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U.S. GEOLOGICAL SURVEY - NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
JOINT OFFICE FOR MAPPING AND RESEARCH

MISCELLANEOUS FIELD STUDIES
MAP MF-2237

INTRODUCTION

The great bulk of the Hawaiian volcanoes lies beneath the sea, and, until recently, only the most general bathymetry of this submarine portion of the volcanoes has been available. Due to the advent of multibeam sonar and improved satellite navigation systems (Global Positioning System) in the last two decades, it is now possible to collect precise swath bathymetry that is accurately located. This map is part of a series of modern bathymetric maps showing the submarine parts of the active Hawaiian volcanoes. The region depicted in this map is the submarine East Rift Zone of Kilauea Volcano, named Puna Ridge, and its flanks. The distal 75 km of the East Rift Zone is submarine, compared with only 55 km that is subaerial.

TOPOGRAPHY

Elevation data were gridded at 200-m spacing and plotted on a Mercator map projection at a scale of 1:150,000. Both subaerial and submarine topographic data were contoured at an interval of 10 m; every tenth (100 m) contour is heavier and marked with ticks on the downslope side. Subaerial topography (area 1 on index map) is indicated by a faint brown tone on the main map and is based on recent digital elevation data from 7.5' quadrangles of the U.S. Geological Survey. The data were generated from parallel scan lines across stereoscopic models projected from aerial photographs.

BATHYMETRY

Nearshore bathymetry (area 2 on index map) was collected by single-beam sonar surveys and is from the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service Hydrographic Database, National Geophysical Data Center. The remainder of the mapped area was surveyed using multibeam swath mapping from the U.S. Navy vessel *Laney Chouest*, Victor Gisclair commanding, in October 1992 as part of a joint program of NOAA, National Undersea Research Program, and the U.S. Navy with M.O. Garcia, Chief Scientist for the small area at the west edge of the map (area 3a on index map), and D.A. Clague, Chief Scientist for the remaining area (area 3b on the index map). The multibeam swaths are overlapping throughout the survey region, and the entire survey was navigated using the Global Positioning System. Previous swath bathymetry of Puna Ridge, collected by the U.S. Navy and by Scripps Institution of Oceanography (Lonsdale, 1989), did not consist of overlapping swaths and was navigated by older, less accurate, techniques. Earlier bathymetric maps, including those by Moore (1971) and Wilde and others (1980), were based on sounding data. Multibeam depth contours are based on an uncorrected oceanic sound speed of 1,500 m/s; consequently, reported depths may deviate slightly from true ocean depths. This map is not intended for navigational purposes.

GEOLOGIC INTERPRETATION

Kilauea volcano has erupted about 50 times since 1823, from vents located at the summit, which is west of the map area, and along the East and Southwest Rift Zones. The subaerial East Rift Zone extends 55 km from Kilauea's summit to the east cape of the island (shown on the map) and continues for an additional 75 km as the submarine Puna Ridge. The East Rift Zone has been particularly active since 1955, with 20 separate subaerial eruptions, including the 10-year-long eruption from 1983 to the present at the Puu Oo and Kupaianaha vents (located west of the map area). Historical data suggest that submarine eruptions occurred along the Puna Ridge in 1790 and in 1924, and a one-day eruption was reported in 1884 slightly offshore at a depth of only 20 m (Stearns and Macdonald, 1946). Formation of a graben near Kapoho in 1924 presumably reflects withdrawal of magma that migrated offshore along the rift. In 1790, the summit magma reservoir drained and led to the largest historic phreatomagmatic eruption at Kilauea. A submarine eruption may have caused the draining of the summit reservoir. The inferred submarine eruption in 1924 also preceded a phreatic eruption at Kilauea's summit.

Puna Ridge is segmented into several morphologic sections. The western 38-km-long section of the ridge, from sea level to 2,100 m, is broad and flat-topped, perhaps resulting from rift-parallel grabens. It is studded with cones as large as 2.5 km in diameter; many of these cones have summit craters. The deepest 6 km of this section maintains a broad crest, but the axis is poorly defined because of the presence of numerous cones. The next section to the east (38 to 52 km from shore and 2,100 to 3,400 m in depth) displays a narrow crest with numerous constructional cones. The easternmost section (52 to 75 km from shore and 3,400 to 5,450 m in depth) has a poorly defined broad crest and no identifiable cones. Both the rift axis and its flanks consist of a series of stairsteps that may represent large shieldlike vents or leveed lava ponds. The detailed structure and morphology of the rift axis has been described by Fornari and others (1978) and Lonsdale (1989). Moore (1965) and Lonsdale (1989) suggest that most of the rift axis consists of pillow lava and pillow fragments, although some sheet flows also occur.

Extensive flat lava flows to the north and southeast at the base of Puna Ridge were identified on GLORIA sonograms (Holcomb and others, 1988). These flows are included in the survey region, but the relief at their margins is less than can be resolved with the multibeam bathymetry, which, at these water depths, is about 10 m. Apparently no vent structures associated with the rift zone occur on the Cretaceous seafloor east of the distal end of Puna Ridge (Lonsdale, 1989). The cone at 154°9.5' W., 19°51' N. coincides with a low backscatter area in the GLORIA images within the high backscatter lava flows (Holcomb and others, 1988); it is probably a sediment-covered volcanic cone of Cretaceous age, similar to another small cone about 5 km farther east.

The flanks of Puna Ridge are also characterized by numerous near-circular structures that resemble volcanic cones. On land, such structures are usually constructional volcanic features that occur only within a narrow strip along the rift axis. The submarine structures on the flanks could be vents that formed along the rift axis and were subsequently rifted away from the axis as new dikes intruded the rift zone. However, it seems more likely that they are small landslide deposits or ponded flows.

Lava has repeatedly crossed the south shoreline of the volcano and flowed into the sea. Large volumes of lava and its fragmented products have, therefore, moved downslope to abyssal depths across the terrain depicted in the westernmost part of this map. The contact between the rough and irregular slope, consisting of pillow-lava flows erupted along the submarine Puna Ridge, and the smooth slope, mantled by mainly fragmental rocks generated where subaerially erupted lavas entered the sea, extends offshore directly downslope towards the south-southeast from the east cape of the island. To the east, the pillow-lava flows create rough terrain, whereas to the west, the fragmental deposits bury the pillow lavas and smooth the terrain. On the basis of sparse dredge samples and bottom photographs, Moore and Fiske (1969) proposed that the areas downslope from land were mainly glassy basaltic sand and scoria and that the areas downslope from submarine eruptive vents were mainly pillow lavas and pillow fragments. The new bathymetric data confirm their interpretation and suggest that the fragmental deposits downslope from land are thick enough to smooth the slope. Since the local relief to the east is roughly 100-200 m, the fragmental mantle must exceed this in thickness.

The southeast flank of the rift zone is characterized by large, rotational slump blocks as far east as 154°24' W., directly downslope from the major change in the character of the rift axis at a depth of 2,100 m. A series of broad basal benches and linear ridges along the southeast flank of the Puna Ridge occurs as far east as 154°18' W. The northeast extent of these benches is also directly downslope from the change in the morphology of the rift axis at a depth of 3,400 m. These relations indicate that the structure of the unbuttressed flank and the rift axis are linked. The north flank of Puna Ridge is much steeper than the south flank to the west of the change in axial morphology at 2,100 m depth.

ACKNOWLEDGMENTS

We are indebted to Donald Butera and Haywood Davidson for their shipboard assistance, without which the multibeam bathymetry could not have been collected. Michael Garcia kindly allowed us to include a small region of multibeam bathymetry collected during his program. The final map was compiled at the NOAA Pacific Marine Environmental Laboratory, Newport, Oregon.

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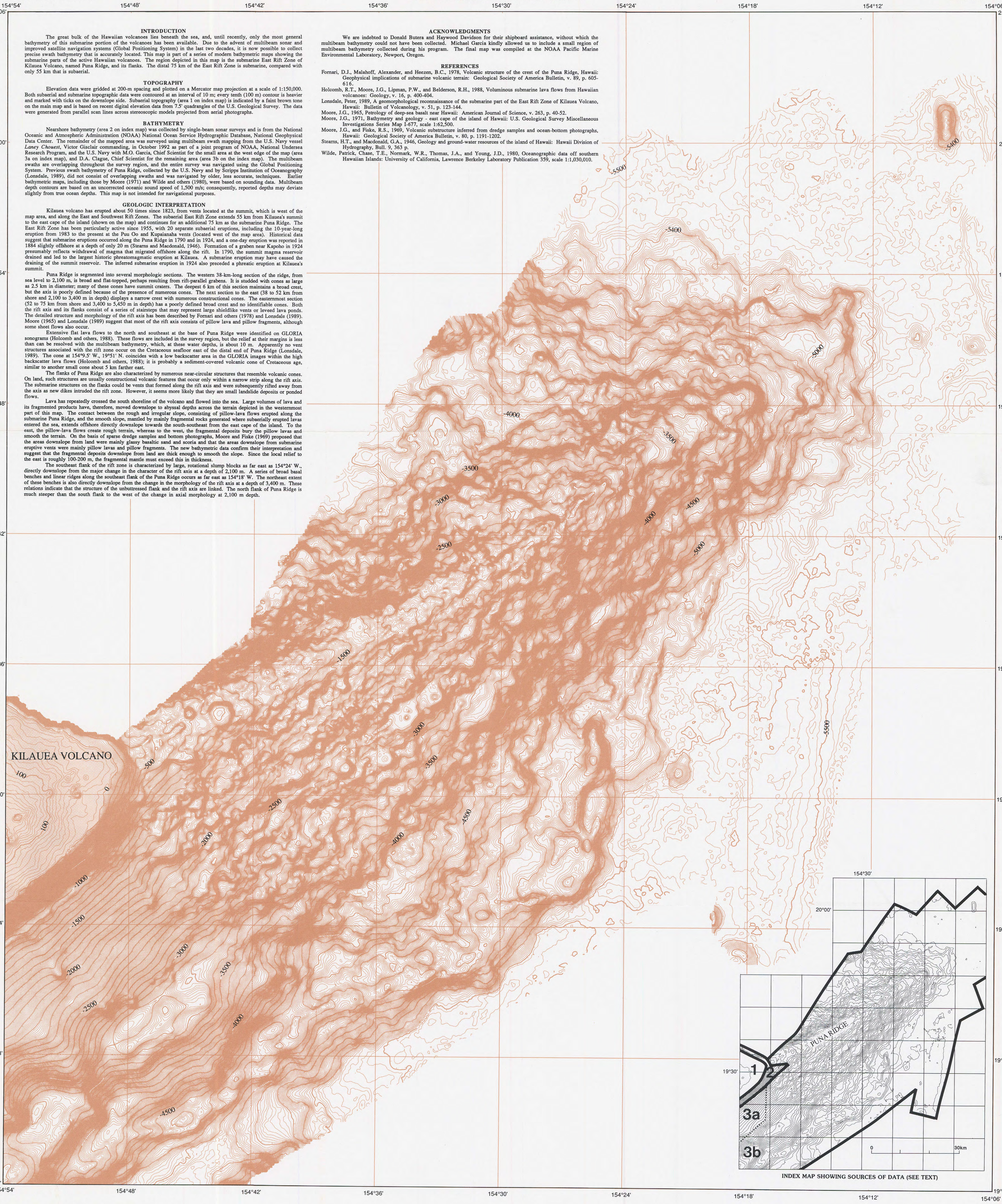

INDEX MAP SHOWING SOURCES OF DATA (SEE TEXT)

NOTE: THIS MAP IS NOT INTENDED FOR NAVIGATION

Mercator projection

SCALE 1:150 000

5 4 3 2 1 0 5 MILES

5 4 3 2 1 0 5 10 KILOMETERS

CONTOUR INTERVAL 10 METERS

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BATHYMETRY OF PUNA RIDGE, KILAUEA VOLCANO, HAWAII

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