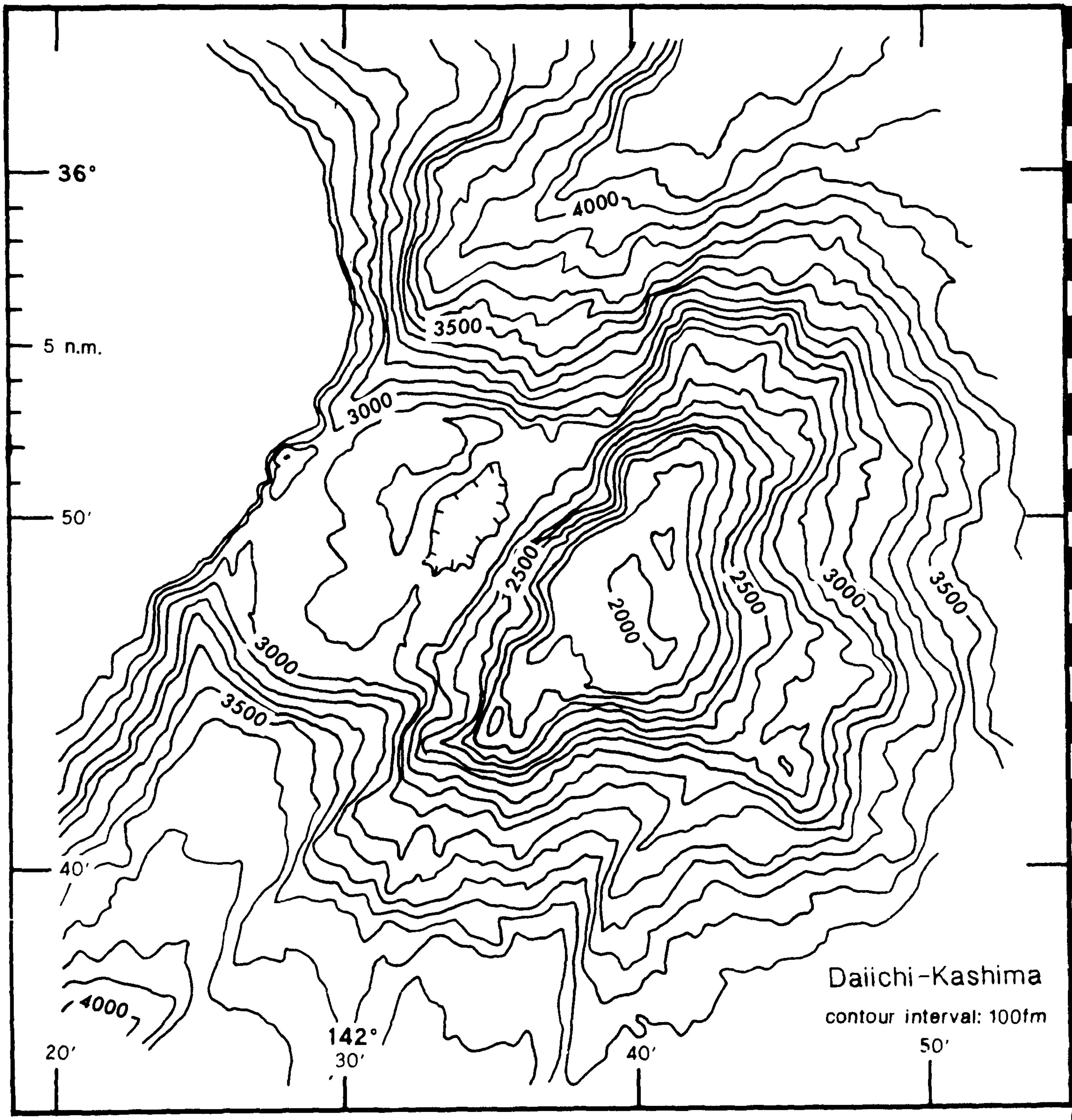

Figure 5. Daiichi-Kashima Guyot.

Of some interest to the study is the naming of the features. The first step in the publication process is to consult the U.S. Board of Geographic Names (USBGN) to see if the feature to be contoured already has a name. If not, the USBGN naming process is followed unless a name can be found in the literature.

This process follows a prescribed procedure. The name must be simple. First priority of a specific name is the general location in which it lies. However, this can be cumbersome as in the case of the Mariana Island, Basin, Ridge (East and West), Trench, and so on. The next priority is to name after ships, individuals, expeditions, organizations, and institutions involved in the study. The author has had names rejected for this category because the investigators were not world renowned. The author was then told that names of deceased people were preferred. Because multibeam exploration is new, most of the people who have worked with it are still living. An exception is a feature the author named Stout Seamount after one of NAVOCEANO's surveyors who died after having made over 100 cruises of exploration. This name was deferred. The next category is the naming of a group of features after specific categories of historical individuals, mythical figures, constellations, and so on. This category is the easiest in which to get a name accepted. Finally, names will be accepted if they are descriptive or have been in common use for many years.

This ongoing study has produced the following USBGN-accepted names in these North Pacific groups: the Gulf of Alaska Guyots (figures 6 through 10), the Emperor Guyots (figures 11 through 19), the Japanese Seamounts (figures 20 through 24), the Michelson Ridge Guyots (figures 25 through 29), the Dutton Ridge Guyots (figures 30 through 35), and the Marcus-Wake Seamounts (figures 36 through 46). They are Showa, Saga, Toba, Nelson, Broken-Top, Smoot, Castor, Pollux, Fryer, Vogt, Lowrie, Hemler, Vibelius, Beatty, McDonnell, Jennings, Sampson, Arnold, and Stout guyots. The Michelson and Dutton Ridges, named after survey ships, have also been accepted.

III. ATLAS OF NORTH PACIFIC GUYOTS

GULF OF ALASKA

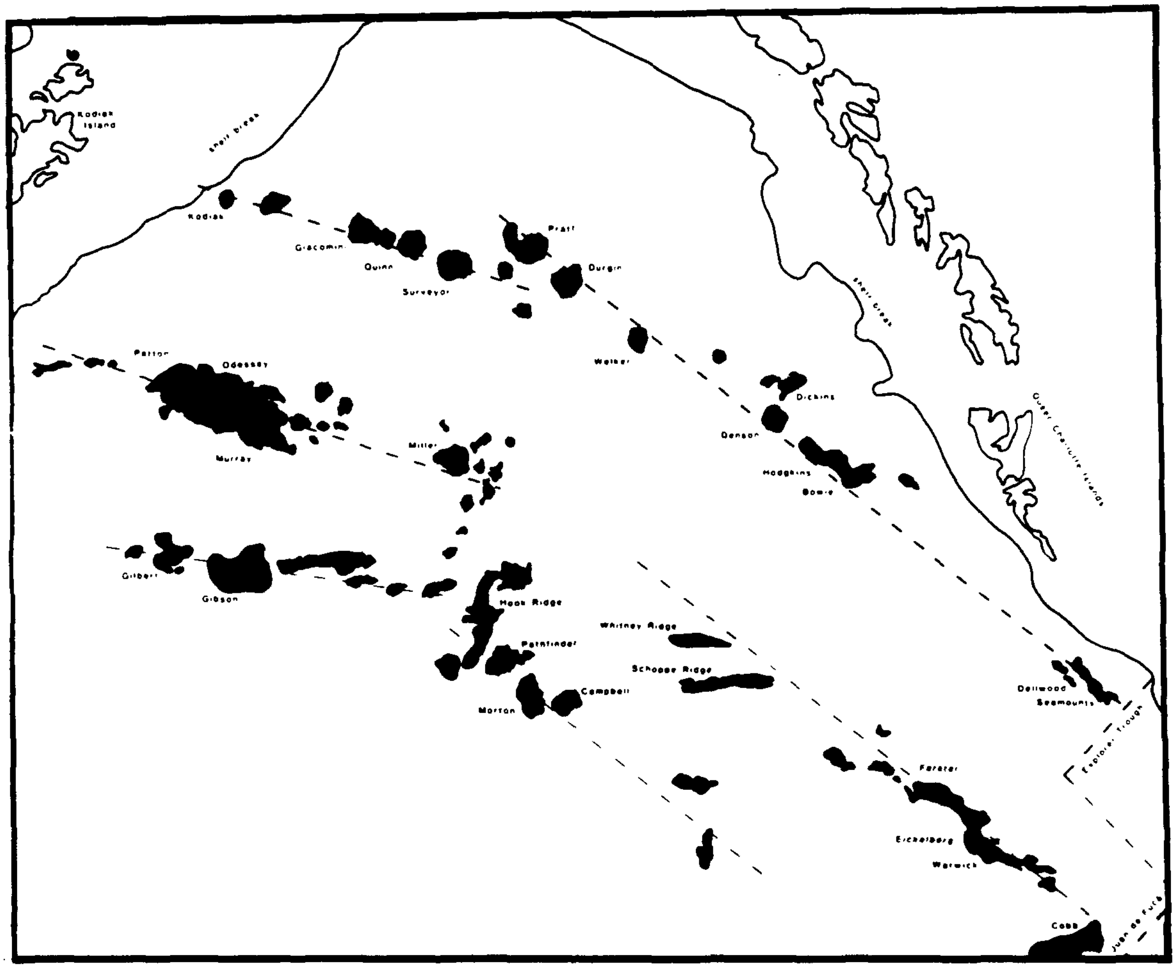

Figure 6. Locator Diagram of Gulf of Alaska Guyots (Smoot, 1985).

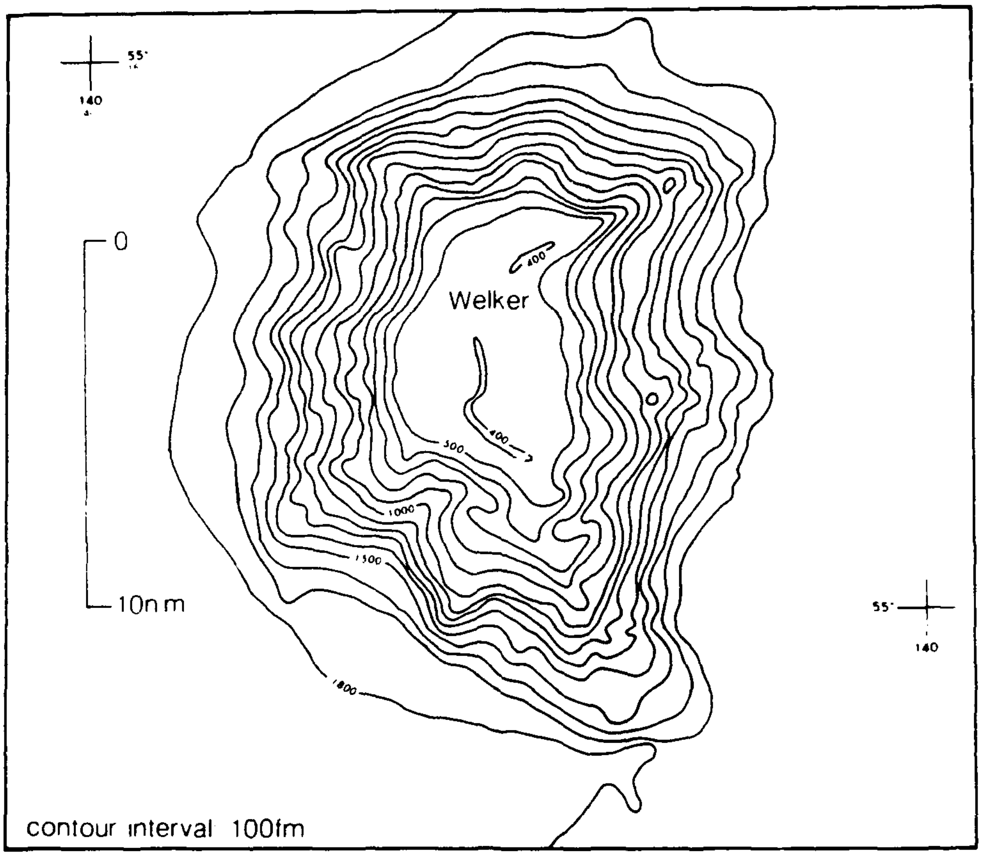

Figure 7. Welker Seamount (adapted from Smoot, 1981). USBGN.

Name: Welker
Latitude: 55°05'N
Longitude: 140°22'W
Minimum guyot depth (fm): 410
Summit plateau break depth (fm): 500
Summit plateau area (n.m.^{2}): 60
Flank break depth (fm):
Upper slope angle (%): 32
Flank slope angle (%):
Regional base depth (fm): 1800
Guyot height (fm): 1390
Guyot age (m.y.): 8

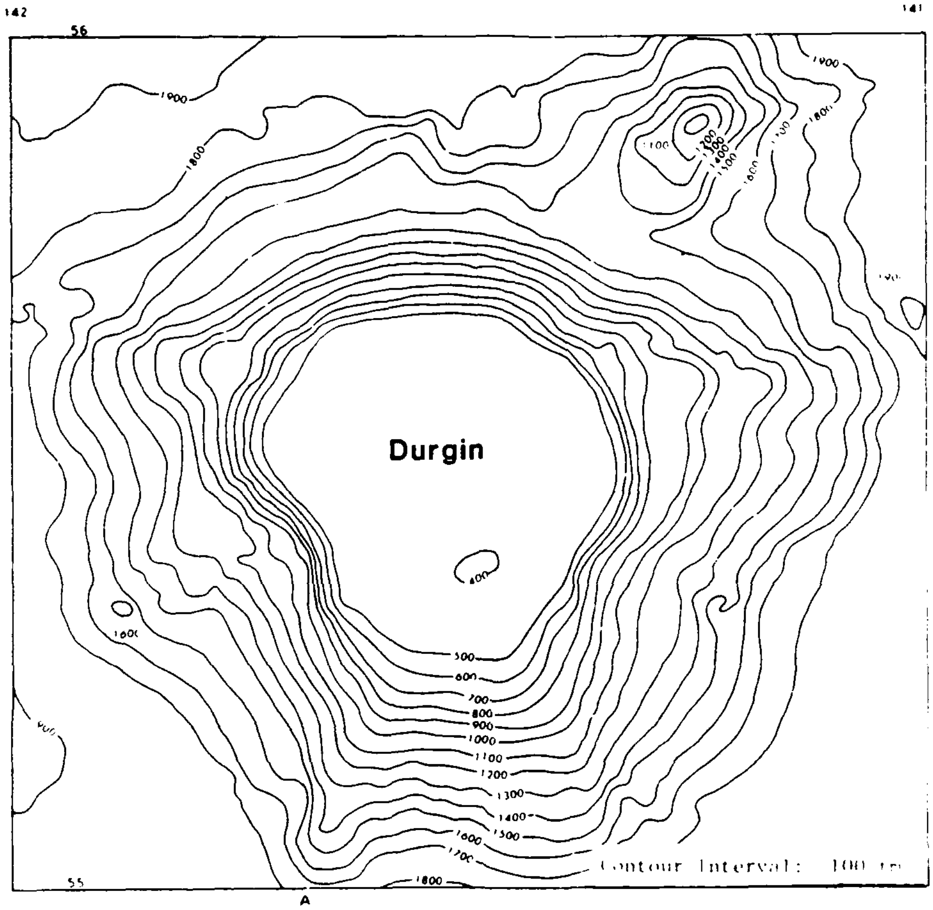

Figure 8. Durgin Seamount (Smoot, 1981). USBGN.

Name: Durgin
Latitude: 55°51'N
Longitude: 141°51'W
Minimum guyot depth (fm): 400
Summit plateau break depth (fm): 500
Summit plateau area (n.m.^{2}): 120
Flank break depth (fm):
Upper slope angle (%): 23
Flank slope angle (%):
Regional base depth (fm): 1900
Guyot height (fm): 1500
Guyot age (m.y.): 12

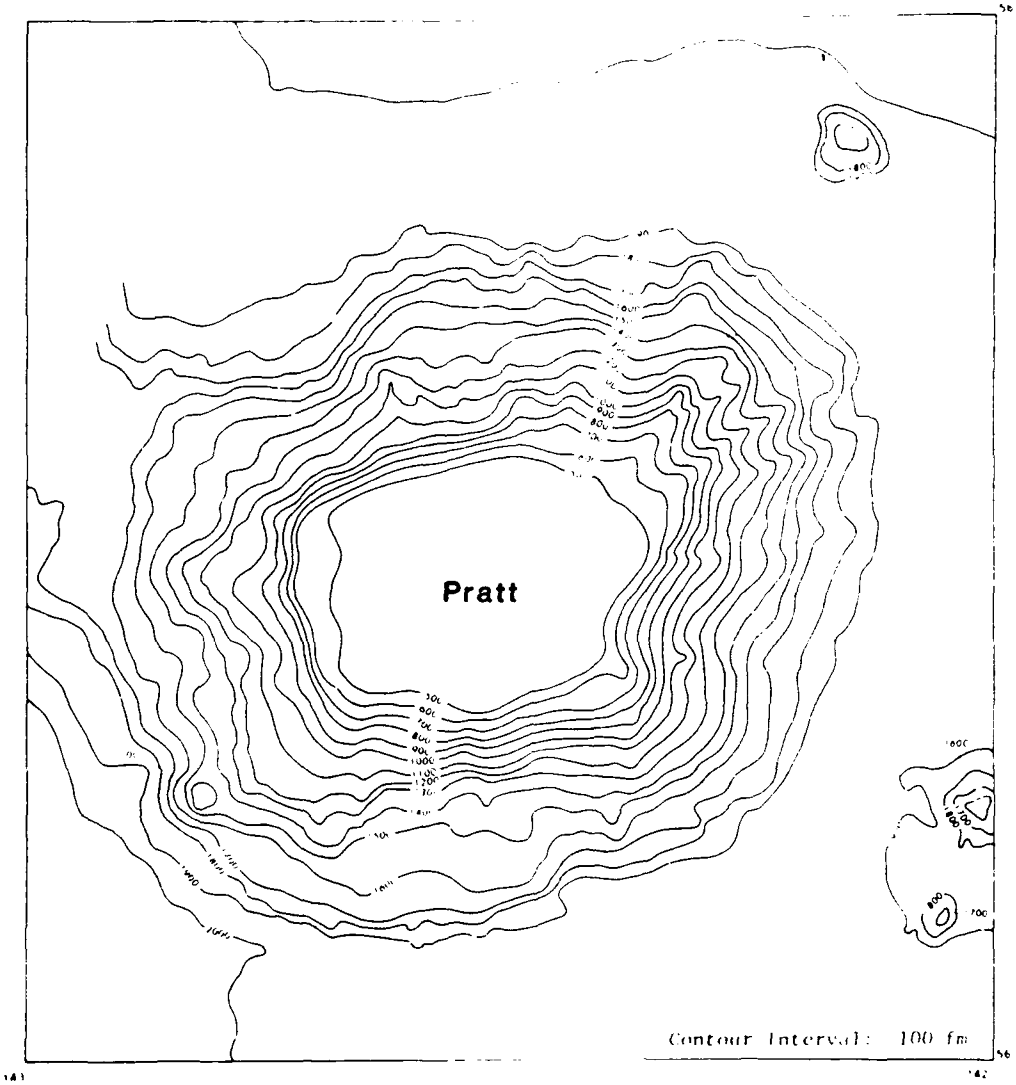

Figure 9. Pratt Seamount (Smoot, 1981). USBGN.

Name: Pratt
Latitude: 56°15'N
Longitude: 142°40'W
Minimum guyot depth (fm): 410
Summit plateau break depth (fm): 500
Summit plateau area (n.m.^{2}): 106
Flank break depth (fm):
Upper slope angle (%): 21
Flank slope angle (%):
Regional base depth (fm): 1950
Guyot height (fm): 1540
Guyot age (m.y.): 12.3

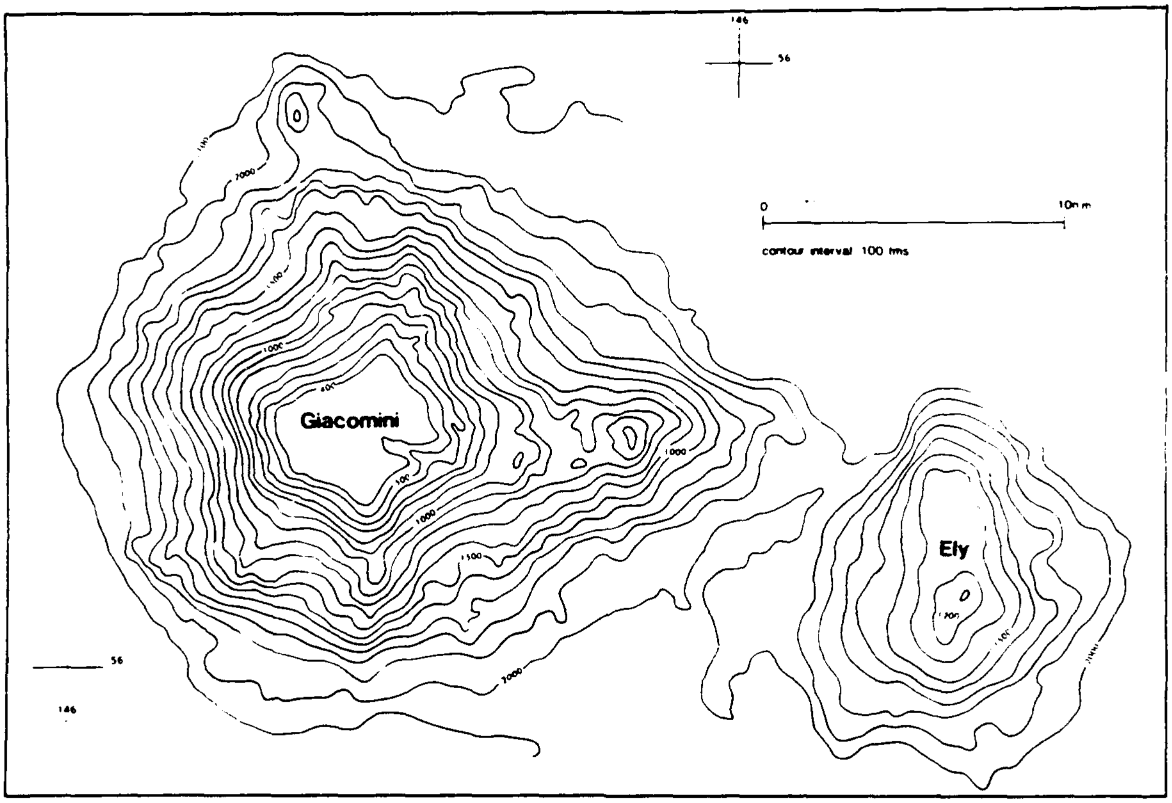

Figure 10. Giacomini Seamount (Smoot, 1985). USBGN.

Name: Giacomini
Latitude: 56°30'N
Longitude: 146°00'W
Minimum guyot depth (fm): 400
Summit plateau break depth (fm): 400
Summit plateau area (n.m.^{2}): 15
Flank break depth (fm): 1900
Upper slope angle (%): 22
Flank slope angle (%):
Regional base depth (fm): 2100
Guyot height (fm): 1700
Guyot age (m.y.): 19.9

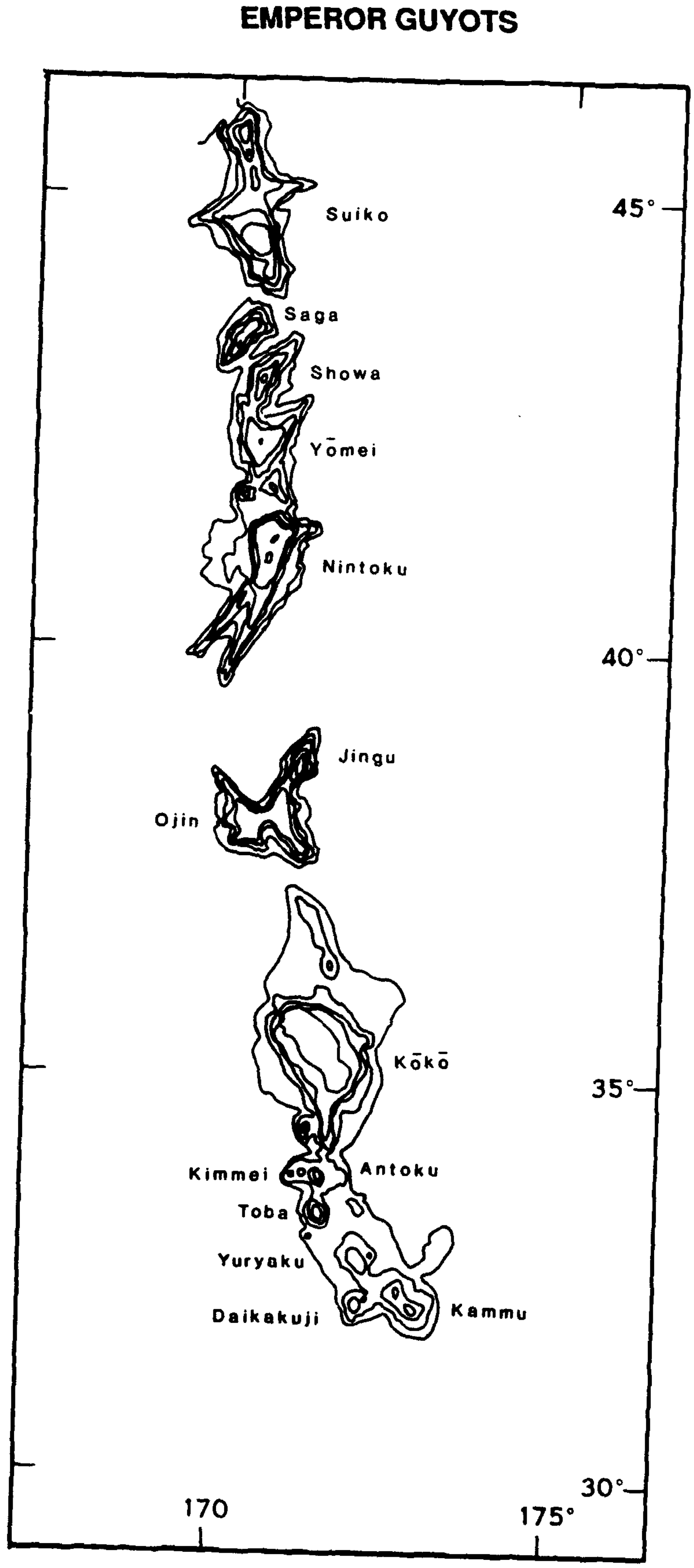

Figure 11. Locator Diagram of the Emperor Guyots (adapted from Mammerickx and Smith, 1984).

Name: Suiko
Latitude: 45°00'N
Longitude: 170°00'E
Minimum guyot depth (fm): 600
Summit plateau break depth (fm): 1000
Summit plateau area (n.m.^{2}): 1558
Flank break depth (fm): 2100
Upper slope angle (%): 27
Flank slope angle (%): 10
Regional base depth (fm): 3300
Guyot height (fm): 2700
Guyot age (m.y.): 64.7

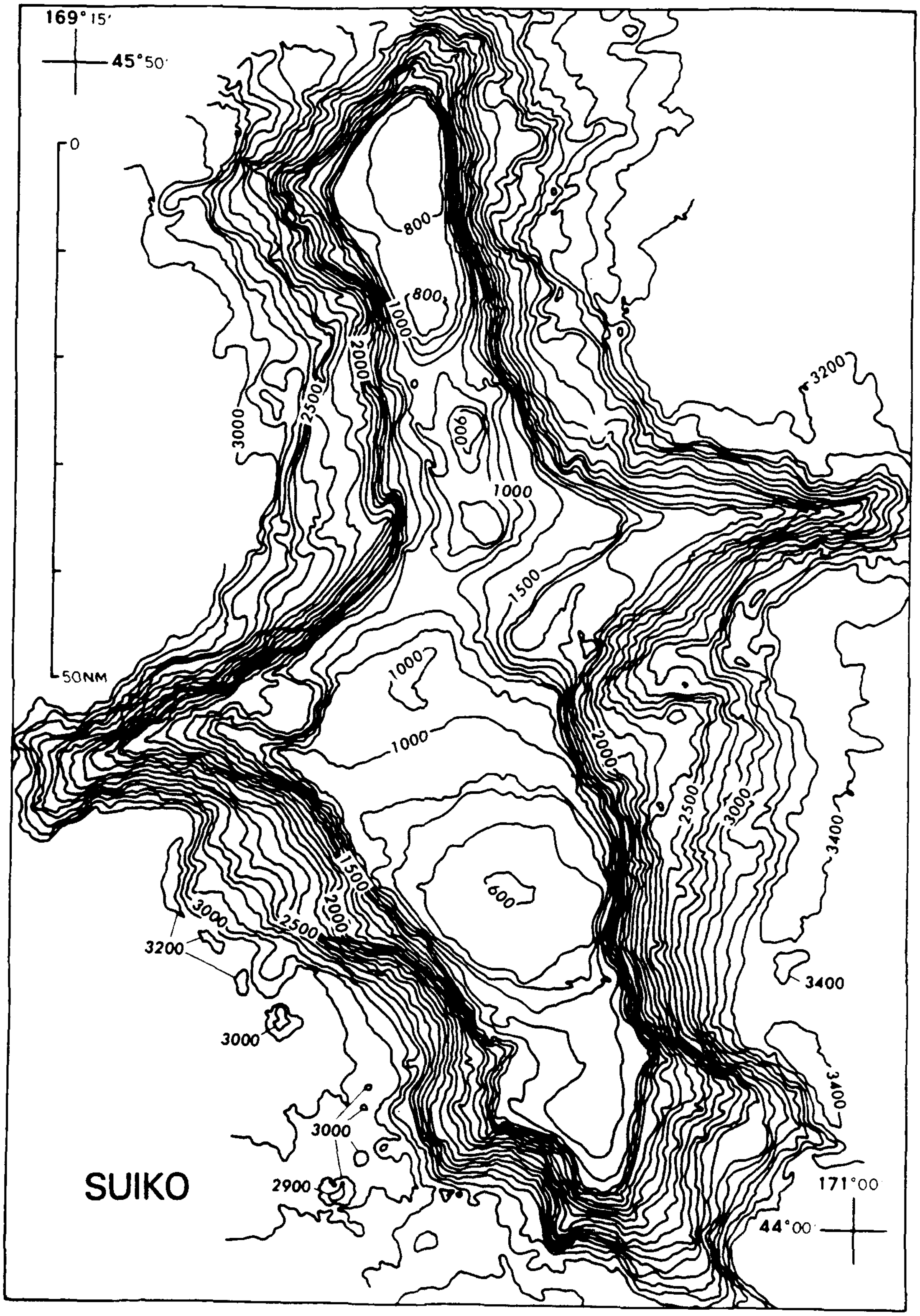

Figure 12. Suiko Guyot (Smoot, 1982). Named by R.S. Deitz (1954) after 33rd ruler of Japan (592-628 A.D.). USBGN.

Name: Saga
Latitude: 43°25'N
Longitude: 170°00'E
Minimum guyot depth (fm): 700
Summit plateau break depth (fm): 1000
Summit plateau area (n.m.^{2}): 136
Flank break depth (fm): 1900
Upper slope angle (%): 25
Flank slope angle (%): 7
Regional base depth (fm): 2800
Guyot height (fm): 2100
Guyot age (m.y.):

Name: Showa
Latitude: 43°00'N
Longitude: 170°20'E
Minimum guyot depth (fm): 800
Summit plateau break depth (fm): 1100
Summit plateau area (n.m.^{2}): 251
Flank break depth (fm): 2100
Upper slope angle (%): 22
Flank slope angle (%): 11
Regional base depth (fm): 3100
Guyot height (fm): 2300
Guyot age (m.y.):

Name: Yomei
Latitude: 42°20'N
Longitude: 170°20'E
Minimum guyot depth (fm): 500
Summit plateau break depth (fm): 1100
Summit plateau area (n.m.^{2}): 406
Flank break depth (fm): 2300
Upper slope angle (%): 24
Flank slope angle (%): 13
Regional base depth (fm): 3000
Guyot height (fm): 2500
Guyot age (m.y.):

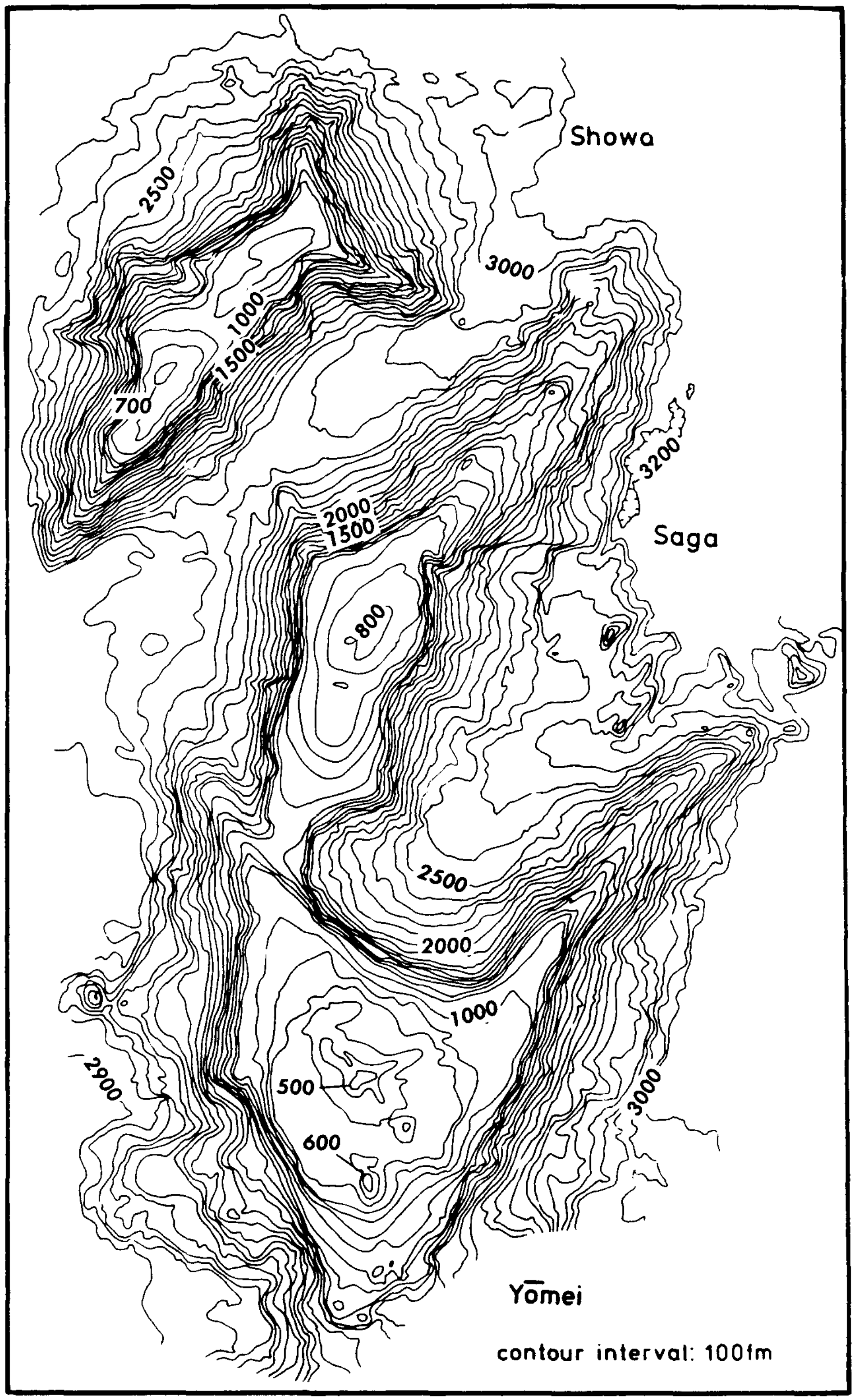

Figure 13. Saga, Showa, and Yomei Guyots. (Smoot 1982; 1984). Saga named by N.C. Smoot (1982) after Soga family. Changed to Saga, Emperor in 814, and accepted by USBGN. Showa also named by Smoot after family name of current reigning Emperor of Japan. USBGN. Yomei named by scientific staff at DSDP leg 55 after 31st Emperor of Japan (585-587 A.D.). USBGN.

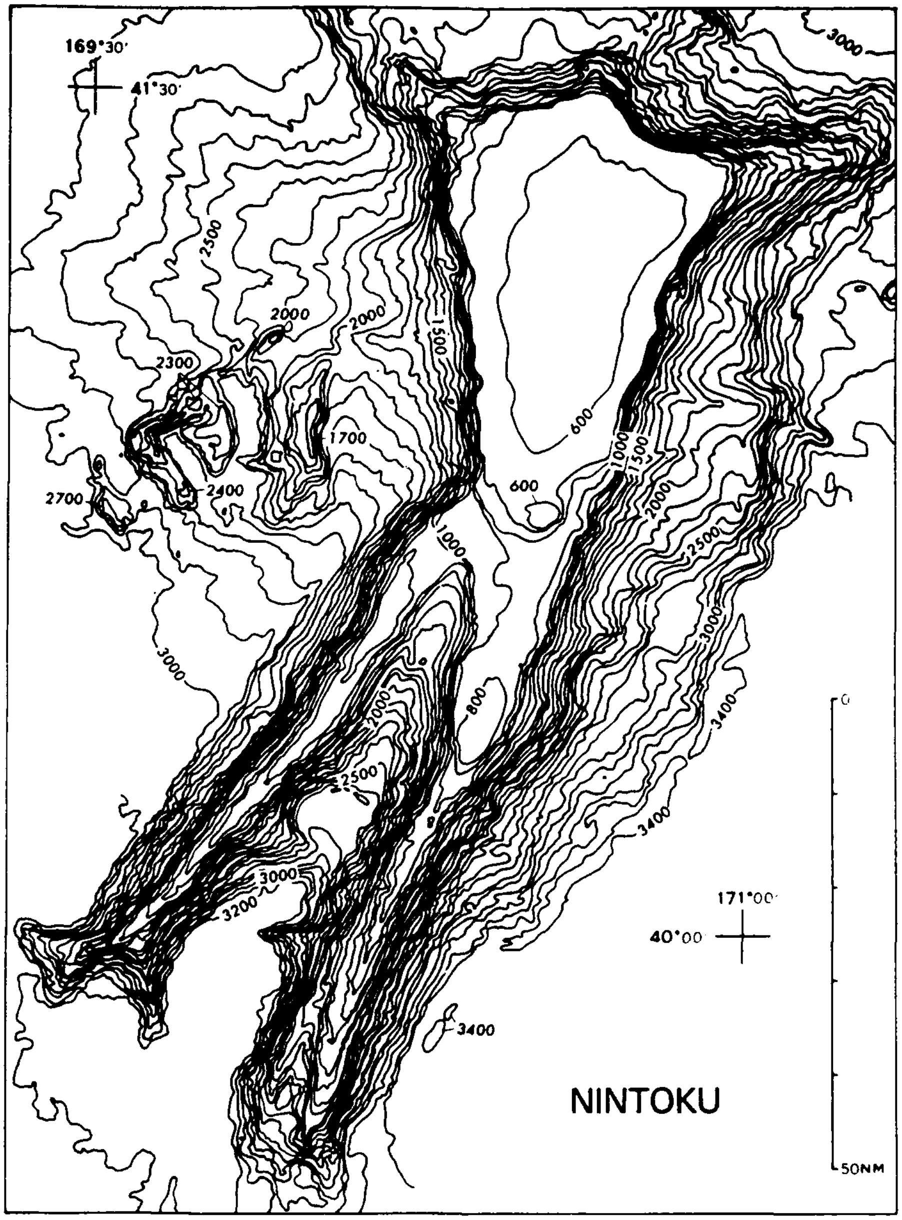

Figure 14. Nintoku Seamount (Smoot, 1982; 1984). Named by R.S. Dietz (1954) after 16th Emperor of Japan (313-399 A.D.). USBGN.

Name: Nintoku
Latitude: 41°00'N
Longitude: 170°30'E
Minimum guyot depth (fm): 600
Summit plateau break depth (fm): 700
Summit plateau area (n.m.^{2}): 1181
Flank break depth (fm): 1600
Upper slope angle (%): 24
Flank slope angle (%): 7
Regional base depth (fm): 3300
Guyot height (fm): 2700
Guyot age (m.y.): 56.2

Name: Jingu
Latitude: 38°40'N
Longitude: 171°10'E
Minimum guyot depth (fm): 500
Summit plateau break depth (fm): 600
Summit plateau area (n.m.^{2}): 91
Flank break depth (fm): 2400
Upper slope angle (%): 32
Flank slope angle (%): 10
Regional base depth (fm): 3200
Guyot height (fm): 2700
Guyot age (m.y.):

Name: Ojin
Latitude: 38°00'N
Longitude: 170°30'E
Minimum guyot depth (fm): 600
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 640
Flank break depth (fm): 2500
Upper slope angle (%): 24
Flank slope angle (%): 10
Regional base depth (fm): 3200
Guyot height (fm): 2600
Guyot age (m.y.): 55.2

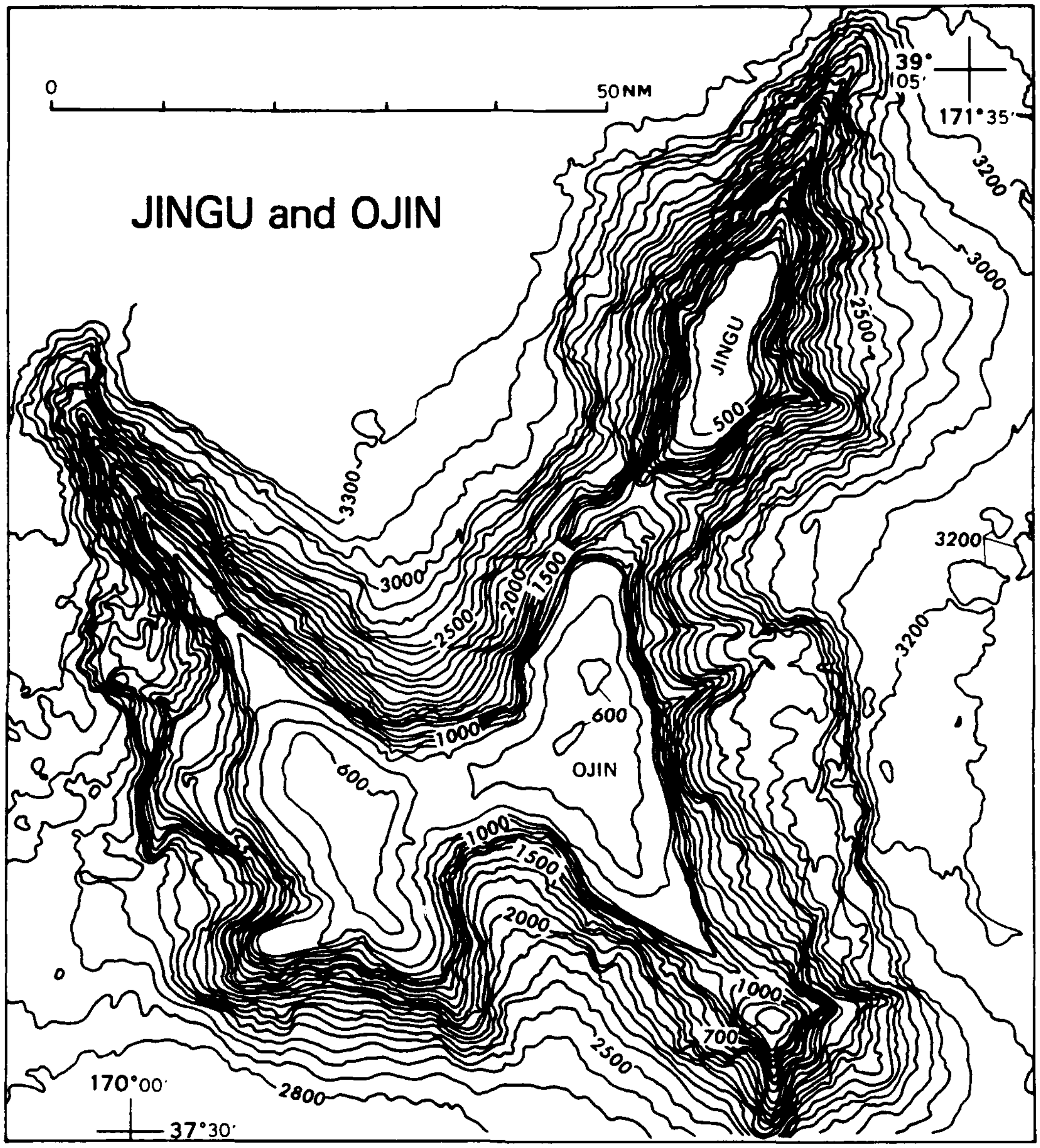

Figure 15. Jingu and Ojin Seamounts (Smoot, 1982). Both named by R.S. Dietz (1954). Jingu was the Empress of Emperor Chui. She reigned from 201 to 269 A.D. Ojin reigned as 15th Emperor (270 to 310 A.D.). USBGN.

Name: Koko
Latitude: 35°00'N
Longitude: 171°30'E
Minimum guyot depth (fm): 200
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 1500
Flank break depth (fm): 1800
Upper slope angle (%): 19
Flank slope angle (%): 5
Regional base depth (fm): 3000
Guyot height (fm): 2800
Guyot age (m.y.): 48

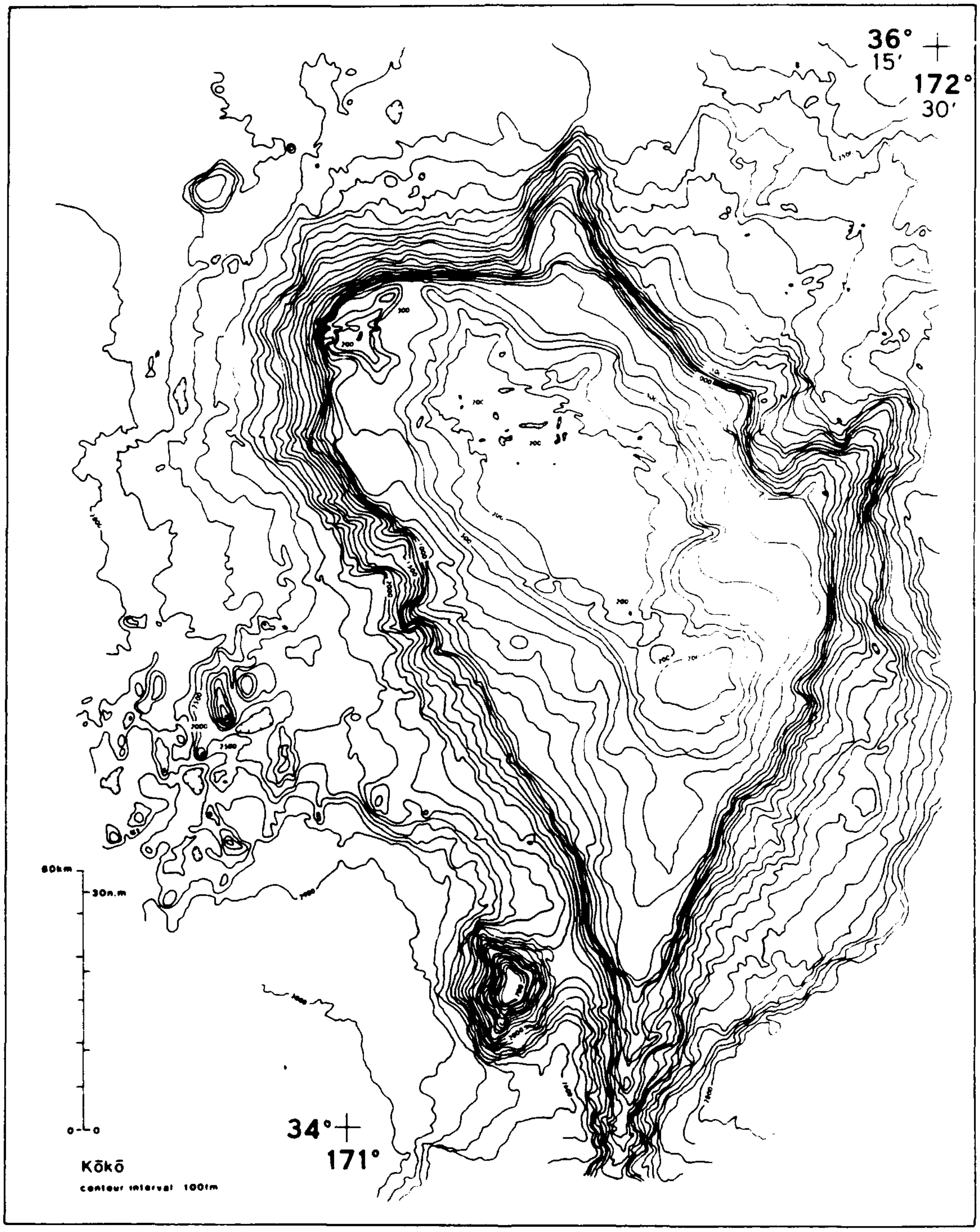

Figure 16. Koko Seamount. Named by T.A. Davies, P. Wilde, and D.A. Clague (1972) after the 58th Emperor of Japan (885 to 887 A.D.). USBGN.

Name: Antoku
Latitude: 33°40'N
Longitude: 171°40'E
Minimum guyot depth (fm): 500
Summit plateau break depth (fm): 600
Summit plateau area (n.m.^{2}): 50
Flank break depth (fm): 2000
Upper slope angle (%): 28
Flank slope angle (%): 5
Regional base depth (fm): 3000
Guyot height (fm): 2500
Guyot age (m.y.):

Name: Toba
Latitude: 33°15'N
Longitude: 171°40'E
Minimum guyot depth (fm): 600
Summit plateau break depth (fm): 700
Summit plateau area (n.m.^{2}): 65
Flank break depth (fm): 1800
Upper slope angle (%): 28
Flank slope angle (%): 4
Regional base depth (fm): 3000
Guyot height (fm): 2400
Guyot age (m.y.):

Name: Yuryaku
Latitude: 32°40'N
Longitude: 172°20'E
Minimum guyot depth (fm): 300
Summit plateau break depth (fm): 700
Summit plateau area (n.m.^{2}): 90
Flank break depth (fm): 1800
Upper slope angle (%): 24
Flank slope angle (%): 6
Regional base depth (fm): 3000
Guyot height (fm): 2700
Guyot age (m.y.): 43

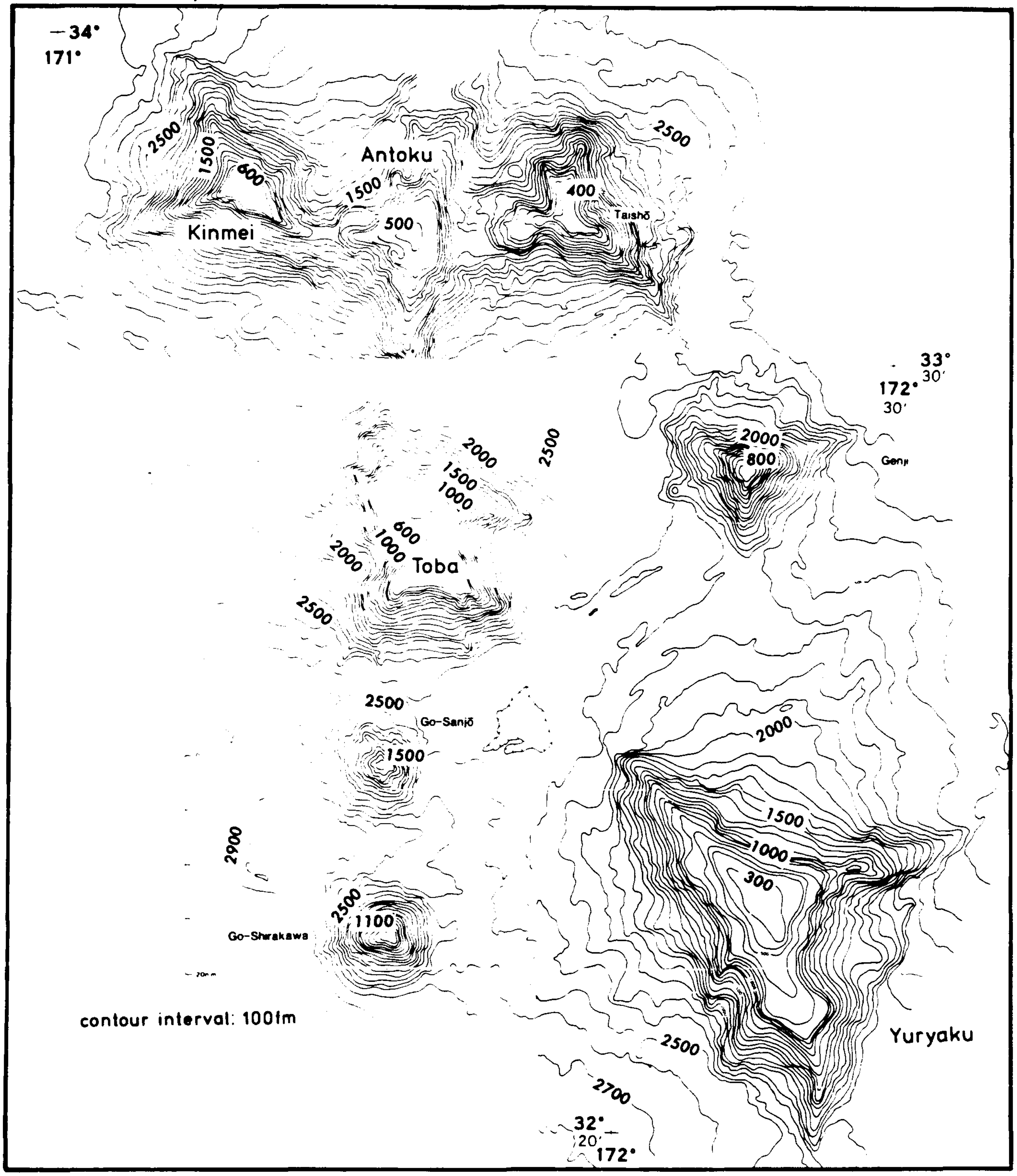

Figure 17. Antoku and Toba Guyots and Yuryaku Seamount (Smoot, 1985a). Antoku named by N.C. Smoot (1985) after Emperor of Japan (1180-1185 A.D.). Submitted to and rejected by USBGN. Toba named by Smoot (1985) after Emperor of Japan (died 1156 A.D.). USBGN. Yuryaku named by R.S. Dietz (1954) after 21st Emperor of Japan (457-479 A.D.). USBGN.

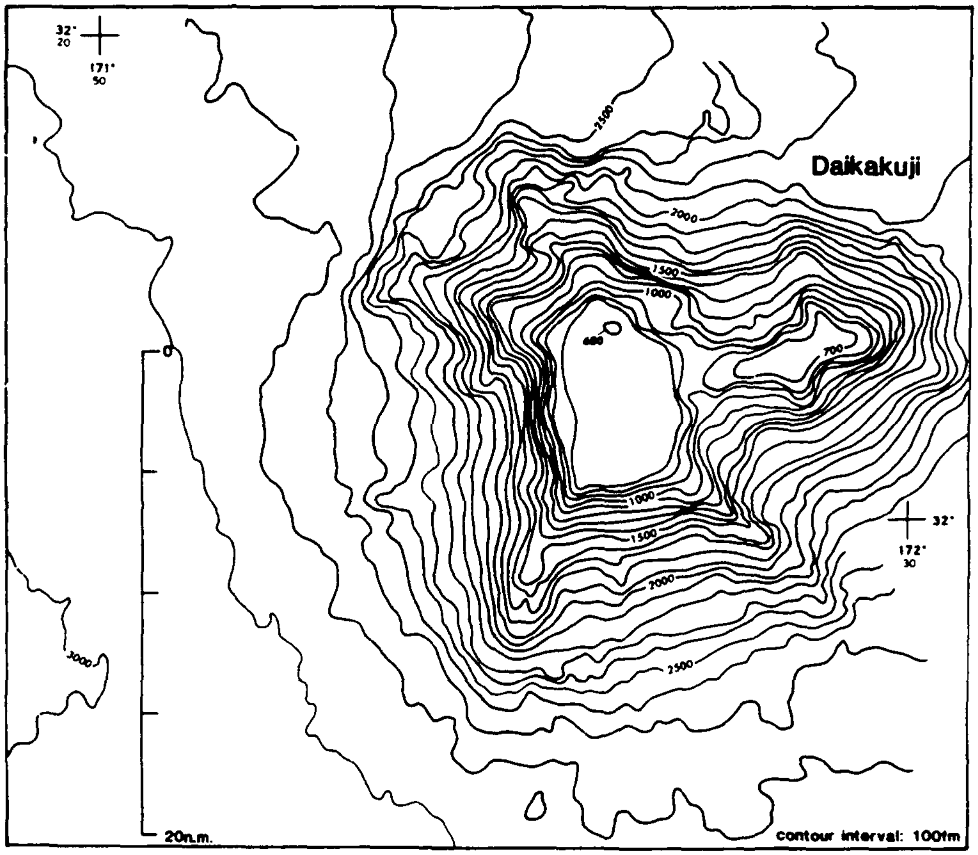

Figure 18. Daikakuji Seamount (Smoot, 1985a). Named by D.A. Clague (1974) after family name of sovereign of Japan (1259-1274 A.D.). USBGN.

Name: Daikakuji
Latitude: 32°05'N
Longitude: 172°15'E
Minimum guyot depth (fm): 600
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 50
Flank break depth (fm): 1800
Upper slope angle (%): 30
Flank slope angle (%): 5
Regional base depth (fm): 3000
Guyot height (fm): 2400
Guyot age (m.y.):

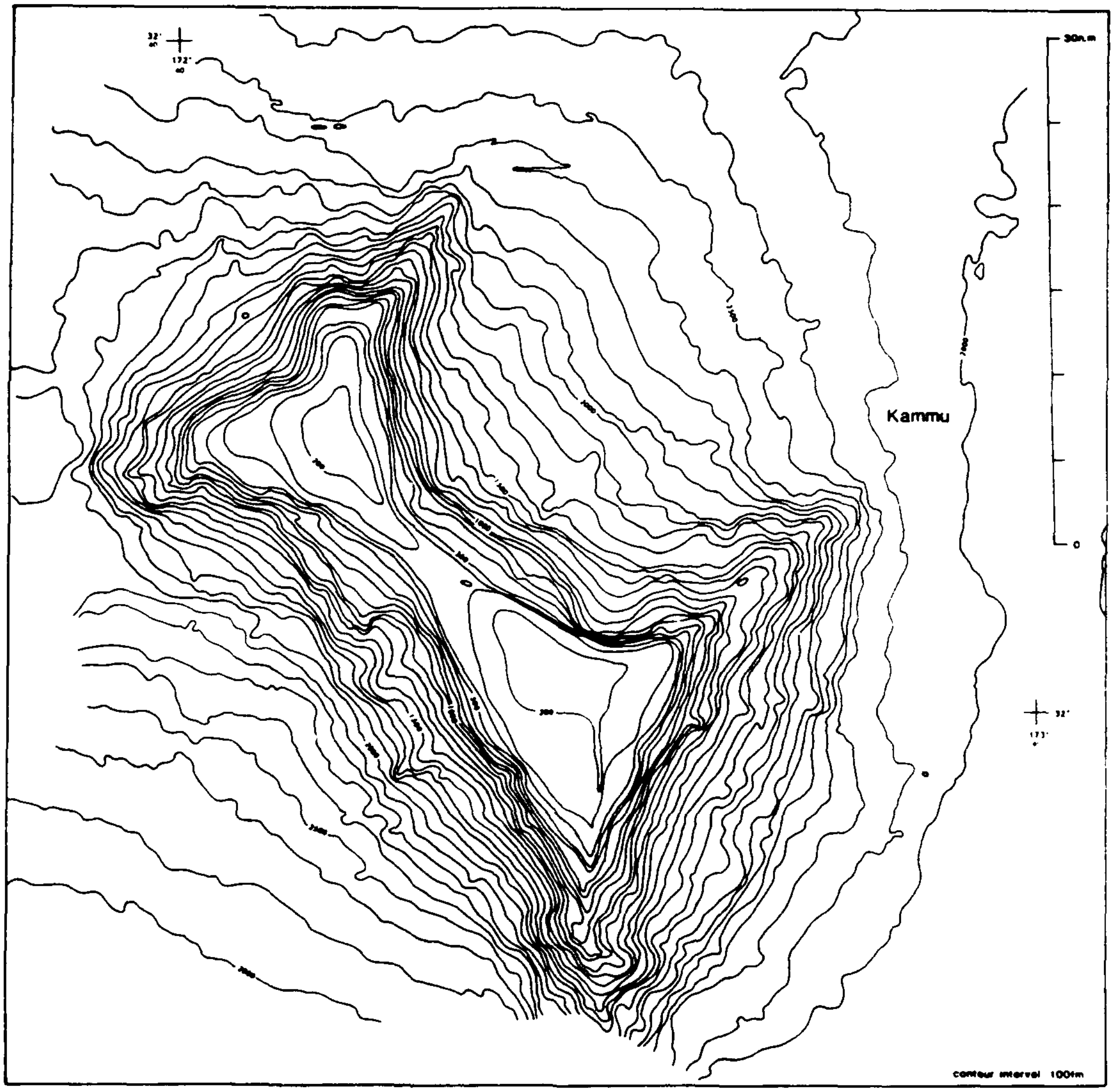

Figure 19. Kammu Seamount (Smoot, 1985a). Named by R.S. Dietz (1954) after 50th Emperor of Japan (782-805 A.D.). USBGN.

Name: Kammu
Latitude: 32°15'N
Longitude: 173°00'E
Minimum guyot depth (fm): 200
Summit plateau break depth (fm): 400
Summit plateau area (n.m.^{2}): 150
Flank break depth (fm): 1700
Upper slope angle (%): 25
Flank slope angle (%): 4
Regional base depth (fm): 3000
Guyot height (fm): 2800
Guyot age (m.y.):

JAPANESE SEAMOUNTS
(GEISHA GUYOTS)

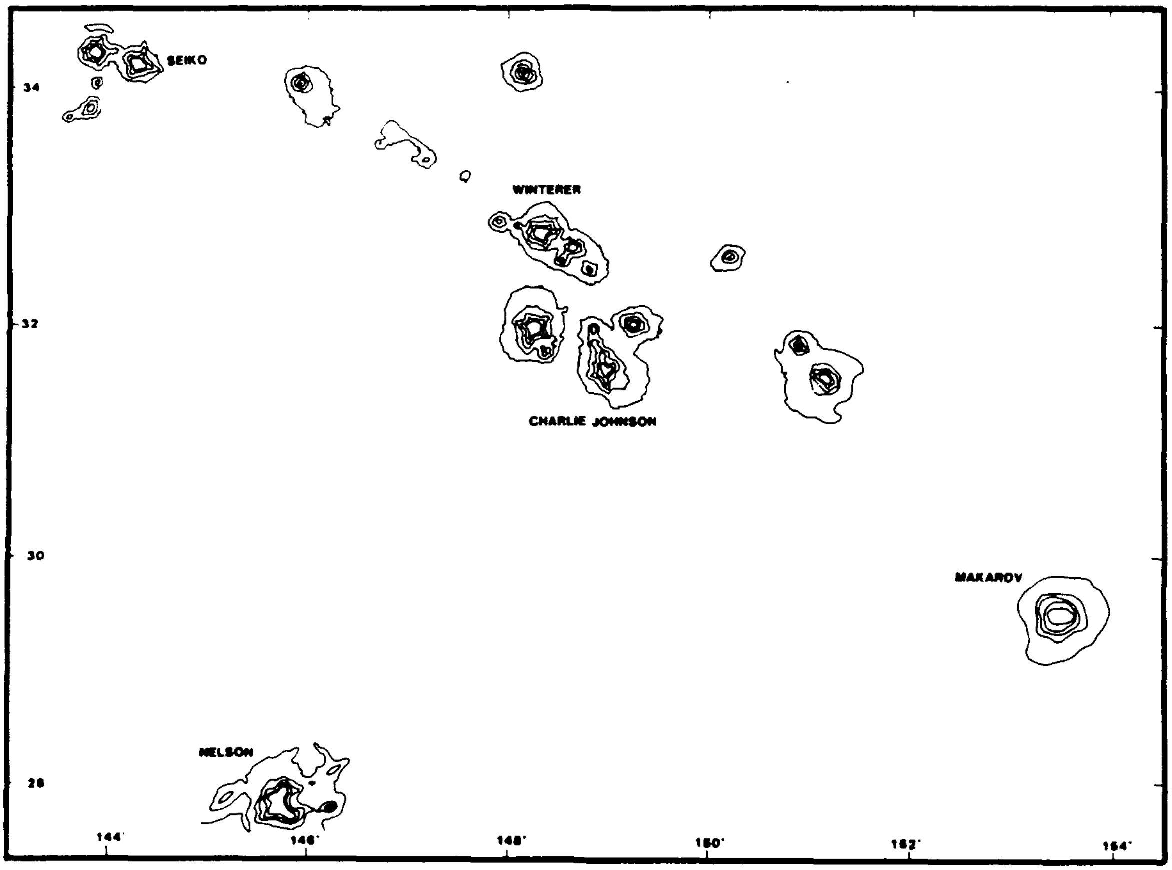

Figure 20. Locator Diagram of the Japanese Seamounts and Nelson Guyot. These features were renamed by the USBGN at the request of the Japanese Hydrographic Office through the author. They used to be the Geisha Guyots.

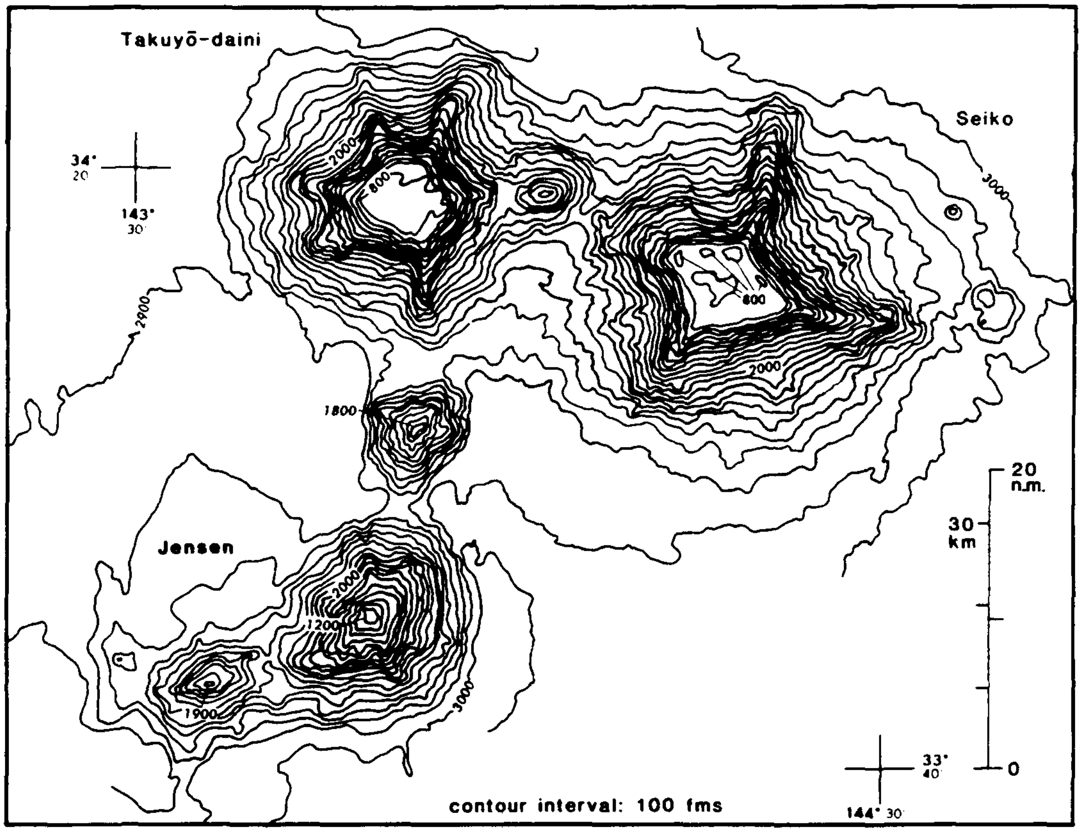

Figure 21. Seiko Seamount (Vogt and Smoot, 1984). USBGN.

Name: Seiko
Latitude: 34°15'N
Longitude: 144°10'E
Minimum guyot depth (fm): 770
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 25
Flank break depth (fm): 1800
Upper slope angle (%): 45
Flank slope angle (%): 6
Regional base depth (fm): 3100
Guyot height (fm): 2330
Guyot age (m.y.): 101.8

Name: Charlie Johnson
Latitude: 32°00'N
Longitude: 148°10'E
Minimum guyot depth (fm): 900
Summit plateau break depth (fm): 1000
Summit plateau area (n.m.^{2}): 35
Flank break depth (fm): 1400
Upper slope angle (%): 37
Flank slope angle (%): 3
Regional base depth (fm): 3200
Guyot height (fm): 2300
Guyot age (m.y.): 99

Name: Winterer
Latitude: 32°40'N
Longitude: 148°20'E
Minimum guyot depth (fm): 760
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 25
Flank break depth (fm): 2500
Upper slope angle (%): 33
Flank slope angle (%): 7
Regional base depth (fm): 3200
Guyot height (fm): 2440
Guyot age (m.y.): 99

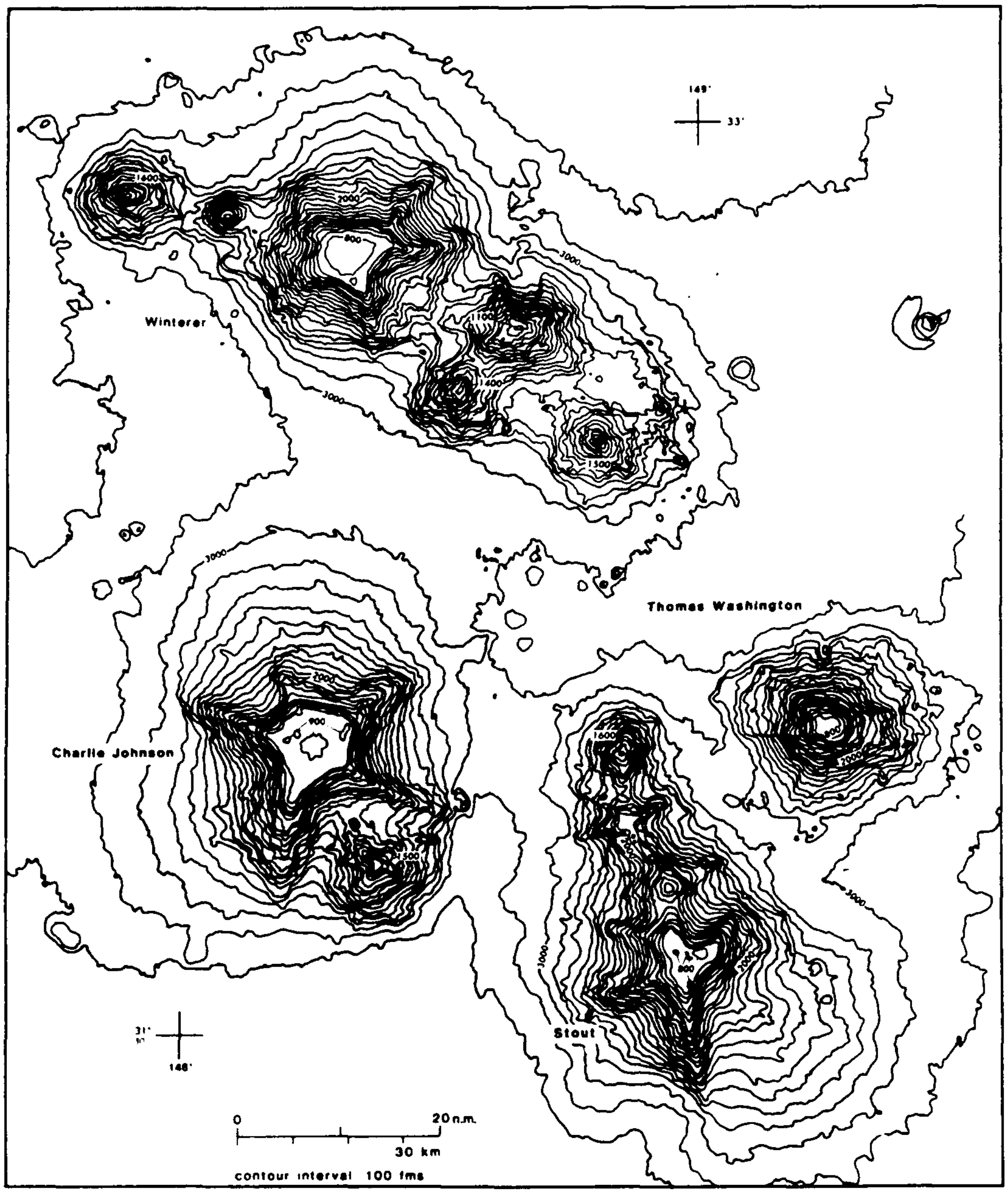

Figure 22. Charlie Johnson and Winterer Guyots (Vogt and Smoot, 1984). Charlie Johnson was named by N.C. Smoot (1984) after a retired surveyor who made over 125 cruises of discovery. Winterer was named by Heezen et al. (1973) after E.L. Winterer, presently of Scripps Institution of Oceanography. Neither submitted to USBGN.

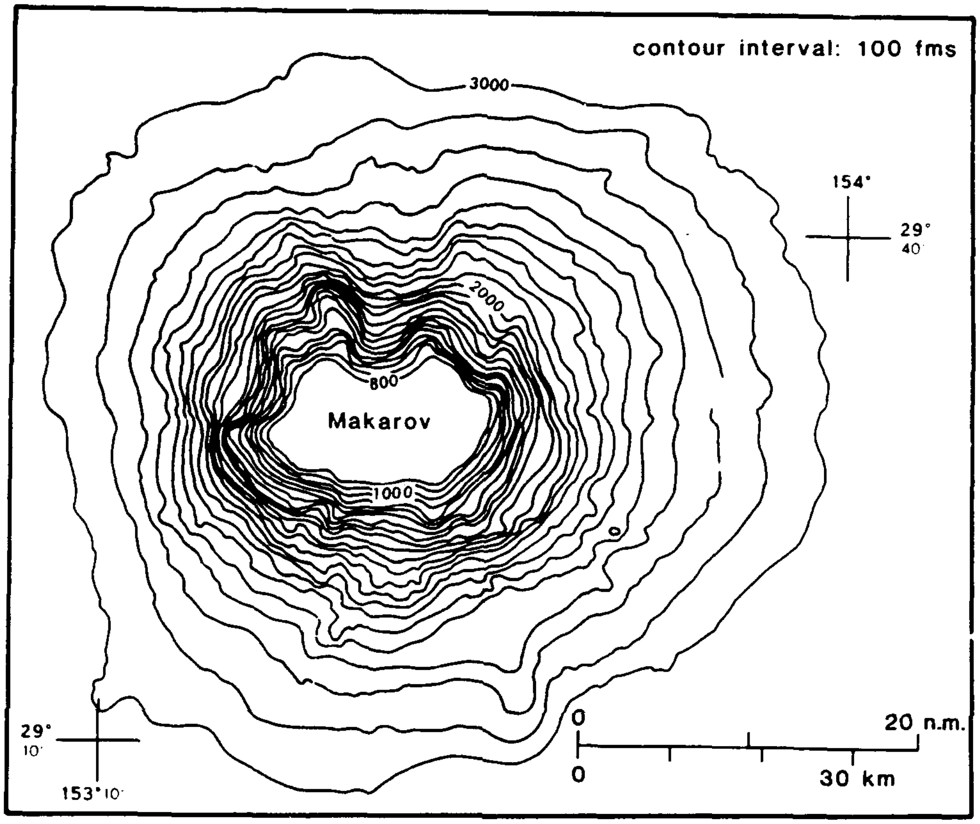

Figure 23. Makarov Seamount (Vogt and Smoot, 1984). USBGN.

Name: Makarov
Latitude: 29°25'N
Longitude: 153°30'E
Minimum guyot depth (fm): 750
Summit plateau break depth (fm): 800
Summit plateau area (n.m ^{2}): 72
Flank break depth (fm): 2100
Upper slope angle (%): 30
Flank slope angle (%): 5
Regional base depth (fm): 3100
Guyot height (fm): 2350
Guyot age (m.y.): 93.9

Name: Nelson
Latitude: $27^{o}50'$N
Longitude: $145^{o}45'$E
Minimum guyot depth (fm): 550
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 77
Flank break depth (fm): 2200
Upper slope angle (%): 18
Flank slope angle (%): 4
Regional base depth (fm): 3000
Guyot height (fm): 2450
Guyot age (m.y.):

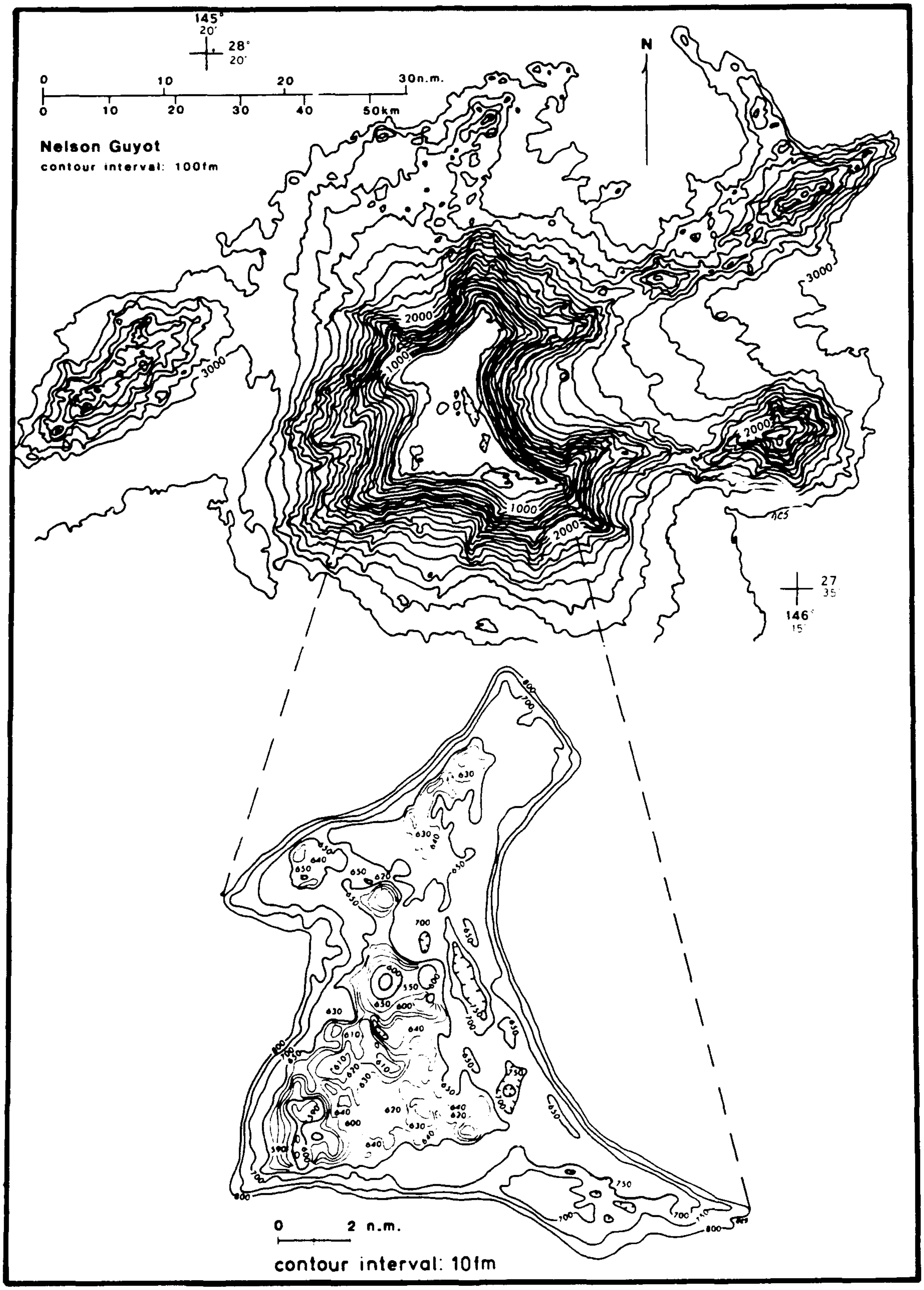

Figure 24. Nelson Guyot (Smoot and Heffner, 1986). Named by N.C. Smoot (1974) after Admiral Lord Nelson. USBGN.

MICHELSON RIDGE

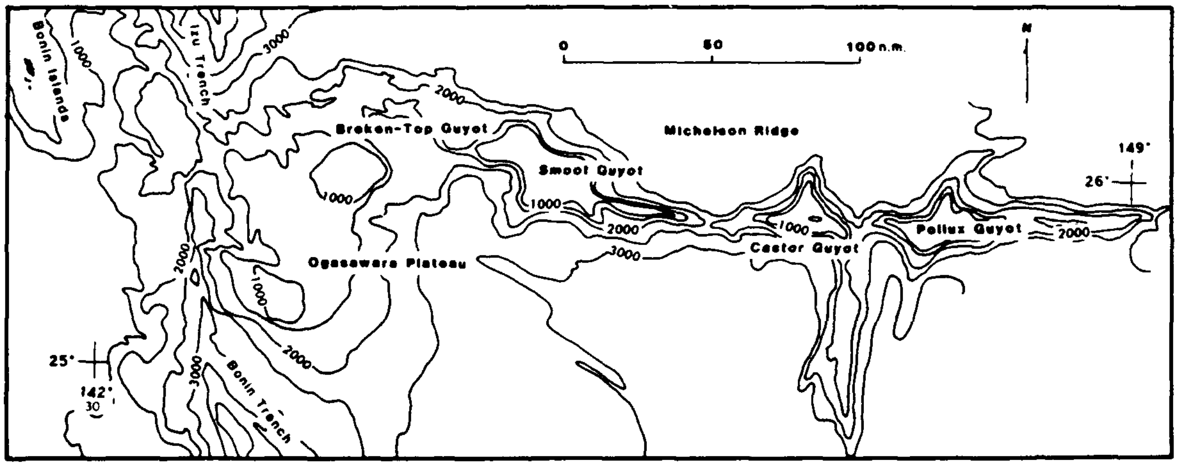

Figure 25. Locator Diagram of Michelson Ridge Guyots (Smoot, 1983d).

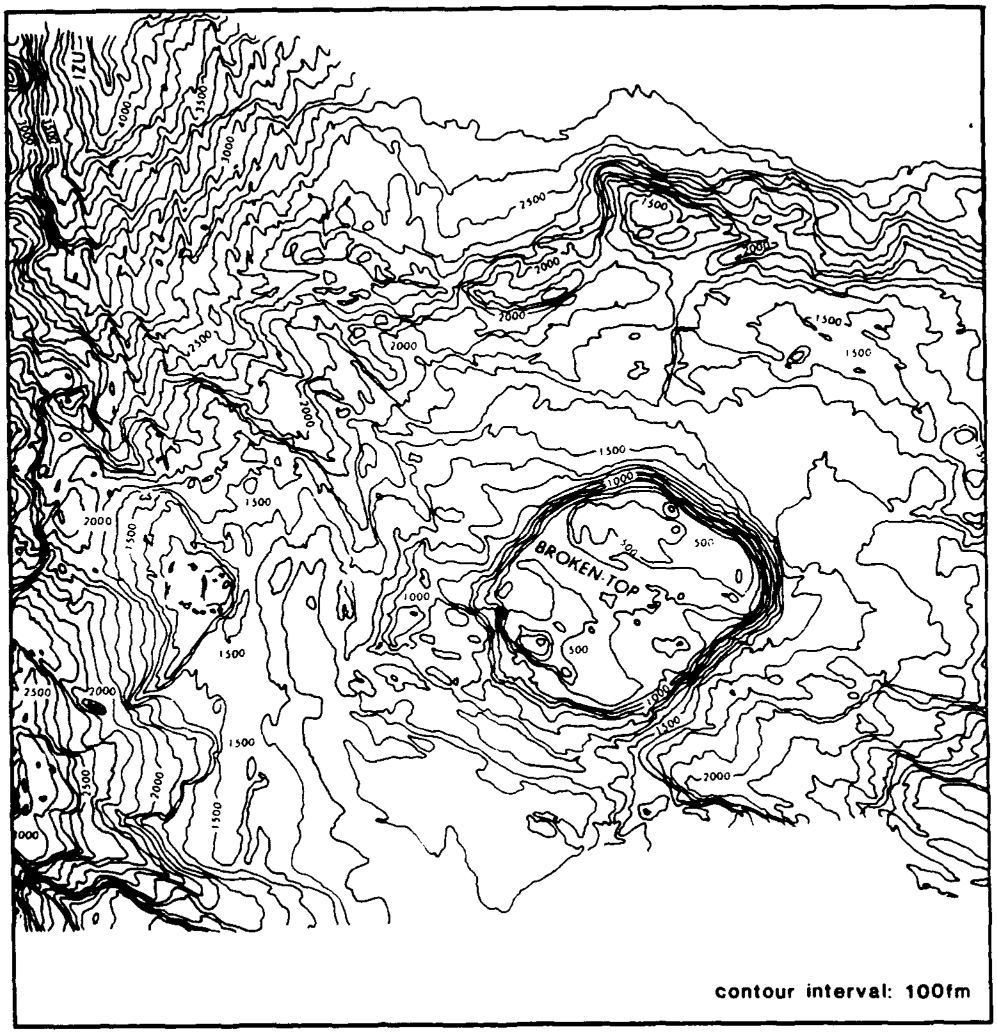

Figure 26. Broken-Top Guyot (Smoot, 1983b). Named by N.C. Smoot (1981) after gross morphology of the fracture transecting. USBGN.

Name: Broken-Top
Latitude: 26°05'N
Longitude: 144°10'E
Minimum guyot depth (fm): 300
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 300
Flank break depth (fm): 1400
Upper slope angle (%): 21
Flank slope angle (%): 3
Regional base depth (fm): 3100
Guyot height (fm): 2800
Guyot age (m.y.):

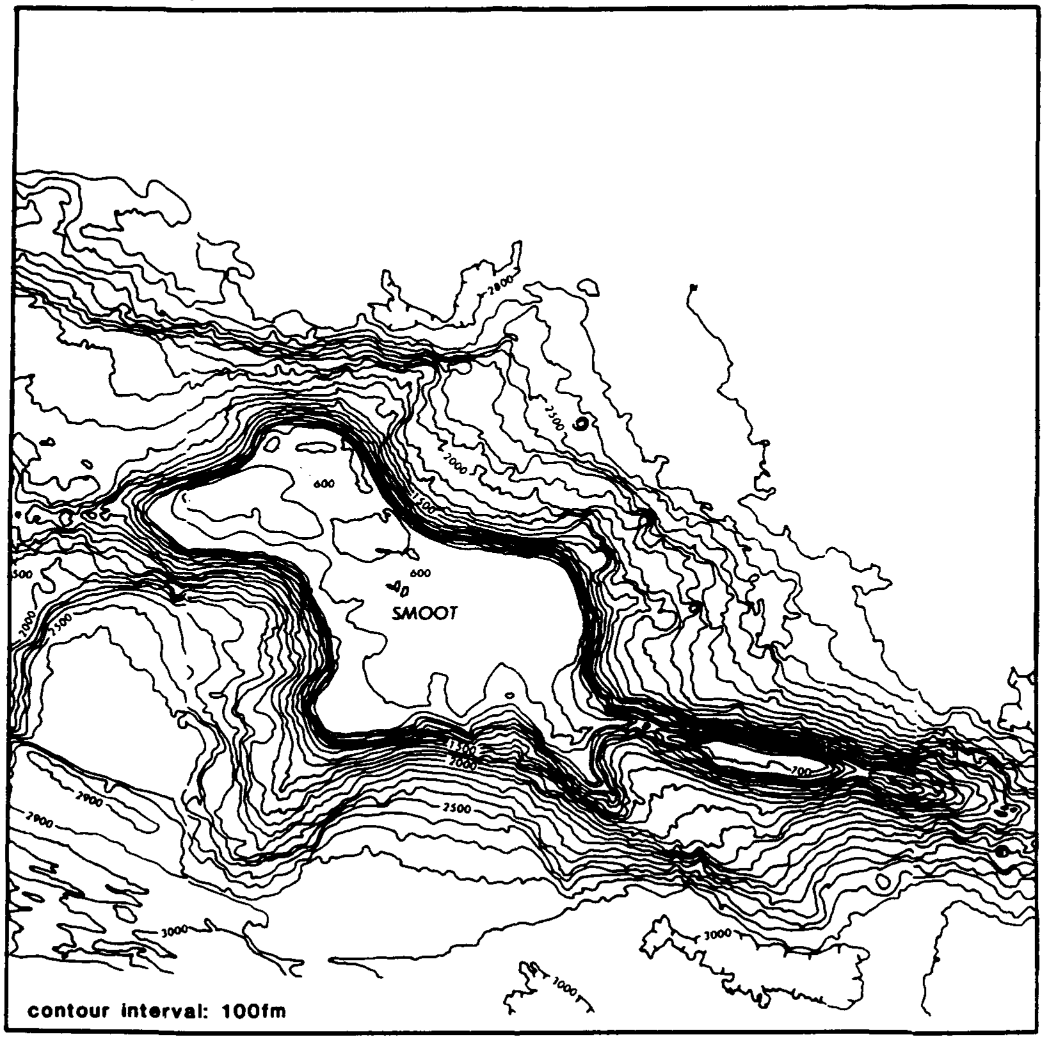

Figure 27. Smoot Guyot (Smoot, 1983b). Name suggested by F.H. Sorenson of the World Chart Group, NAVOCEANO, for work done by the author on guyots. USBGN.

Name: Smoot
Latitude: 26°05'N
Longitude: 145°20'E
Minimum guyot depth (fm): 580
Summit plateau break depth (fm): 700
Summit plateau area (n.m.^{2}): 650
Flank break depth (fm): 1900
Upper slope angle (%): 28
Flank slope angle (%): 4
Regional base depth (fm): 3000
Guyot height (fm): 2420
Guyot age (m.y.):

Name: Castor
Latitude: 25°50'N
Longitude: 147°00'E
Minimum guyot depth (fm): 479
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 250
Flank break depth (fm): 2400
Upper slope angle (%): 30
Flank slope angle (%): 4
Regional base depth (fm): 3000
Guyot height (fm): 2521
Guyot age (m.y.):

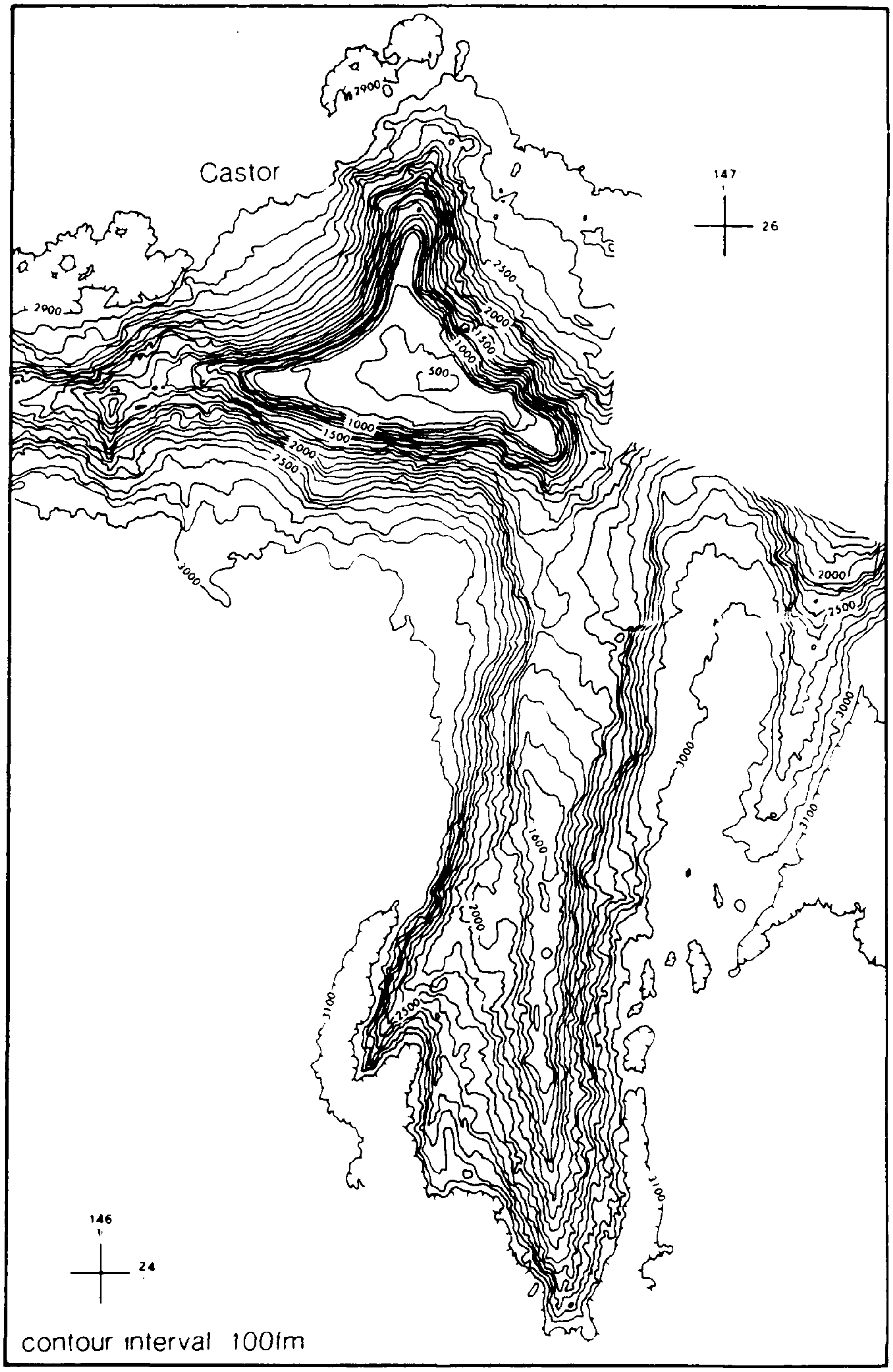

Figure 28. Castor Guyot (adapted from Smoot, 1983b). Named by N.C. Smoot (1974) after one of two sons of Leda from classical mythology. Castor and Pollux are regarded as protectors of persons at sea. USBGN.

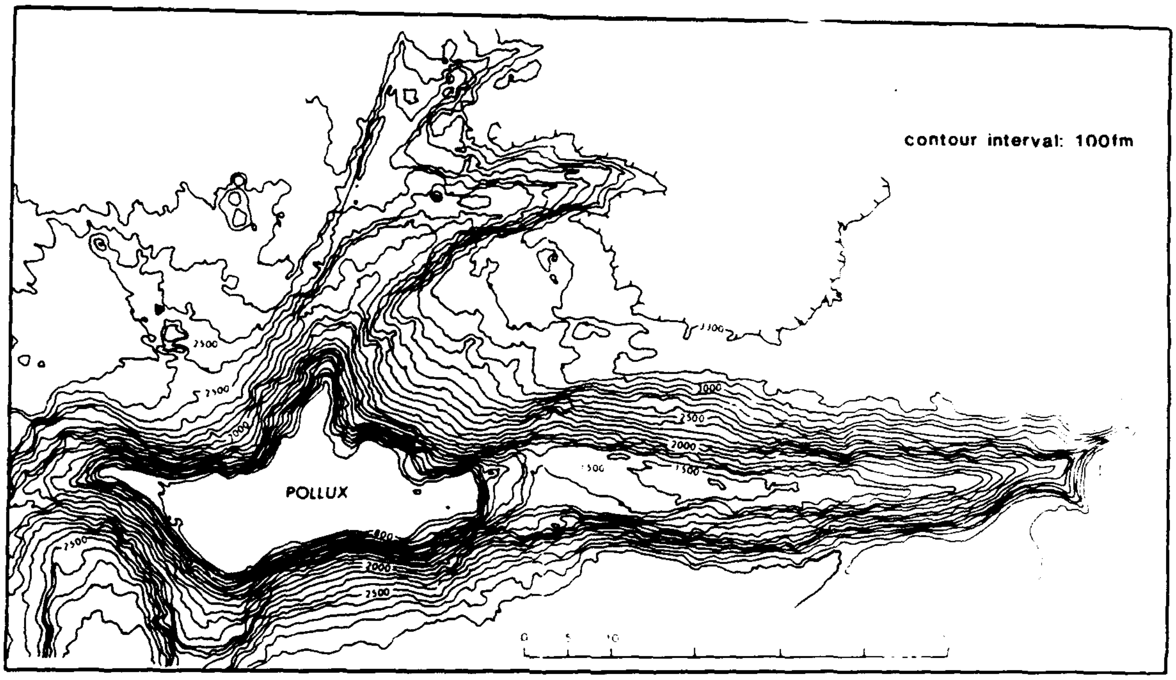

Figure 29. Pollux Guyot (Smoot, 1983b). USBGN.

Name: Pollux
Latitude: 25°45'N
Longitude: 147°50'E
Minimum guyot depth (fm): 710
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 300
Flank break depth (fm): 2500
Upper slope angle (%): 34
Flank slope angle (%): 4
Regional base depth (fm): 3300
Guyot height (fm): 2590
Guyot age (m.y.):

DUTTON RIDGE

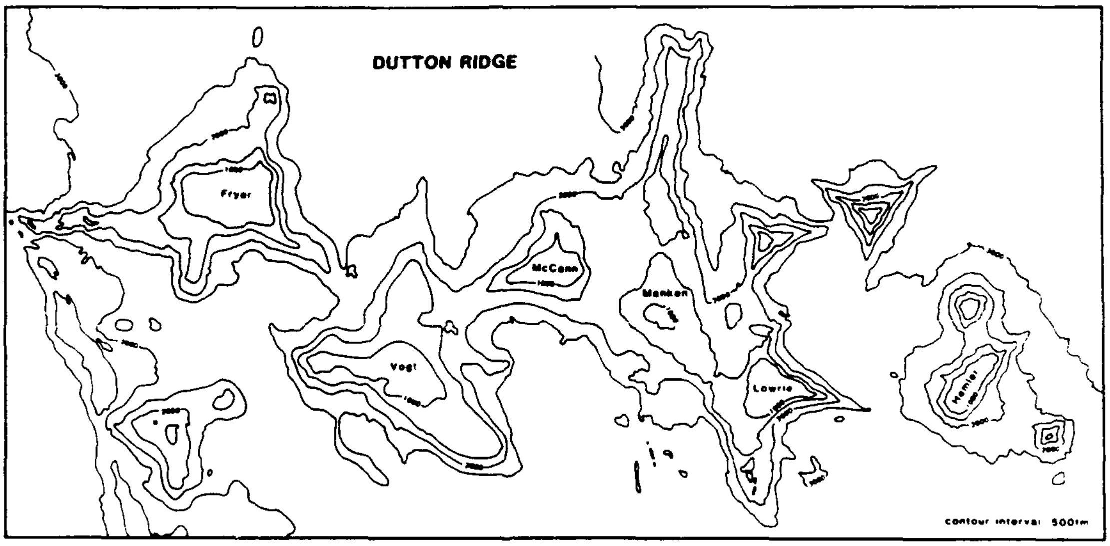

Figure 30. Locator Diagram of Dutton Ridge Guyots (adapted from Smoot, 1983c).

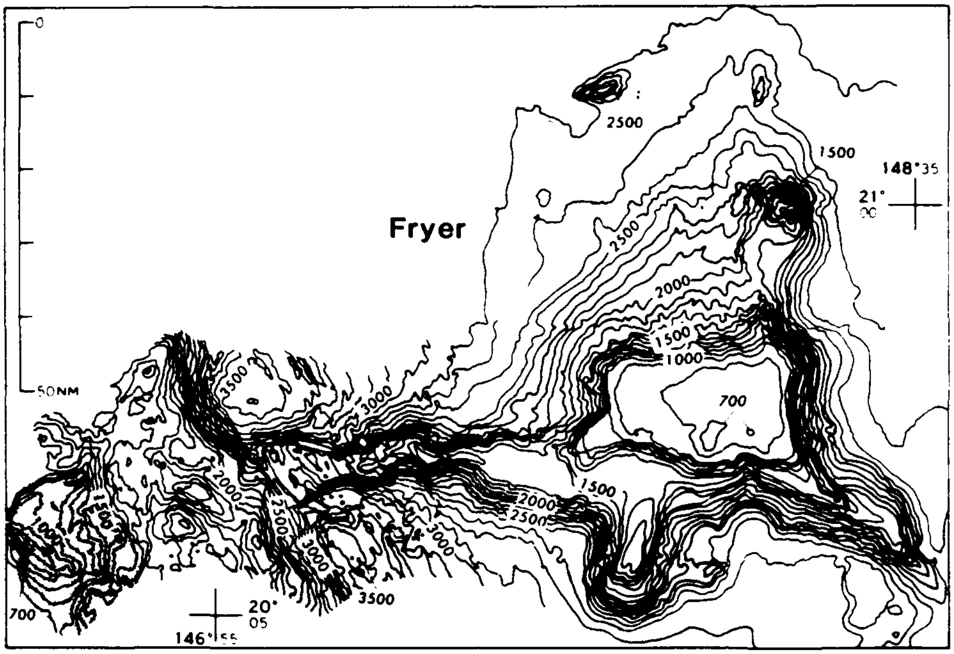

Figure 31. Fryer Guyot (Smoot, 1983c). Named by N.C. Smoot after Patricia Fryer of Hawaii Institution of Geophysics. USBGN.

Name: Fryer
Latitude: 20°30'N
Longitude: 148°00'E
Minimum guyot depth (fm): 720
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 336
Flank break depth (fm): 1600
Upper slope angle (%): 17
Flank slope angle (%): 3
Regional base depth (fm): 2800
Guyot height (fm): 2080
Guyot age (m.y.):

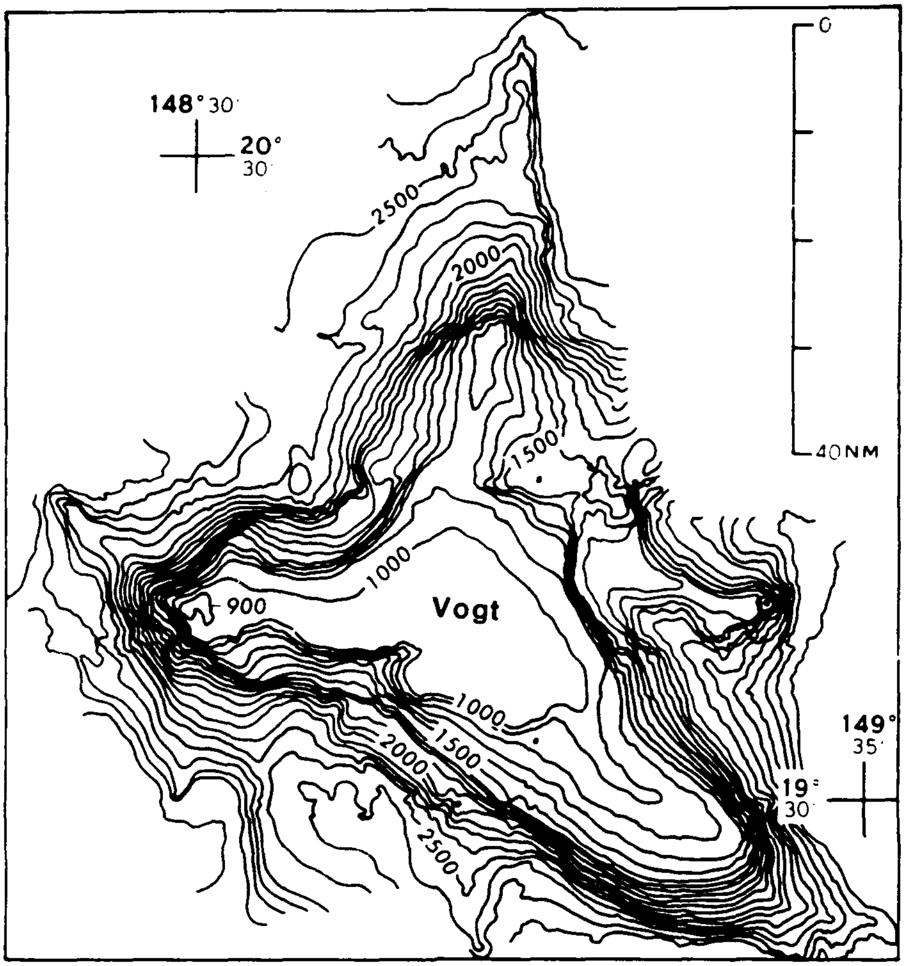

Figure 32. Vogt Guyot (Smoot, 1983c). Named by N.C. Smoot (1983) after Peter R. Vogt of the Naval Research Laboratory. USBGN.

Name: Vogt
Latitude: 19°50'N
Longitude: 149°00'E
Minimum guyot depth (fm): 890
Summit plateau break depth (fm): 1100
Summit plateau area (n.m.^{2}): 638
Flank break depth (fm): 2000
Upper slope angle (%): 20
Flank slope angle (%): 5
Regional base depth (fm): 2800
Guyot height (fm): 1910
Guyot age (m.y.):

Name: McCann
Latitude: 20°10'N
Longitude: 149°39'E
Minimum guyot depth (fm): 780
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 108
Flank break depth (fm): 2200
Upper slope angle (%): 16
Flank slope angle (%): 5
Regional base depth (fm): 2900
Guyot height (fm): 2120
Guyot age (m.y.):

Name: Manken
Latitude: 20°00'N
Longitude: 150°10'E
Minimum guyot depth (fm): 950
Summit plateau break depth (fm): 1100
Summit plateau area (n.m.^{2}): 150
Flank break depth (fm): 2400
Upper slope angle (%): 14
Flank slope angle (%): 5
Regional base depth (fm): 3100
Guyot height (fm): 2150
Guyot age (m.y.):

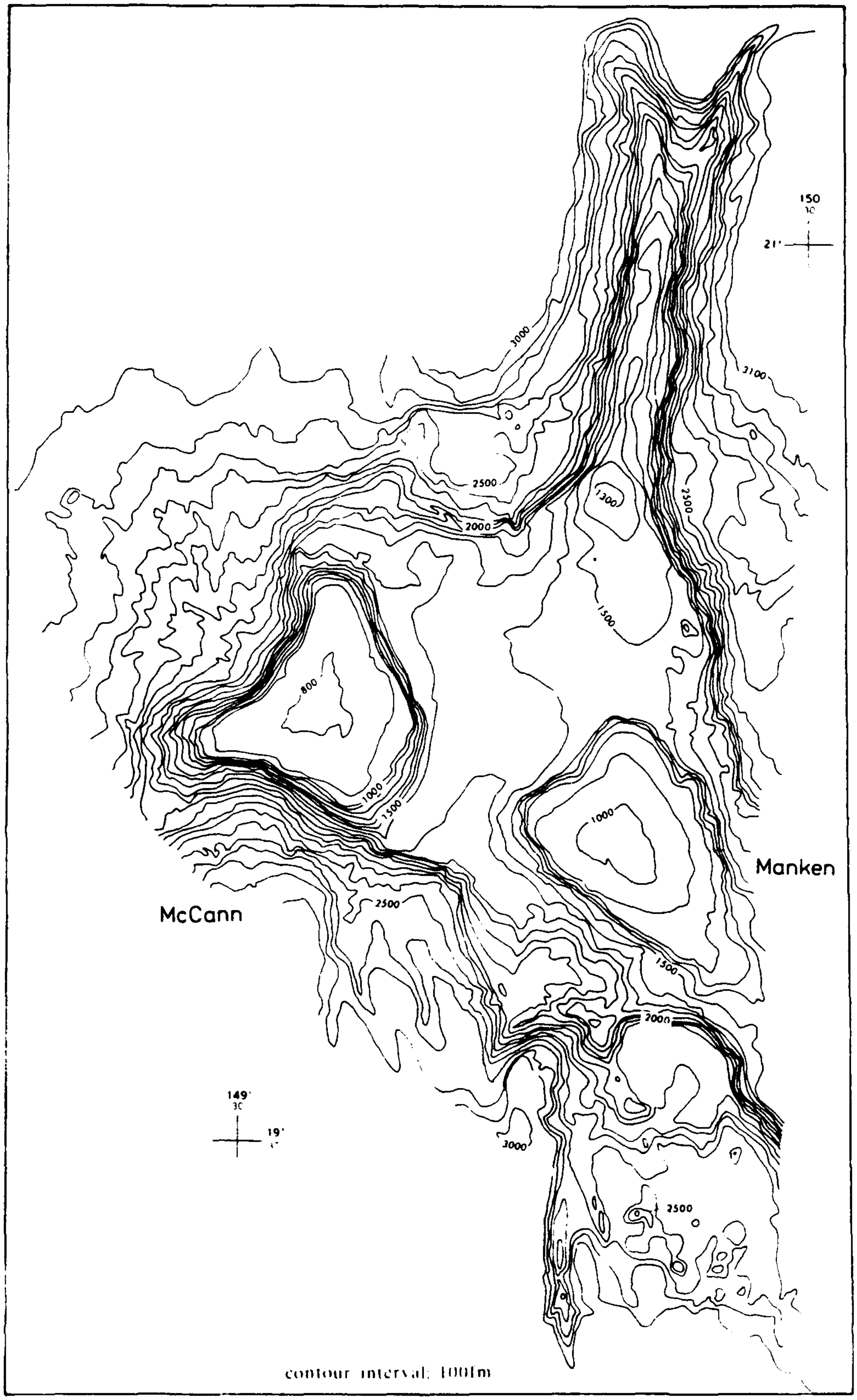

Figure 33. McCann and Manken Guyots (Smoot, 1983c). Both named by N.C. Smoot (1983) after Tom McCann and John Manken, retired senior scientists from NAVOCEANO who made many voyages of discovery. Not submitted to USBGN.

Name: Lowrie
Latitude: 19°40'N
Longitude: 150°47'E
Minimum guyot depth (fm): 790
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 156
Flank break depth (fm): 2500
Upper slope angle (%): 25
Flank slope angle (%): 7
Regional base depth (fm): 3000
Guyot height (fm): 2210
Guyot age (m.y.):

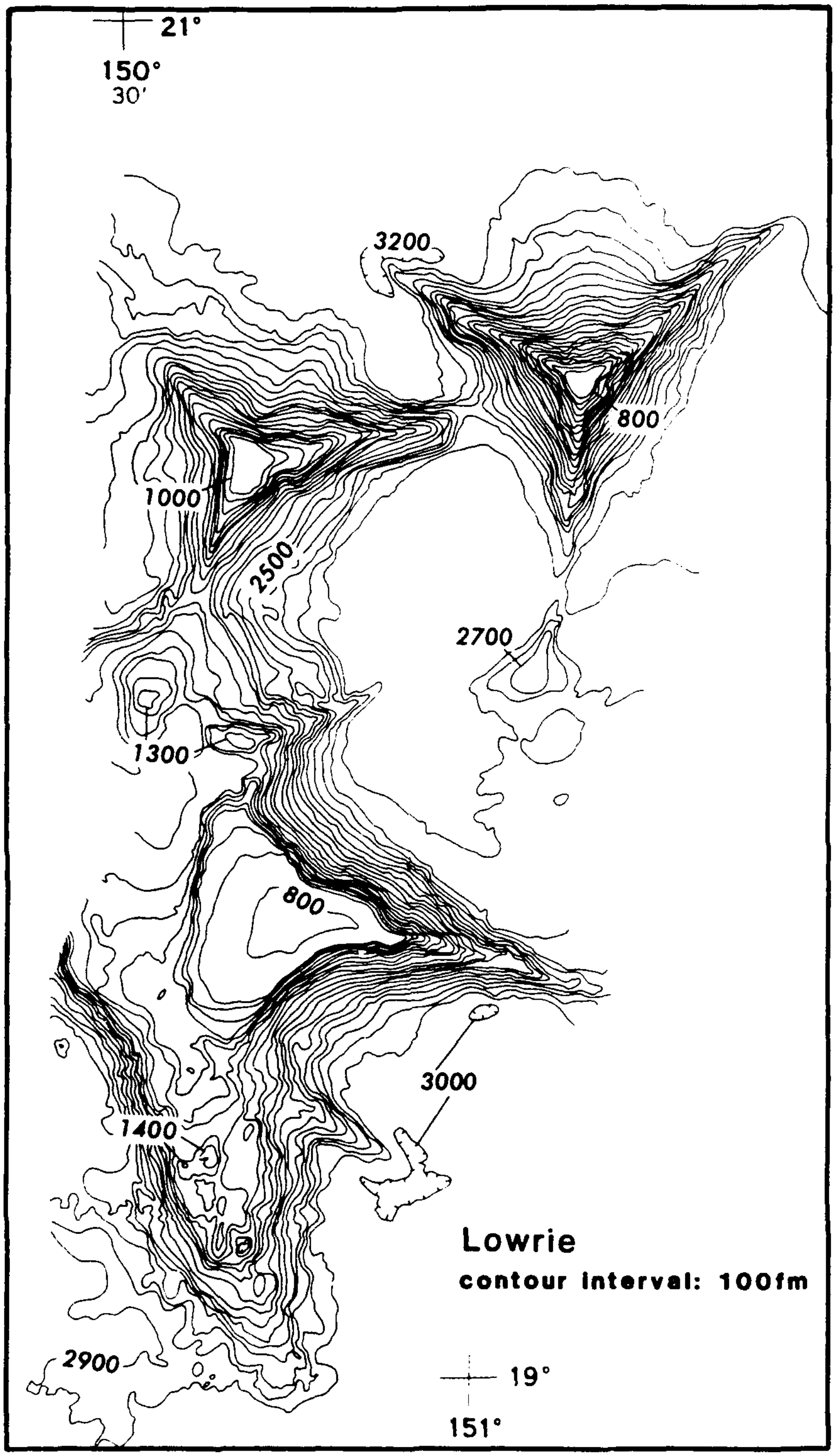

Figure 34. Lowrie Guyot (adapted from Smoot, 1983c). Named by N.C. Smoot (1983) after Allen Lowrie of NAVOCEANO for his extensive work on sea floor features. USBGN.

Name: Hemler
Latitude: 19°40'N
Longitude: 151°40'E
Minimum guyot depth (fm): 710
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 61
Flank break depth (fm): 1900
Upper slope angle (%): 25
Flank slope angle (%): 3
Regional base depth (fm): 3000
Guyot height (fm): 2290
Guyot age (m.y.):

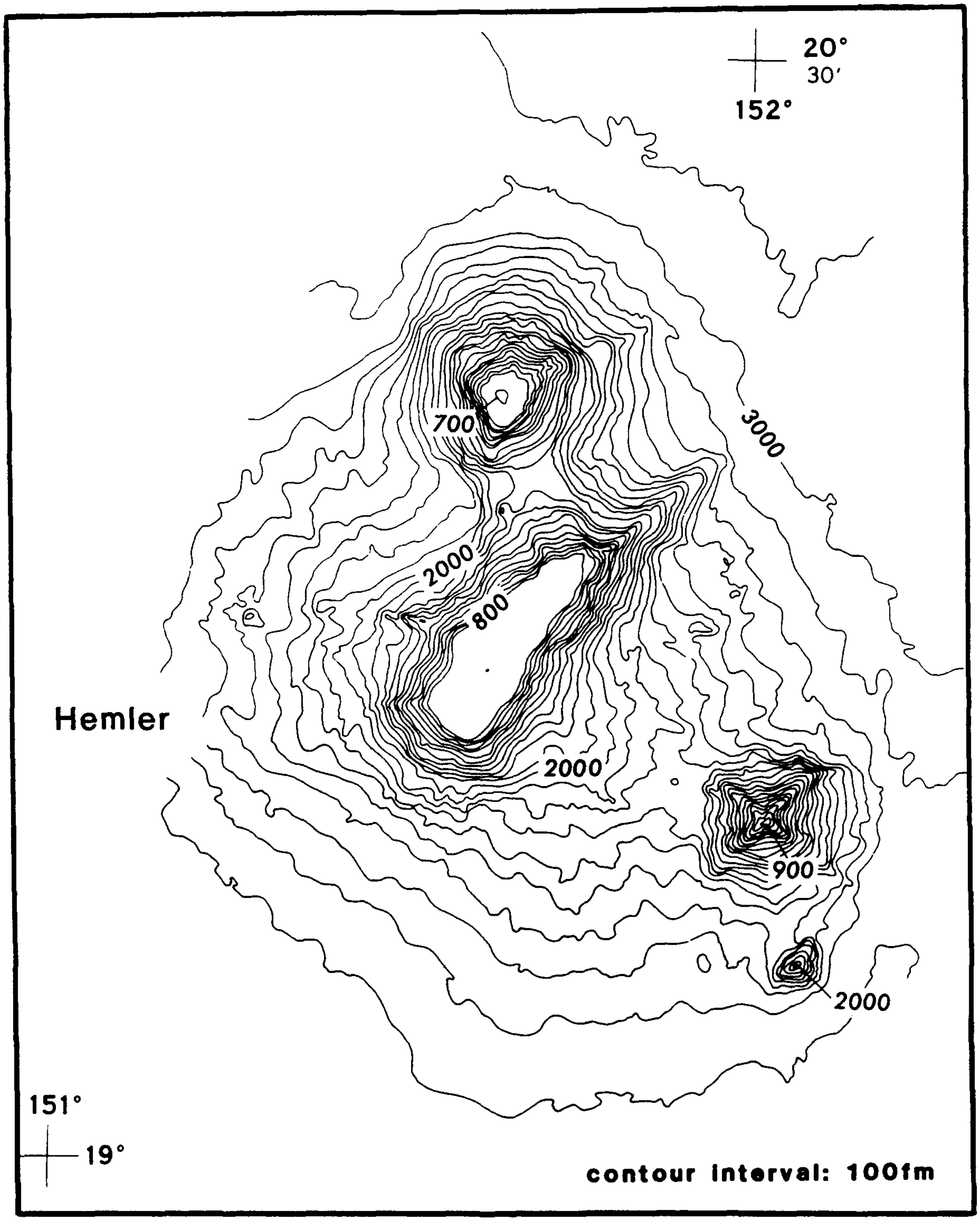

Figure 35. Hemler Guyot (adapted from Smoot, 1983c). Named by N.C. Smoot (1983) for Louis G. Hemler, deceased computer programmer for the Naval Ocean Research and Development Activity. USBGN.

MARCUS - WAKE SEAMOUNTS

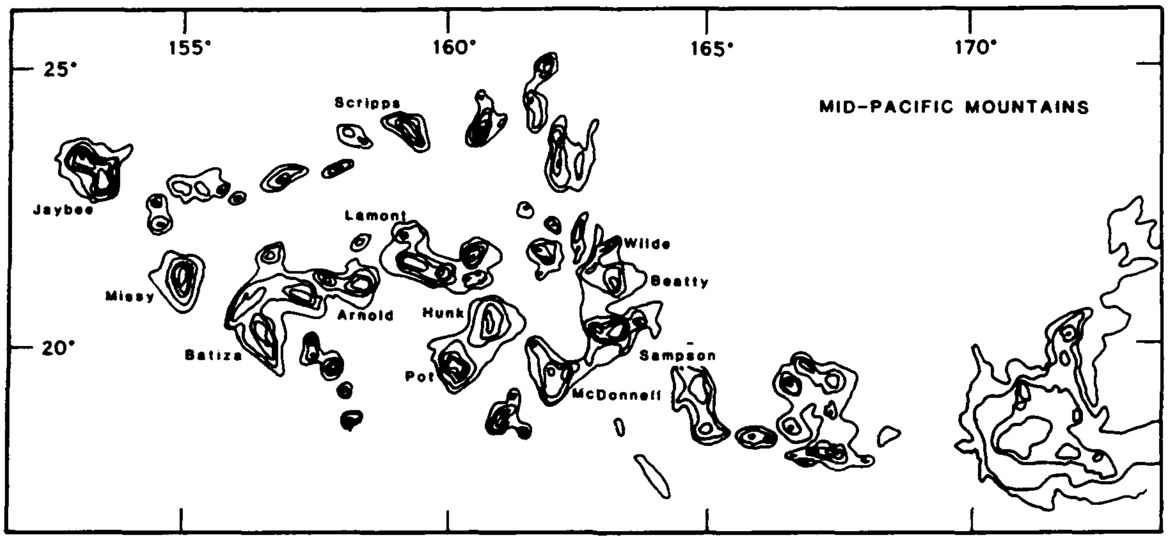

Figure 36. Locator Diagram of the Marcus-Wake Seamounts (adapted from Mammerickx and Smith, 1984).

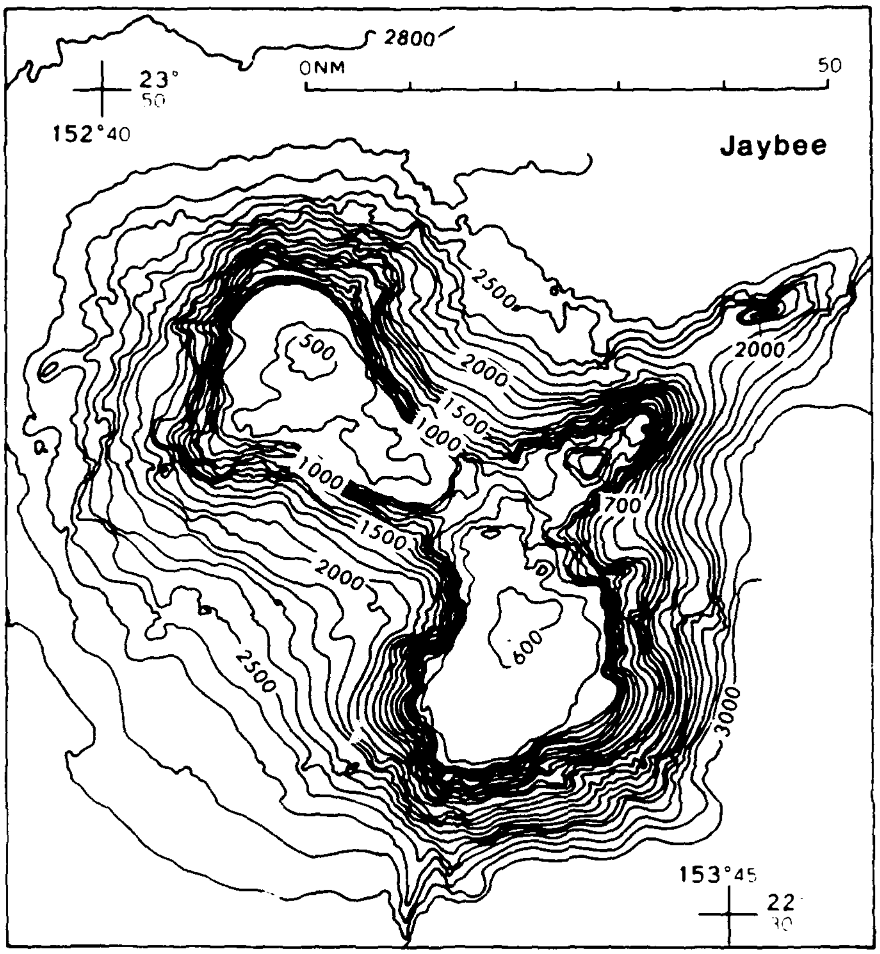

Figure 37. Jaybee Guyot (Smoot, 1983c). Named by N.C. Smoot (1983) after wife. Nar submitted to and rejected by USBGN.

Name: Jaybee
Latitude: 23°10'N
Longitude: 153°20'E
Minimum guyot depth (fm): 460
Summit plateau break depth (fm): 700
Summit plateau area (n.m.^{2}): 541
Flank break depth (fm): 1900
Upper slope angle (%): 22
Flank slope angle (%): 4
Regional base depth (fm): 3000
Guyot height (fm): 2540
Guyot age (m.y.):

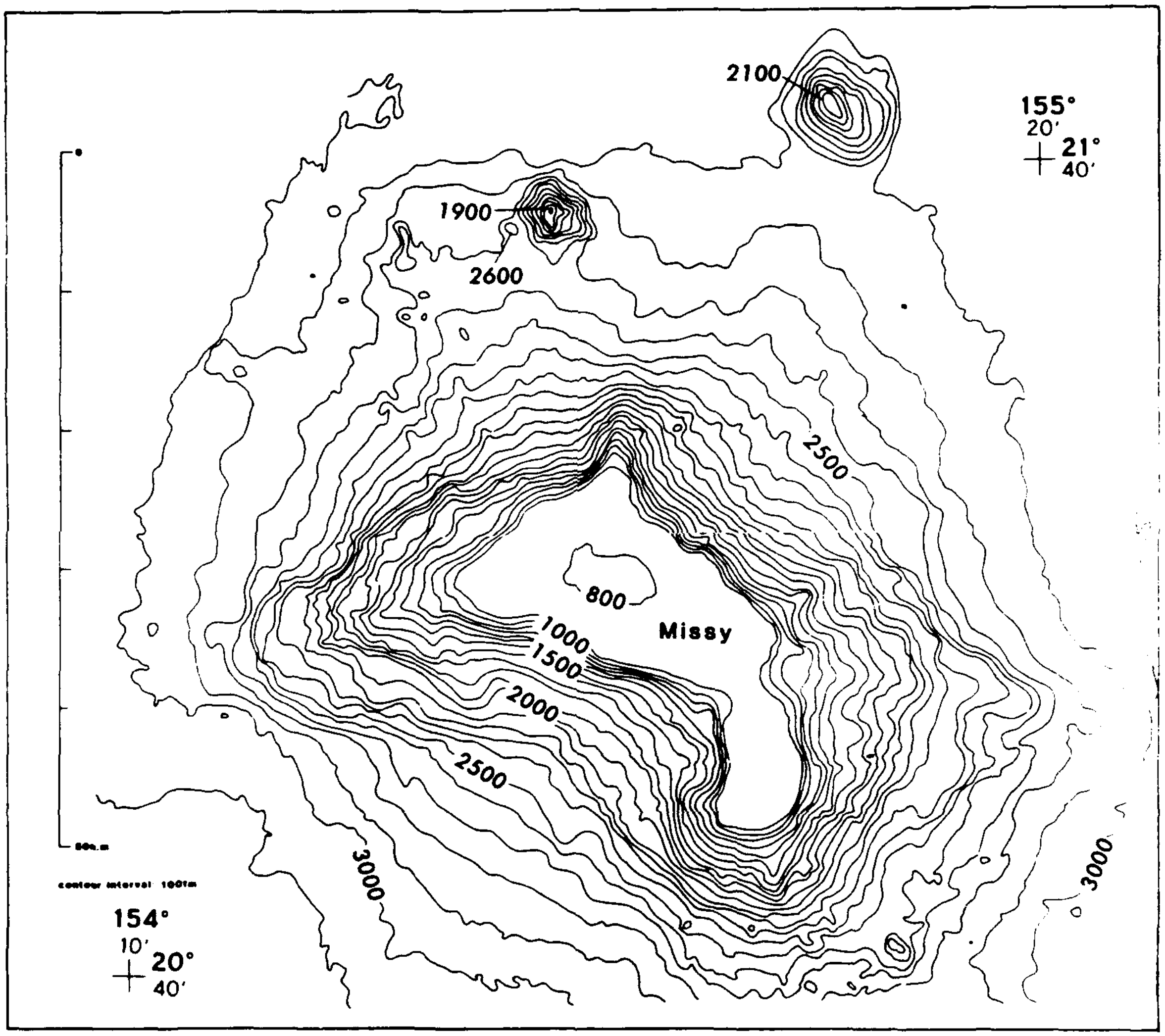

Figure 38. Missy Guyot. Named by N.C. Smoot (1985) after common nickname of Southern womanhood. Not submitted to USBGN.

Name: Missy
Latitude: 21°00'N
Longitude: 154°40'E
Minimum guyot depth (fm): 800
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 254
Flank break depth (fm): 2000
Upper slope angle (%): 20
Flank slope angle (%): 2
Regional base depth (fm): 3100
Guyot height (fm): 2300
Guyot age (m y.):

Name: Jennings
Latitude: 21°00'N
Longitude: 156°15'E
Minimum guyot depth (fm): 1100
Summit plateau break depth (fm): 1400
Summit plateau area (n.m.^{2}): 168
Flank break depth (fm): 2200
Upper slope angle (%): 20
Flank slope angle (%): 3
Regional base depth (fm): 3000
Guyot height (fm): 1900
Guyot age (m.y.):

Name: Batiza
Latitude: 20°00'N
Longitude: 156°30'E
Minimum guyot depth (fm): 900
Summit plateau break depth (fm): 1200
Summit plateau area (n.m.^{2}): 280
Flank break depth (fm): 2000
Upper slope angle (%): 21
Flank slope angle (%): 4
Regional base depth (fm): 3000
Guyot height (fm): 2100
Guyot age (m.y.):

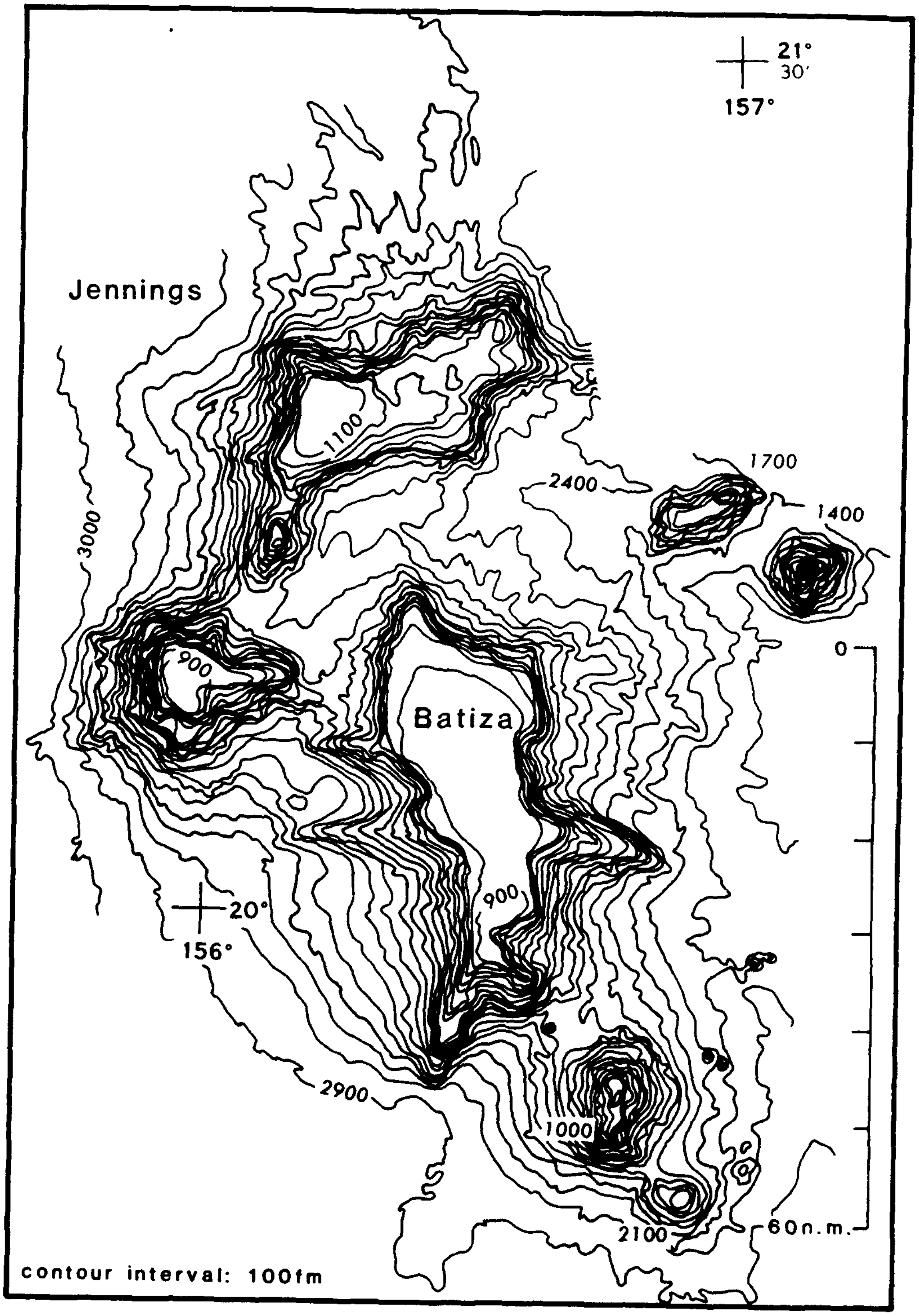

Figure 39. Jennings and Batiza Guyots. Named by N.C. Smoot (1985). C.A. Jennings is a retired DEW-Line NAVOCEANO surveyor who was also the head of the SASS Data Reduction Section. R. Batiza, world-renowned geologist presently with the Hawaii Institution of Geophysics, is the source of the other. USBGN.

Name: Maloney
Latitude: $20^{o}50'N$
Longitude: $157^{o}15'E$
Minimum guyot depth (fm): 1000
Summit plateau break depth (fm): 1100
Summit plateau area (n.m.^{2}): 120
Flank break depth (fm): 2200
Upper slope angle (%): 24
Flank slope angle (%): 5
Regional base depth (fm): 3000
Guyot height (fm): 2000
Guyot age (m.y.):

Name: Arnold
Latitude: $21^{o}05'N$
Longitude: $158^{o}30'E$
Minimum guyot depth (fm): 800
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 126
Flank break depth (fm): 1400
Upper slope angle (%): 19
Flank slope angle (%): 3
Regional base depth (fm): 3000
Guyot height (fm): 2200
Guyot age (m.y.):

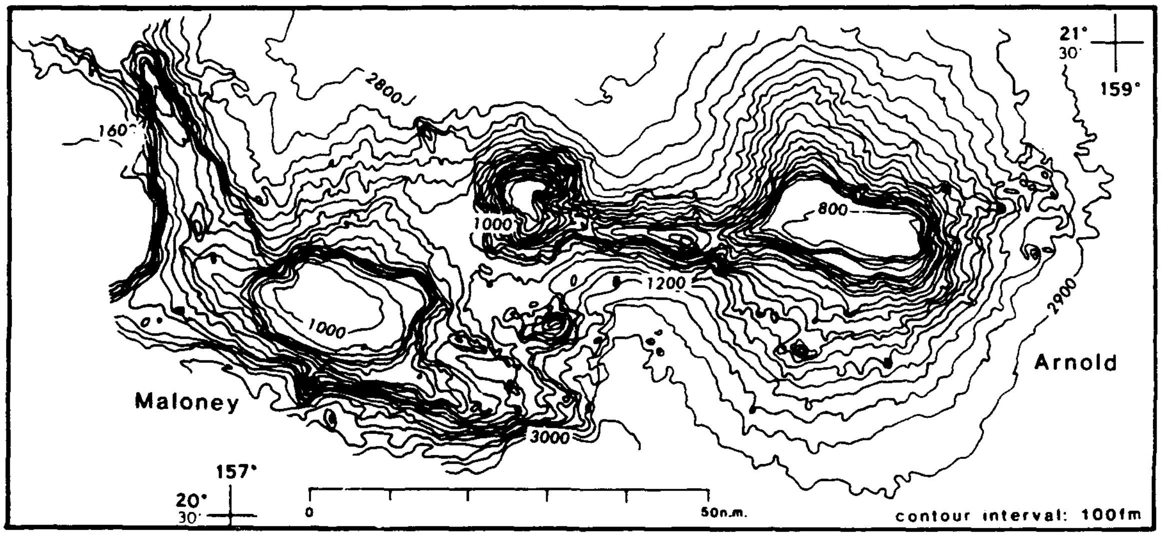

Figure 40. Maloney and Arnold Guyots. Named by N.C. Smoot (1985). J.E. Maloney is a retired DEW-Line Surveyor who was also the Head of the Ocean Surveys Branch. Arnold is Guyot's first name. What could be more appropriate? Both USBGN.

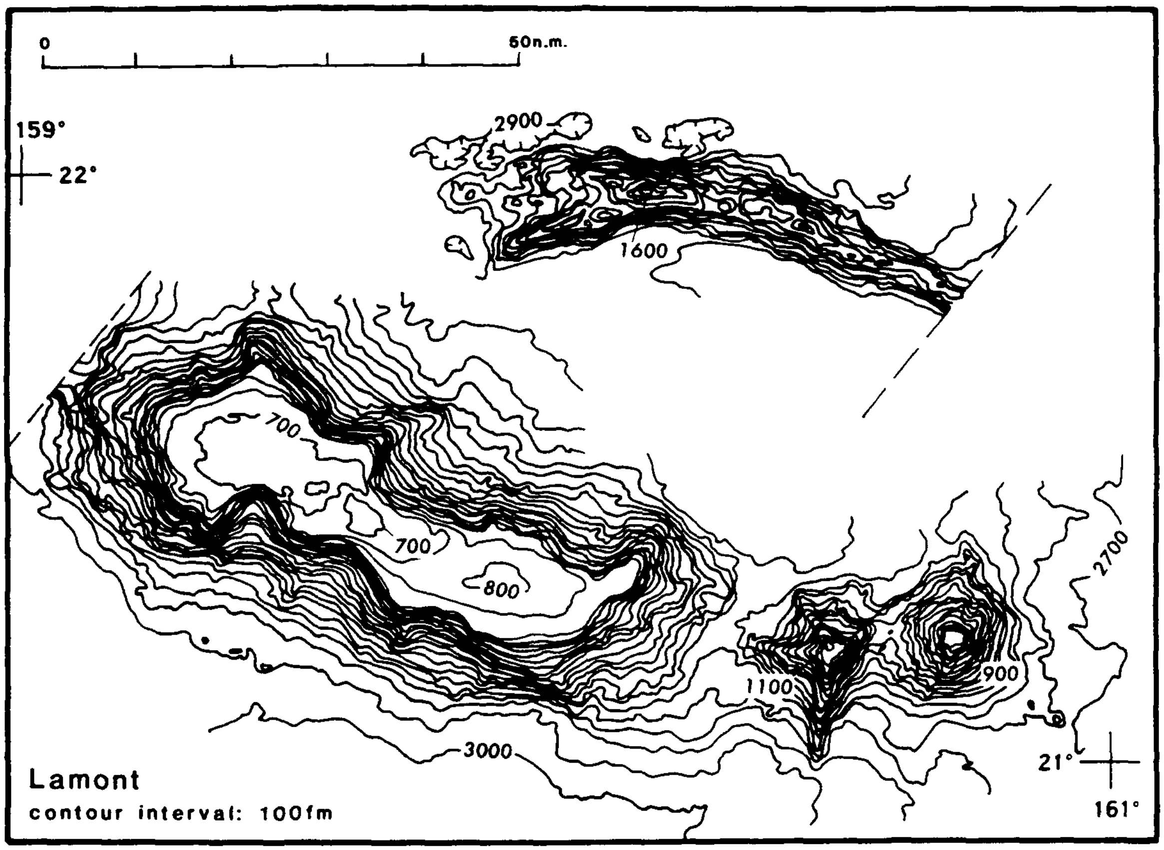

Figure 41. Lamont Guyot. Named by Heezen et al. (1973) after Columbia University's Lamont-Doherty Geological Observatory. Not submitted to USBGN.

Name: Lamont
Latitude: 21°30'N
Longitude: 160°00'E
Minimum guyot depth (fm): 700
Summit plateau break depth (fm): 1000
Summit plateau area (n.m.^{2}): 450
Flank break depth (fm): 2500
Upper slope angle (%): 22
Flank slope angle (%): 3
Regional base depth (fm): 3000
Guyot height (fm): 2300
Guyot age (m.y.): 90.5

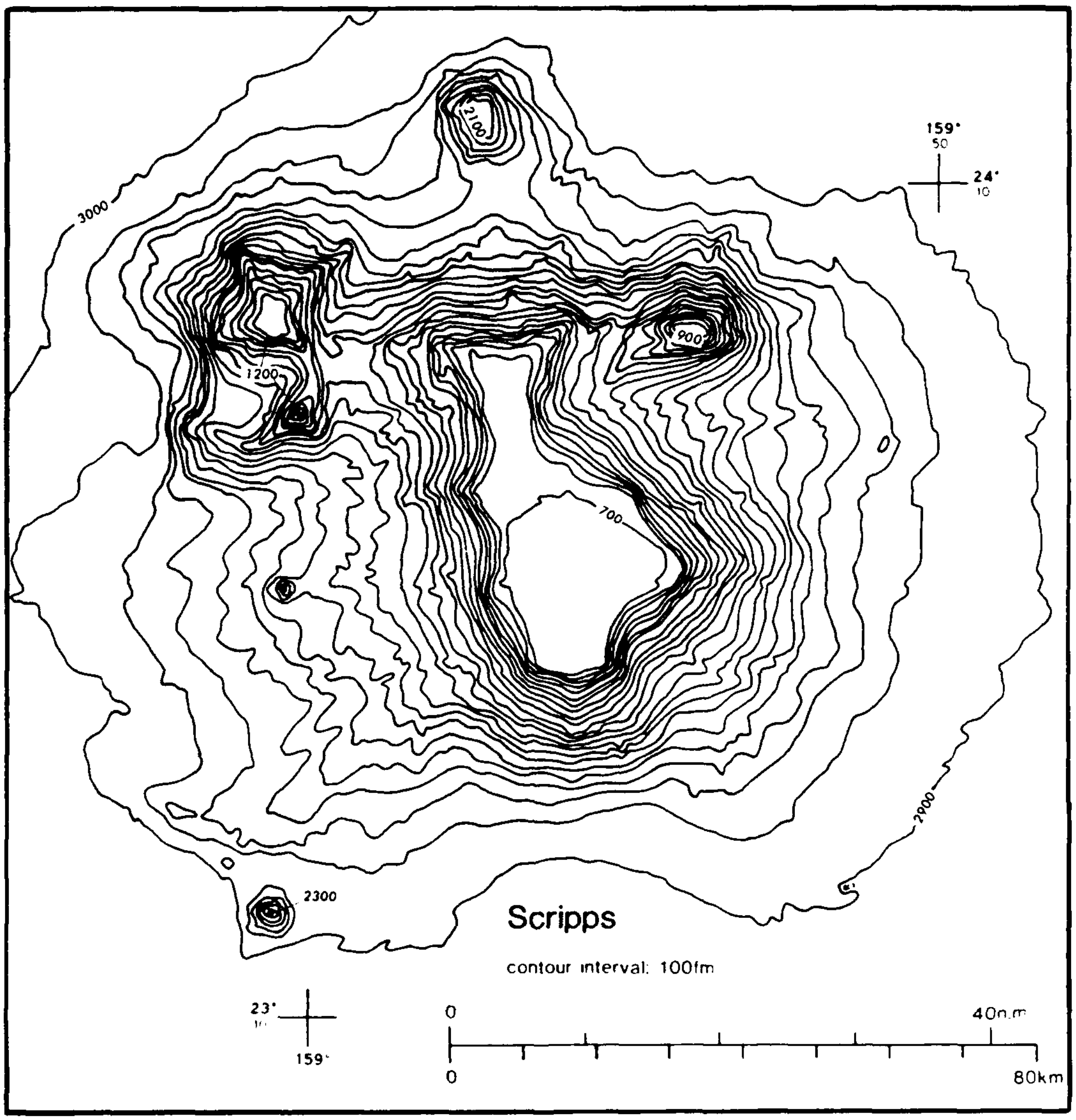

Figure 42. Scripps Guyot. Named by Heezen et al. (1973) after the Scripps Institution of Oceanography at the University of California, San Diego. USBGN.

Name: Scripps
Latitude: 23°40'N
Longitude: 159°30'E
Minimum guyot depth (fm): 700
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 184
Flank break depth (fm): 2400
Upper slope angle (%): 24
Flank slope angle (%): 4
Regional base depth (fm): 3000
Guyot height (fm): 2300
Guyot age (m.y.): 84.6

Name: Hunk
Latitude: 20°00'N
Longitude: 160°51'E
Minimum guyot depth (fm): 900
Summit plateau break depth (fm): 1100
Summit plateau area (n.m.^{2}): 280
Flank break depth (fm): 2000
Upper slope angle (%): 18
Flank slope angle (%): 2
Regional base depth (fm): 3000
Guyot height (fm): 2100
Guyot age (m.y.):

Name: Pot
Latitude: 19°30'N
Longitude: 160°10'E
Minimum guyot depth (fm): 700
Summit plateau break depth (fm): 900
Summit plateau area (n.m.^{2}): 254
Flank break depth (fm): 2200
Upper slope angle (%): 19
Flank slope angle (%): 3
Regional base depth (fm): 2900
Guyot height (fm): 2200
Guyot age (m.y.):

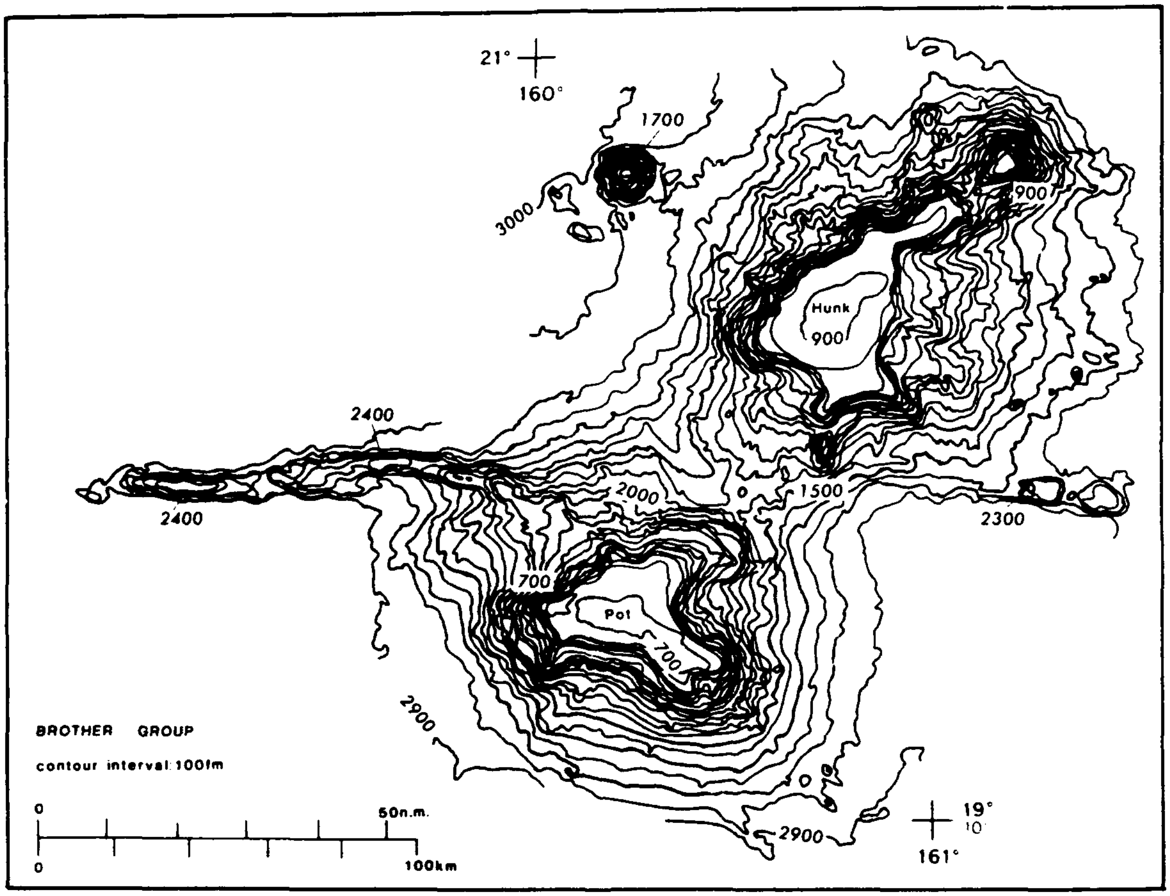

Figure 43. The Brother Group. Named by N.C. Smoot (1985) because of the proximity of the two features on one edifice, the upper being a large hunk of rock and the lower resembling a pot with the handle off to the west. Submitted to and rejected by USBGN.

Name: Beatty
Latitude: 21°00'N
Longitude: 163°20'E
Minimum guyot depth (fm): 800
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 120
Flank break depth (fm): 1700
Upper slope angle (%): 20
Flank slope angle (%): 5
Regional base depth (fm): 2800
Guyot height (fm): 2000
Guyot age (m.y.):

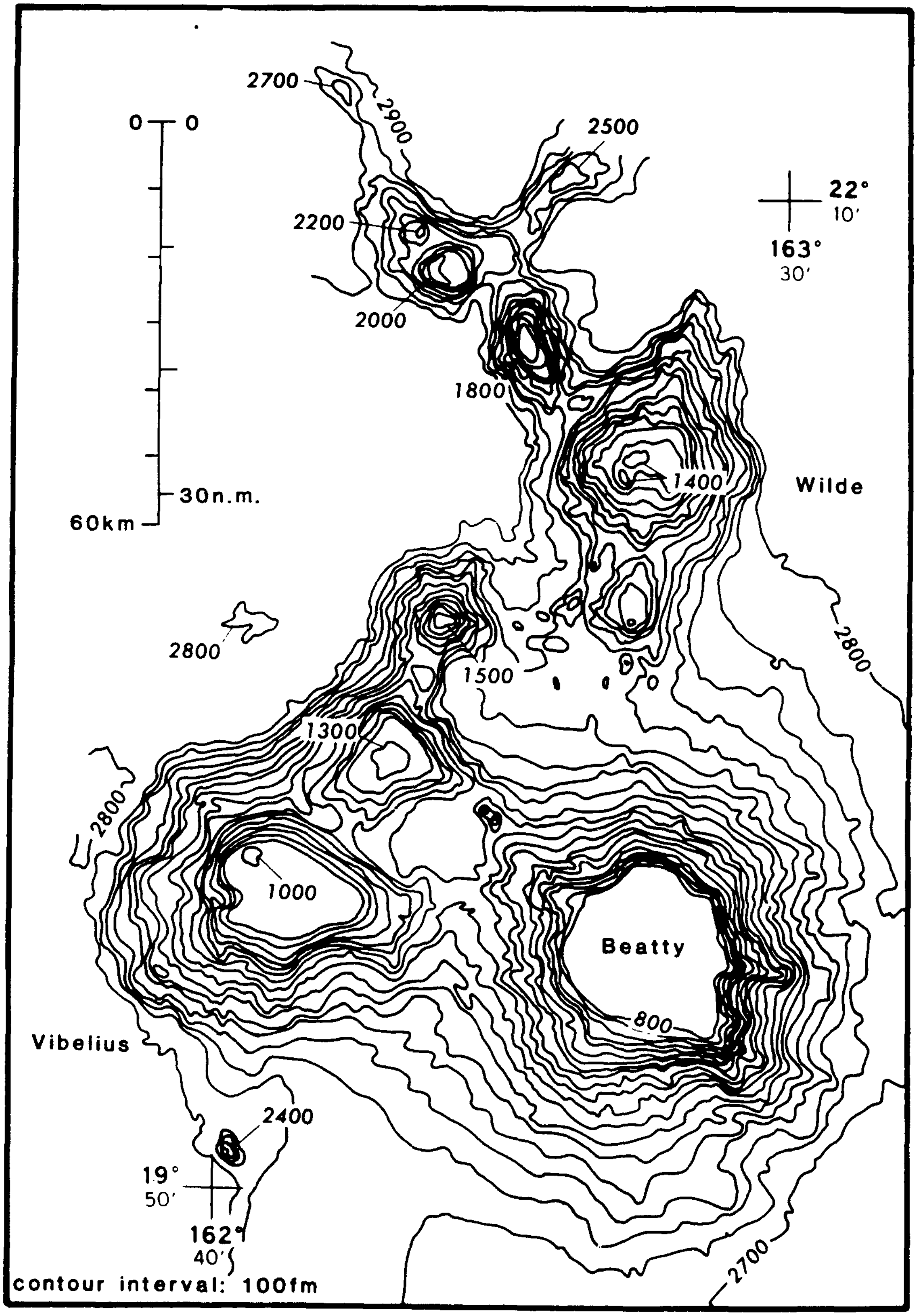

Figure 44. The Beatty Group. Wilde was named by a previous expedition. Charles E. Beatty, a NAVOCEANO surveyor, sailed on over 175 voyages of exploration entailing 1.7 million survey miles. Richard Vibelius is a retired NAVOCEANO surveyor with over 100 cruises to his credit. USBGN.

Name: McDonnell
Latitude: $19^{o}40'$N
Longitude: $162^{o}00'$E
Minimum guyot depth (fm): 700
Summit plateau break depth (fm): 700
Summit plateau area (n.m.^{2}): 170
Flank break depth (fm): 1600
Upper slope angle (%): 16
Flank slope angle (%): 4
Regional base depth (fm): 2800
Guyot height (fm): 2100
Guyot age (m.y.):

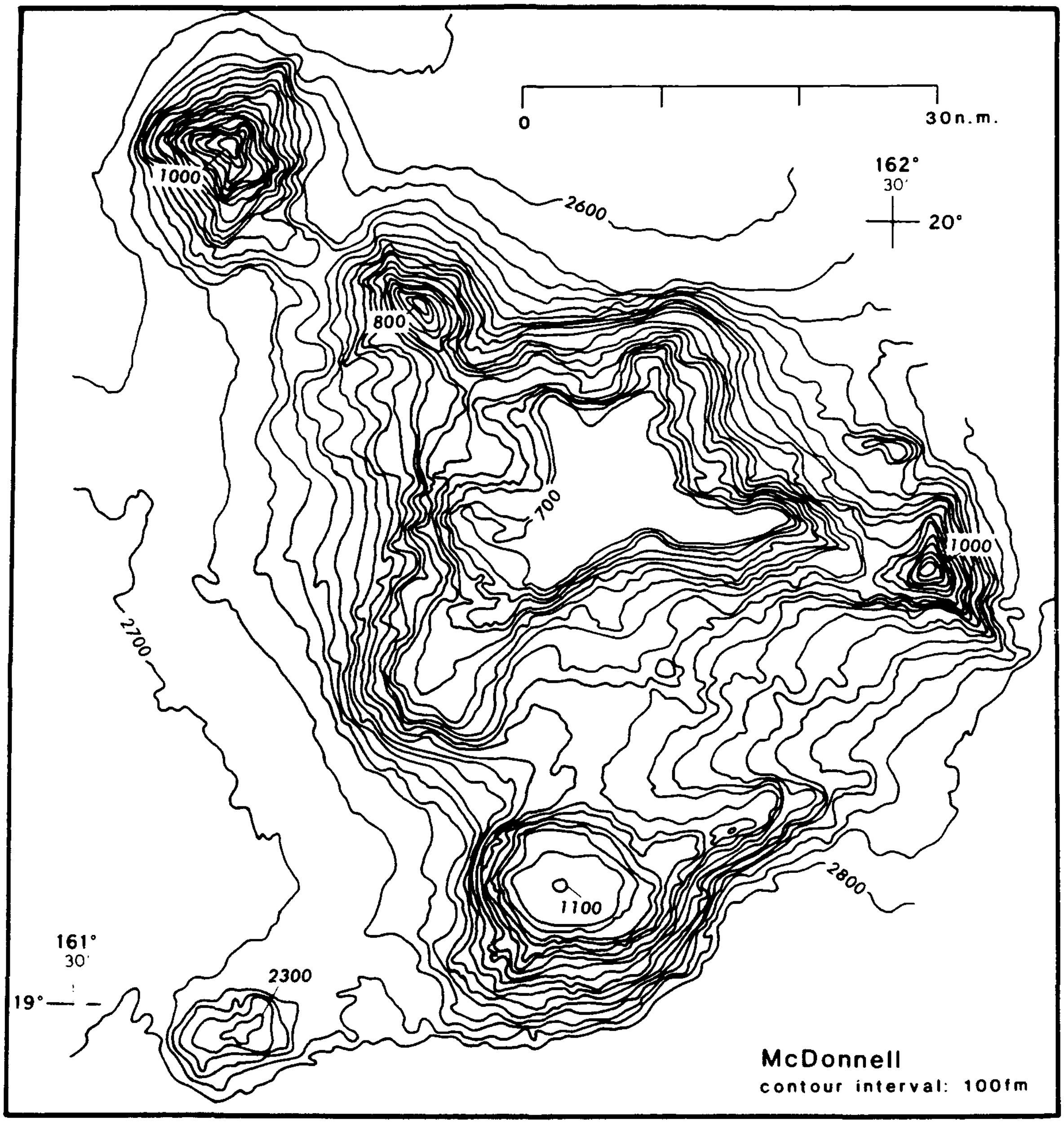

Figure 45. McDonnell Guyot. Named by N.C. Smoot (1985) after John E. McDonnell (deceased), one-time head of the Ocean Survey Program, Commanding Officer of NAVOCEANO itself, and first Commander, Naval Oceanography Command. "Captain John" started the release of this data. USBGN.

Name: Sampson
Latitude: 20°15'N
Longitude: 163°00'E
Minimum guyot depth (fm): 700
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 216
Flank break depth (fm): 1800
Upper slope angle (%): 20
Flank slope angle (%): 3
Regional base depth (fm): 2800
Guyot height (fm): 2100
Guyot age (m.y.):

Name: Delilah
Latitude: 20°30'N
Longitude: 163°45'E
Minimum guyot depth (fm): 800
Summit plateau break depth (fm): 800
Summit plateau area (n.m.^{2}): 38
Flank break depth (fm): 1600
Upper slope angle (%): 24
Flank slope angle (%): 3
Regional base depth (fm): 2900
Guyot height (fm): 2100
Guyot age (m.y.):

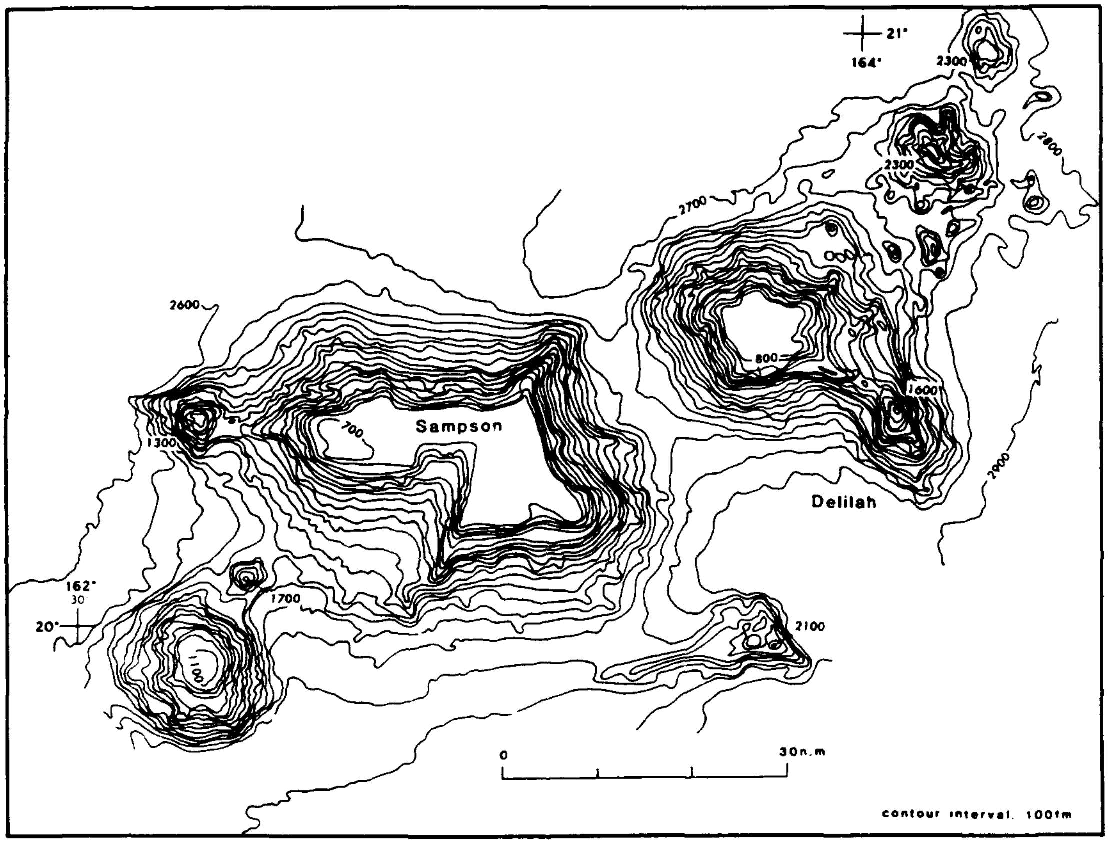

Figure 46. Sampson and Delilah Guyots. Named by N.C. Smoot (1985). Jesse Sampson was the first head of the Ocean Survey Program. Delilah seemed to fit as a name beside Sam(p)son. Sampson is USBGN.

IV. DISCUSSION

Research prior to the advent of multibeam sonar led to the accepted United Nations guyot definition by way of the General Bathymetric Chart of the Oceans Advisory Committee (GEBCO) as presented by the U.S. Board on Geographic Names (USBGN) (Holcombe, 1977): namely, a seamount having a comparatively smooth top. This top has to be deeper than 100 fm by definition because oceanic banks, pedestals, and plateaus lie above that. GEBCO also recognized a seamount as rising 500 fm or more above the sea floor and of limited extent across the summit. This limited extent is important because 50 n.m.^{2} minimum surface area has been suggested (Smoot, 1980) for incorporation as a cutoff figure to separate guyots from seamounts with mere breaks in relief, which are legion in the North Pacific. These features will be called quasi-guyots for the purposes of this study. Smaller-area summits are not flat enough over a large enough area, nor do they exhibit volcanic features on most of the seamounts on which the author has surveyed and compiled.

Table 1 shows that Pacific basin guyots range from 200 to 1000 fm in summit depth and 1800 to 3200 fm in basal depth. The average Pacific Ocean guyot displays these measurements: 653 fm summit depth, 2272 fm height, 24.2 percent upper slope angle, a considerably lesser flank slope angle, and 281 n.m.^{2} summit plateau area (figure 47). These figures do not change appreciably with the exclusion of the Gulf of Alaska guyots, which are hardly of a size to be significant in a study of the larger guyots. Figure 48 shows the surface area distribution by histogram. A statistical analysis incorporating all 46 guyot summits gave a mean of 280.7 with a standard deviation (1) of $\pm$347.1. The lower cutoff limit could not be adequately determined by statistical analysis.

The flank slope break is suspected as being caused by sedimentation. Materials for sedimentation may be primarily from eroded tops which have merely rained down the sides of each respective feature (Smoot, 1983a). This theory cannot be supported by seismic data because of the lack of available data from the National Oceanic and Atmospheric Administration's National Geophysical Data Center. The lesser slope would be on the side away from the prevailing current at the time of erosion. Also, a larger summit area guyot would have lost more to erosion and created a lower angle flank slope (Smoot, 1983a; Smoot et al., 1985).

Guyots generally have absolutely no symmetry or geomorphic conformity to each other whatsoever. Nor do the break points necessarily indicate regional sea level at the time of truncation, because the in-chain variation is as large as 600 fm for the Emperor Chain itself (Smoot, 1982; Smoot, 1985a, b). Differential subsidence rates will not account for this because smaller volume guyots have deeper break points than larger guyots in some

Table 1. Geomorphology of North Pacific Guyots
(Names Arranged in Order of Atlas)

Guyot	Minimum Depth (fm)	Platform Break Depth (fm)	Summit Area (n.m.2)	Flank Break Depth (fm)	Upper Slope (%)	Flank Slope (%)	Height (fm)
Welker	410	500	60		32		1390
Durgin	400	500	120		23		1500
Pratt	410	500	106		21		1540
Giacomini	400	400	15	1900	22		1700
Suiko	600	1000	1558	2100	27	10	2700
Showa	800	1100	251	2100	22	11	2300
Saga	700	1000	136	1900	25	7	2100
Yomei	500	1100	406	2300	24	13	2500
Nintoku	600	700	1181	1600	24	7	2700
Jingu	500	600	91	2400	32	10	2700
Ojin	600	800	640	2500	24	10	2600
Koko	200	900	1500	1800	19	5	2840
Antoku	500	600	50	2000	28	5	2500
Tobu	600	700	65	1800	28	4	2400
Yuryaku	300	700	90	1800	24	6	2700
Daikakuji	600	800	50	1800	30	5	2400
Kammu	200	400	150	1700	25	4	2800
Seiko	770	900	25	1800	45	6	2330
Charlie Johnson	900	1000	35	1400	37	3	2300
Winterer	760	900	25	2500	33	7	2440
Makarov	750	800	72	2100	30	5	2350
Nelson	550	800	77	2200	18	4	2450
Broken-Top	300	800	300	1400	21	3	2800
Smoot	580	700	650	1900	28	4	2420
Castor	480	800	250	2400	30	4	2520

Table 1. Geomorphology of North Pacific Guyots
(Names Arranged in Order of Atlas) (con.)

Guyot	Minimum Depth (fm)	Platform Break Depth (fm)	Summit Area (n.m.2)	Flank Break Depth (fm)	Upper Slope (%)	Flank Slope (%)	Height (fm)
Pollux	710	800	300	2500	34	4	2590
Fryer	720	900	336	1600	17	3	2080
Vogt	890	1100	638	2000	20	5	1910
McCann	780	900	108	2200	16	5	2120
Manken	950	1100	150	2400	14	5	2150
Lowrie	790	900	156	2500	25	7	2210
Hemler	710	800	61	1900	25	3	2290
Jaybee	460	700	541	1900	22	4	2540
Missy	800	900	254	2000	20	2	2300
Batiza	900	1200	280	2000	21	4	2100
Jennings	1100	1400	168	2200	20	3	1900
Maloney	1000	1100	120	2200	24	5	2000
Arnold	800	900	126	1400	19	3	2200
Lamont	700	1000	450	2500	22	3	2300
Scripps	700	900	184	2400	24	4	2300
Hunk	900	1100	280	2000	18	2	2100
Pot	700	900	254	2200	19	3	2200
Beatty	800	800	120	1700	20	5	2000
McDonnell	700	700	170	1600	16	4	2100
Sampson	700	800	216	1800	20	3	2100
Delilah	800	800	38	1600	24	3	2100
	30,020	38,700	12,853	86,000	1,112	213	104,530
$\bar{X}$	653	841	281	2,000	24.2	5.1	2,272.4
			± 347				

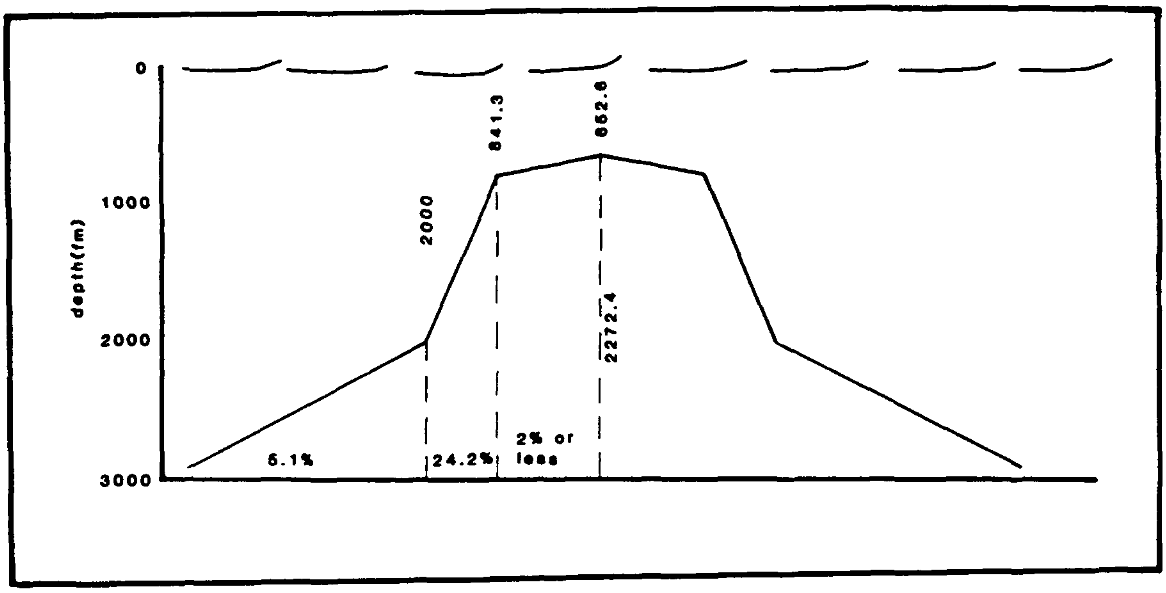

Figure 47. Typical North Pacific Statistical Guyot. The vertical exaggeration is used to demonstrate more clearly the slope breaks for the summit and flanks.

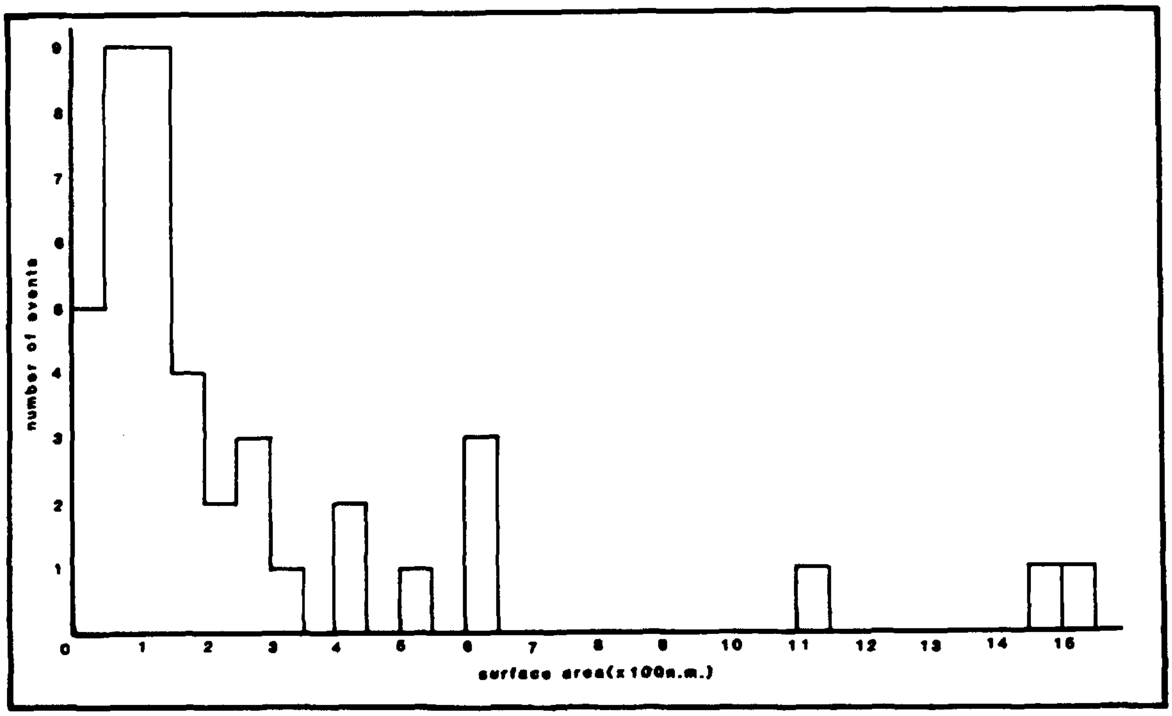

Figure 48. Guyot Summit Area Distribution.

cases; nor will plate undulation because the tops do not vary as alternating higher and lower summit depths in echelon.

NAVOCEANO surveys have proven that only three guyots as defined exist in the Gulf of Alaska. Giacomini, 15 n.m.^{2} and Quinn Seamounts, 32 n.m.^{2}, are just that--seamounts or quasi-guyots. Surveyor, Miller, and the others are even smaller and do not even have flat tops. Neither does Kashima Guyot in the Northwest Pacific. Preliminary indications are that it is a quasi-guyot. The earlier-named Japanese Seamounts (Geisha Guyots) exist as quasi-guyots with possibly two exceptions. The reader will note the paper (Hollister et al., 1978) on Western Pacific features. While features V, B, and C all exhibit relatively flat summits and are of volcanic derivation, they range only between 160 and 214 fm in height from the sea floor and are properly not called guyots. This definition can be tested by seismic surveys and coring of summits to prove whether some seamounts and quasi-guyots have been at the surface.

The morphology of most open-ocean guyots approximates the typical morphology of Vogt-Nelson guyots (table 1) in size of top and depth with the Koko Guyot in the Emperor Chain showing multi-crater tops also. One other possibility is a tilted subducting top, such as Hilde Horst on the Ogasawara Plateau (Smoot, 1983d). The deeper side is nearer the trench where its breakup is imminent. This tilted top could also happen to a ridge-formed feature which eroded while still on the upper flank of the ridge.

The most significant problem with the archaic survey methods is missed peaks on features. A simple explanation here is that a survey line along the flank of any elongated seamount using broad-beam sonar will always give a slope break and a flat surface fathometer trace. Consequently, the feature is erroneously named a guyot, a paper published on same, and it becomes part of the literature. It then becomes almost impossible to change that name or strike it from the records.

Even the most undiscerning of guyot students can easily see that the main reason for the purging of the guyot files is advanced survey technology. Five or six lines in a star pattern based on dead reckoning and broad-beam sonar is not enough information on which to base guyot morphology. These survey methods initially worked for the larger features, such as the Mid-Pacific Mountains (Heezen et al., 1973). Slowly but surely the new breeds of multibeam array sonar will show actual bottom topography and abet this purging. Already the guyot names presented here have been accepted and some published by the USBGN. The process is in motion.

V. RECOMMENDATIONS FOR FUTURE STUDY AND CONCLUSIONS

Future Study

The first recommendation for future study is that publishing preference be given to manuscripts containing new data instead of old or reworked data. Some researchers in the field of guyot study continue to rework papers or produce later-generation papers that add nothing to the overall data bank; there are also some researchers who have adopted and adapted the newer survey techniques and are advancing the overall scientific infrastructure. The first "cry in the wilderness" was an article in 1981 (van Andel, 1981) which predicted the demise of the roaming marine geologist and his method of expanding a rock into an entire mid-ocean ridge system. Others who were not recognized or even trained in the field of marine geology had begun to make inroads. However, even though scientists always disagree, the experts in their provincialism were trying to keep the field closed to the dilettantes and their unchained curiosity (Feyerabend, 1984). This problem is compounded by the plethora of literature on any topic, most of which is merely cluttering the files. An example from Thomson (1984) will serve. Twenty years ago when there were fewer scientists and journals, the average readership of a scientific paper, excluding reviewers and editors, was one (van Andel, 1981). Just as establishing a classic book from all the world's literature is difficult, the distilling of anything worthwhile from the publish-or-perish atmosphere of the 1970's and 1980's is difficult to imagine. One of the American Geophysical Union satellite journals, EOS, has even suggested that the regressive referees be done away with at least once a year so that some inspired, exciting research ideas might be presented (Baker, 1985).

Secondly, it is recommended that newer studies be performed using the newer survey systems. Commercially available multibeam sonar is expanding the availability of total coverage features for study. NOAA has SeaBeam mounted on at least one of its hulls. Columbia University's Lamont-Doherty Geological Observatory and the University of California, San Diego Scripps Institution of Oceanography have SeaBeam, as does the research vessel "Jean Charcot" in France. The University of Hawaii has SeaMARC II, which incorporates side-scan sonar with a bathymetry capability. Admittedly the bathymetry does not tell the entire story, but it is a major part of guyot investigation. A geophysical study of something whose position or even existence is not known is rather difficult to establish.

Some of the newer work known to the author is that being done on seamount growth (Batiza and Vanko, 1983/1984). By using ship of opportunity data, it has now been determined that large conical seamounts evolve from submarine flat-topped seamounts. With the addition of the computer to the cartographic stable, an eroded top can be replaced onto a guyot and the 3-D feature rotated for a closer look at the gross morphology (Smoot et al., 1985) (figure 49). Predictions about crustal age and seamount height have been suggested (Marcva, 1982 among others). This atlas is an excellent case in point. Many of the guyots, especially in the Mid-Pacific Mountains, have not been bathymetrically updated in the last ten years because no ships of opportunity have gone to survey specifically those features. These data will rectify that. Even more recent is the Carbonate Bank and Guyot Workshop sponsored by the Joint Oceanographic Institutions, Inc., in August of 1985. Major problems and design drilling plans were addressed to attack these problems.

One of the suggestions the author proposed for this workshop involved the Japanese Seamounts. Drilling combined with data from table 1 might prove that some of the accepted flat-topped seamounts in the Japanese Seamounts never broke the sea surface. The author now suggests that these features, with the exception of Makarov Guyot, never broke the surface and should be named the Japanese Seamounts as they are already called in some literature. The upper slopes on these features average 60 percent higher than the average upper slopes of all the other North Pacific guyots (table 1), in all probability because the features in this chain reached near enough to the surface for carbonate caps (reefs) to form before subsidence began (figure 50). Then, additions to these reefs at a rate compounded by subsidence may have caused the steeper upper slopes and account for the fact that nothing but reef materials has been dredged from them. Drilling is suggested to test the theory.

Finally, the author expects to compile an updated version of the atlas portion of this report at such time when all the latest dredge and coring data are acquired and site investigations have been made on some of the features with remotely operated vehicles or submersibles. Only then will we know enough about guyots.

Conclusion

Given the results of this report, a guyot summit still lies deeper than 100 fm. The feature itself possibly represents a sunken island and has upward concave sides and a convex or irregular top. As a result of this study, the author would now suggest that a guyot has a relatively horizontal summit plateau of less than 2 percent overall slope, and exceeds 50 n.m.^{2} in areal extent. If there were more guyots extant, it might also be a good idea to limit the upper areal extent to 1000 n.m.^{2} and derive another definition just as for mesas and plateaus on land. GEBCO's "tablemount" could be used for the larger guyots.

Possibly for the purists another avenue is open. The alteration of the old-school definition may seem repugnant to some who are then left with a mere three guyots in the Gulf of Alaska that fit that definition, and Hess did his work in the Western Pacific. All of the rest are not flat, round, or symmetrical. A

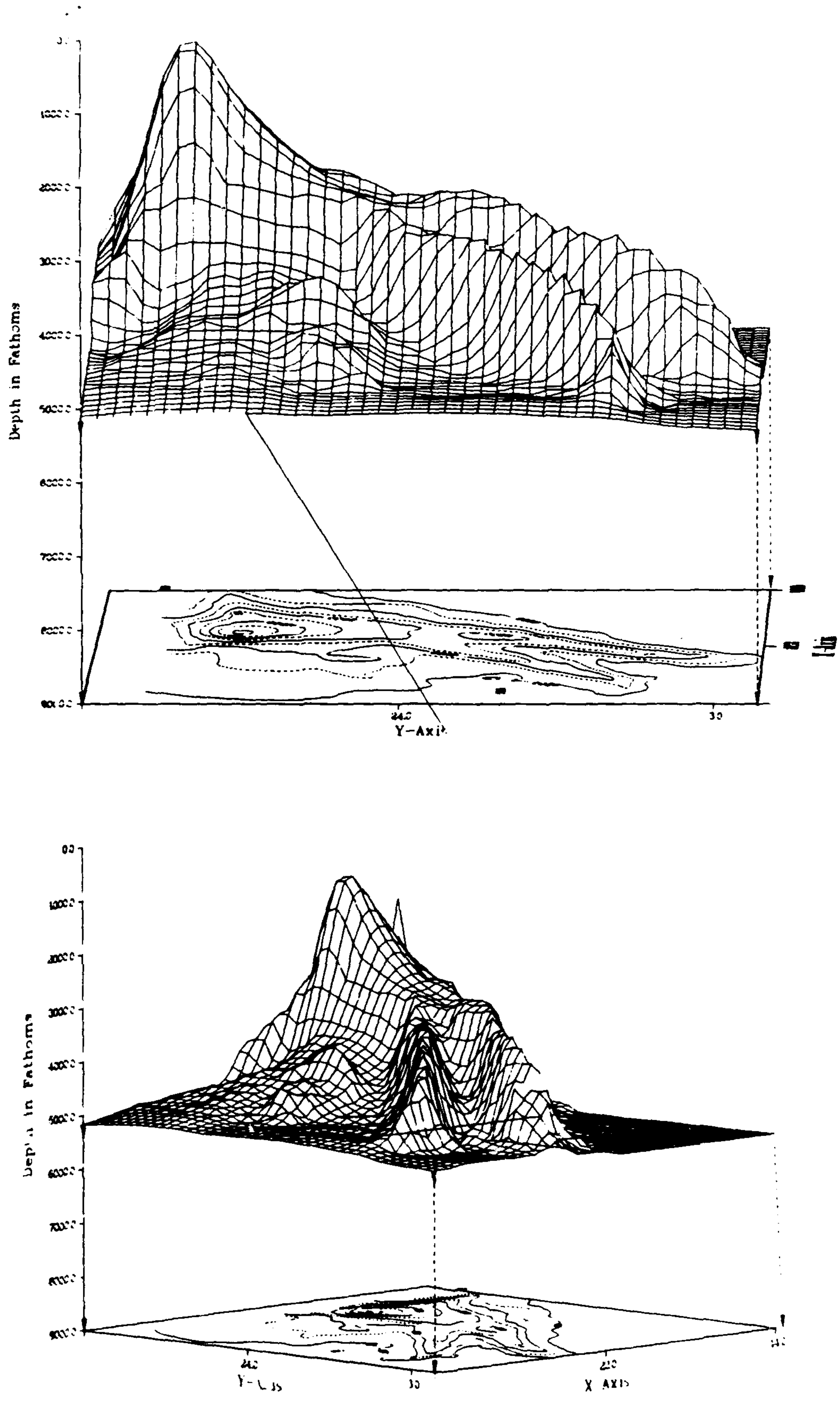

Figure 49. Nintoku Guyot With a Computer-Generated Top.

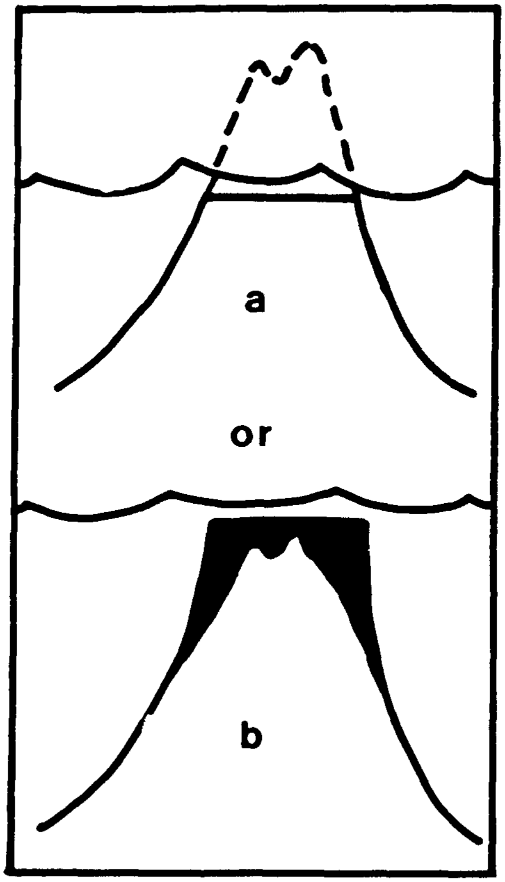

Figure 50. Hypothetical Flat-Top Formation. Formation is by (a) guyot formation by the historic definition or (b) reef formation on a submarine seamount that approaches the surface either through eustatic sea level change or growth. This could be an explanation for the steep sides on the Japanese Seamounts.

new name must now be derived for them to add to the plethora of new scientific terms. The author suggests that the purists bend their definition just a little to receive these amendments or that all of the real world guyots actually be called tablemounts and the word "guyot" itself be purged.

Last, guyots have been called dipsticks to measure paleo-ocean depths (Heezen and Hollister, 1971). This idea, using just guyot heights or minimum depths, will never work. There is too much difference between minimum depths in-chain, such as Koko and Antoku in the Emperors (figures 16 and 17) and quasi-guyots in the Gulf of Alaska (Smoot, 1985b). These alone belie the dipstick theory.

VI. REFERENCES

Adams, T. 1983. "Mapping the ocean floor." Science and Mechanics, (March/April), 36-103.

Allenou, J.P., and Renard, V. 1978. "Sea Beam, multiple beam echosounder of the oceanographic ship 'Jean Charcot.'" Scientific and Technical Report No. 37 (Publications of the National Center for Ocean Exploration [CNEXO], Brest, France), 1-28.

Baker, D.N. 1985. "JGR peer review suggestion." EOS, Transactions, American Geophysical Union, 66, 17, 157.

Batiza, R., and Vanko, D. 1983/1984. "Volcanic development of small oceanic central volcanoes on the flanks of the East Pacific Rise inferred from narrow-beam echo-sounder surveys." Marine Geology, 54, 53-90.

Dunham, S.J., and Shostack, B.H. 1980. "Precise reconstruction of ship's position." IEEE Plans 80 Position Location and Navigation Symposium, 430-435.

Feyerabend, P. 1984. "The expert as con man." Science Digest, 92, 2, 83.

Glenn, M.F. 1970. "Introducing an operational multibeam array sonar." International Hydrographic Review, 47, 35-39.

Glenn, M.F. 1976. "Multi-narrow beam sonar systems." IEEE Oceans '76 Proceedings, 8D-1-2.

Hamilton, E.L. 1956. "Sunken islands of the Mid-Pacific Mountains." Memoir, Geological Society of America, 64, 1-55.

Heezen, B.C., and Hollister, C.D. 1971. The Face of the Deep. New York: Oxford University Press.

Heezen, B.C., Matthews, J.L., Catalano, R., Natland, J., Coogan, A., Tharp, M., and Rawson, M. 1973. "Western Pacific guyots." Initial Reports of the Deep Sea Drilling Project, 20, 653-723.

Hess, H.H. 1946. "Drowned ancient islands of the Pacific basin." American Journal of Science, 244, 11, 772-791.

Holcomb, T.L. 1977. "Ocean bottom features - terminology and nomenclature." GeoJournal, 1, 6, 25-47.

Hollister, C.D., Glenn, M.F., and Lonsdale, P.F. 1978. "Morphology of seamounts in the Western Pacific and Philippine Basin from multibeam sonar data." Earth and Planetary Science Letters, 41, 405-418.

Jackson, E., Koizumi, Dalrymple, G., Clague, D., Kirkpatrick, R.J., and Greene, H.G. 1980. "Introduction and summary of results from DSDP leg 55, the Hawaiian hot-spot experiment." Initial Reports of the Deep Sea Drilling Project, 55, 5-32.

Kaneoka, I. 1972. "Evidence of subsidence of seamounts in the Northwestern Pacific." Marine Geophysical Researches, 1, 412-417.

Karig, D.E., Peterson, M.N.A., and Shor, G.G. 1970. "Sediment-capped guyots in the Mid-Pacific Mountains." Deep-Sea Research, 17, 373-378.

Mammerickx, J., and Smith, S.M. 1984. "Bathymetry of the North Central Pacific. "Geological Society of America Map and Chart Series MC-52."

Marova, N.A. 1982. "Relationship between the heights of Pacific seamounts and the age of the lithosphere." Oceanology, 22, 3, 322-324.

Menard, H.W., and Ladd, H.S. 1963. "Islands, seamounts, guyots, and atolls." The Sea, 3, 365-385.

Ozima, M., Honda, M., and Saito, K. 1977. "^{40}Ar-^{39}Ar ages of guyots in the Western Pacific and discussion of their evolution." Geophysical Journal of the Royal Astronomical Society, 51, 475-485.

Pautot, G., Nakamura, K., et al., 1987. "Deep sea submersible survey in the Suruga, Sagami, and Japan Trenches: preliminary results of the 1985 Kaiko cruise, leg 2. Earth Planet, Sci. Lett., 83, 300-312.

Simkin, T. 1972. "Origin of some flat-topped volcanoes and guyots." Geological Society of America Memoir 132, 183-193.

Smoot, N.C. 1980. "Interpretation of deep seasounding data." Technical Paper of the American Congress of Surveying and Mapping, Fall Meeting, MS-2-D-I-IO.

Smoot, N.C. 1981. "Multibeam sonar surveys of guyots of the Gulf of Alaska." Marine Geology, 43, M87-M94.

Smoot, N.C. 1982. "Guyots of the Mid-Emperor Chain mapped with multibeam sonar." Marine Geology, 47, 153-163.

Smoot, N.C. 1983a. "Detailed bathymetry of guyot summits in the North Pacific by multibeam sonar." Surveying and Mapping, 43, 1, 53-60.

Smoot, N.C. 1983b. "Multibeam surveys of the Michelson Ridge guyots: subduction or obduction." Tectonophysics, 99, 363-380.

Smoot, N.C. 1983c. "Guyots of the Dutton Ridge at the Bonin/Mariana Trench juncture as shown by multibeam surveys." Journal of Geology, 91, 211-220.

Smoot, N.C. 1983d. "Ogasawara Plateau: multibeam sonar bathymetry and possible tectonic implications." Journal of Geology, 91, 591-598.

Smoot, N.C. 1984. "Guyots and tectonics of the Mid-Emperor Chain." in: Proceedings of the 27th International Geological Congress, 6, 135-152.

Smoot, N.C. 1985a. "Guyot and seamount morphology and tectonics of the Hawaiian-Emperor elbow by multibeam sonar." Marine Geology, 64, 203-215.

Smoot, N.C. 1985b. "Observations on Gulf of Alaska seamount chains by multibeam sonar." Tectonophysics, 115, 235-246.

Smoot, N.C., and Heffner, K.J. 1986. "Bathymetry and possible tectonic interaction of the Uyeda Ridge with its environment." Tectonophysics.

Smoot, N.C., Delaine, K., and Gregory, R.L. 1985. "A 3-D model of Nintoku Guyot to predict paleo-island morphology." ACSM Bulletin, 23-27.

Tamaki, K. 1977. "Appendix II. Continuous seismic reflection profiling survey in the Bonin (Izu-Ogasawara) Island arc." Deep Sea Mineral Resources Investigation in the Central-Eastern Part of Central Pacific Basin, Cruise Report No. 8, 197-201.

Thomson, K.S. 1984. "The literature of science." American Scientist, 72, 185-187.

Turner, D.L., Forbes, R.B., and Naiser, C.W. 1973. "Radiometric ages of Kodiak seamount and Giacomini guyot in the Gulf of Alaska: Implications for circum-Pacific tectonics." Science, 182, 589-591.

van Andel, T.H. 1981. "The ocean floor closely observed: will it subvert marine geology?" Nature, 289, 9-10.

Vogt, P.R., and Ostenso, N.A. 1967. "Steady state crustal spreading." Nature, 215, 5102, 810-817.

Vogt, P.R., and Smoot, N.C. 1984. "The Geisha Guyots: multibeam bathymetry and morphometric interpretation." Journal of Geophysical Research, 89, B13, 11,085-11,107.

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