Sediment Distribution in the Hawaiian Archipelago[1]

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ABSTRACT: Four sediment types were differentiated in 125 samples of marine sediments taken from the sea floor around the Hawaiian Islands. These were: shallow-water carbonates and detritus around the islands, calcareous oozes on bathymetric highs distant from shore, brown clay on the Hawaiian Arch, and siliceous ooze in the Hawaiian Deep and west of the island of Hawaii.

A MAP OF SEDIMENT TYPES around the Hawaiian Islands was prepared from a synthesis of data compiled from recent studies of 111 gravity cores and 14 grab samples from the Hawaiian Archipelago (Fig. 1). Of the 111 samples, 21 were collected by the Scripps Institution of Oceanography, and the rest were collected by the Hawaii Institute of Geophysics. Due to uneven distribution of the sampling locations, some of the boundaries of the different sediments shown in Figure 2 are not well defined. However, the general pattern of sediment types portrayed is believed to be essentially correct.

Marine sediments in the Hawaiian Archipelago can be classified into the following types: (1) shallow-water carbonates and detritus; (2) calcareous ooze; (3) brown clay; and (4) siliceous ooze.

The shallow-water carbonates, similar to those found in beach sands, comprise foraminifera, molluscs, red algae, echinoids, coral, and *Halimeda.* The detritus is composed of olivine, pyroxene, plagioclase, magnetite, ilmenite, gibbsite, palagonite, kaolinite, halloysite, montmorillonite, and illite. Allophane and other amorphous materials were also found. X-ray diffraction results of the detrital muds, grain diameters ($< 64\mu$) show they are characterized by the kaolinite-montmorillonite-plagioclase-magnetite assemblages. The detrital muds are concentrated around the Hawaiian Islands, becoming increasingly intermixed with brown clay farther from shore. However, they remain an important constituent of the sediment as far north of Oahu as the crest of the Hawaiian Arch. Authigenic chlorite derived from gibbsite is reported near the mouth of Waimea River in Waimea Bay off the coast of Kauai (Swindale and Fan, 1967).

The clastic sediments being shed from the Hawaiian Islands into the surrounding oceanic depths are primarily detrital muds, but some are silty calcareous sands. Graded beds of silty calcareous sands have occasionally been found in cores from the Hawaiian Trench.

It seems logical to ascribe the graded calcareous sand layers found in the sediments of the Hawaiian Deep to transport and deposition from shallower water by turbidity currents. The detrital muds rarely show graded bedding and are probably carried in suspension by bottom currents into abyssal depths. No comprehensive study of bottom currents has been conducted around the Hawaiian Islands, but J. N. Carruthers (Belshe, 1965) measured some bottom currents west of Kauai at depths from 800 to 2,200 meters. These currents were tidal and variable in direction, and velocities sometimes reached magnitudes of one-fourth knot. K. Wyrtki (personal communication) measured similar bottom currents north of the Hawaiian Arch.

The brown clay of the Hawaiian Arch is dark yellowish-brown in color, has a median diameter of 2 microns, and consists of less than 1 percent sand. Mineralogically, the sediment is composed of illite, quartz, and chlorite; and lesser amounts of kaolinite, montmorillonite,

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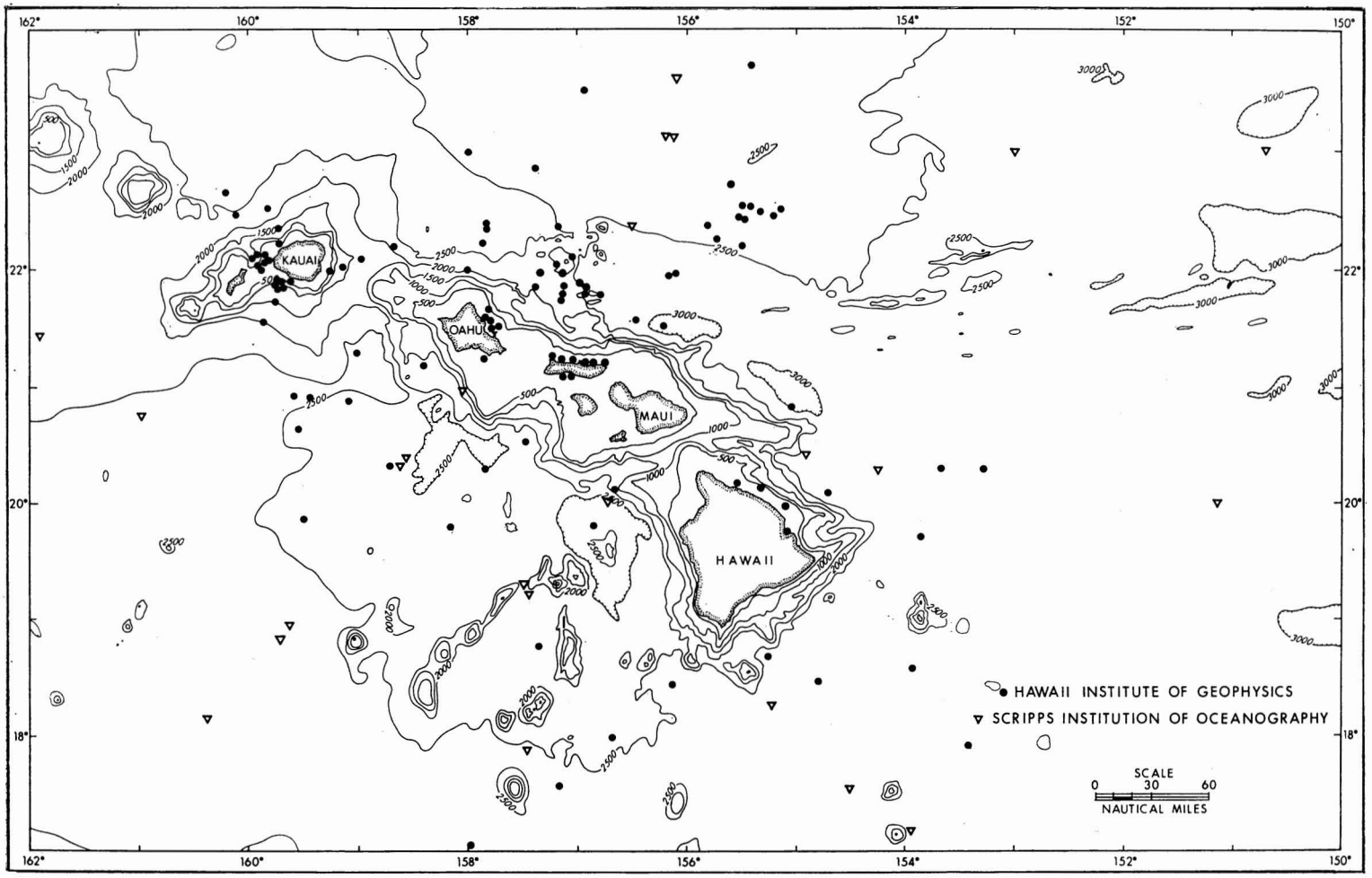

Fig. 1. Sample locations. Contour interval 500 fathoms.

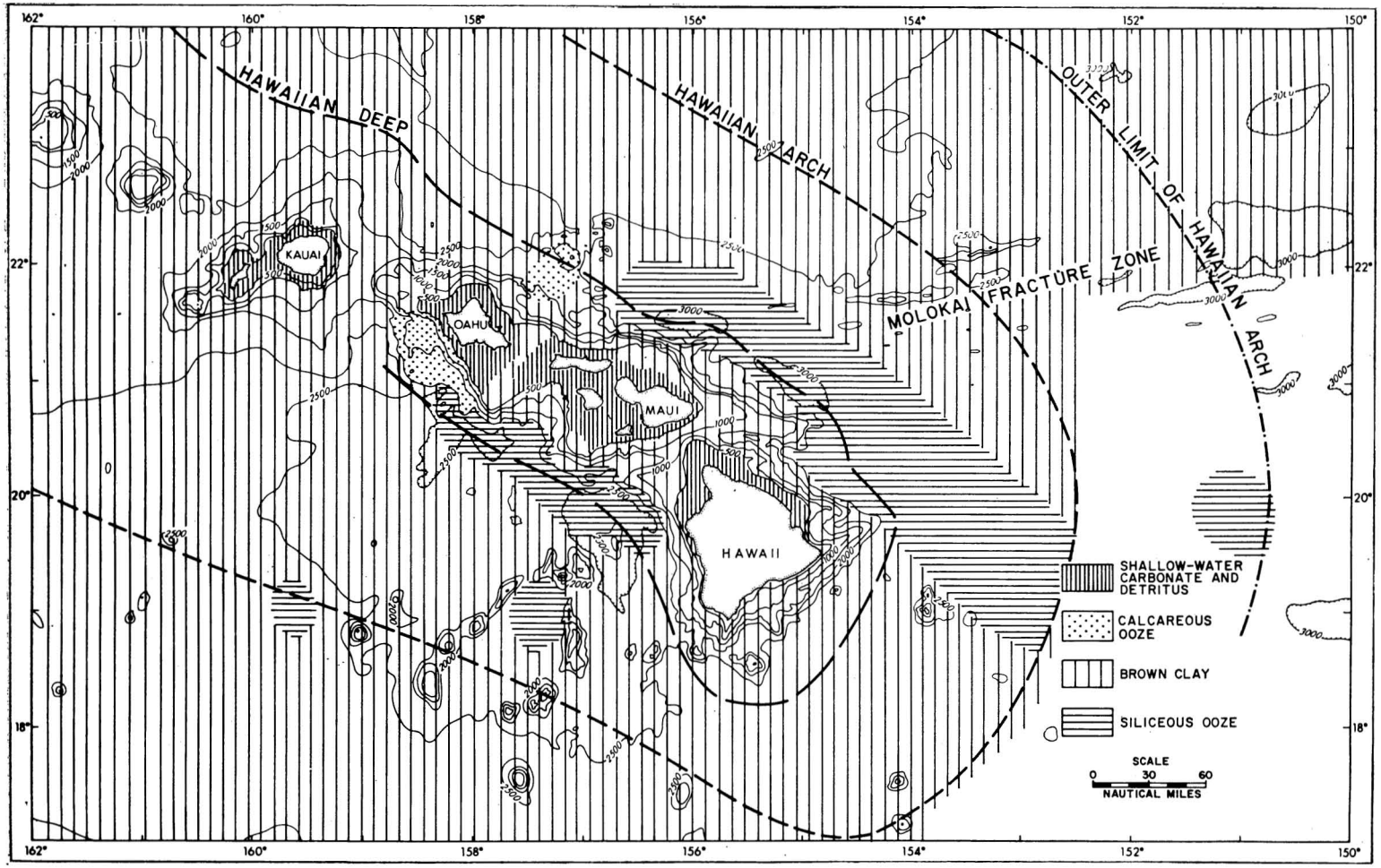

FIG. 2. The sediment distribution pattern near the Hawaiian Islands.

plagioclase, pyroxene, and allophane, and opal derived from radiolarians, sponge spicules, and diatoms. X-ray diffraction results show that the clay minerals have much sharper peaks and better crystallinity than the clay minerals of the detrital muds (Moberly, Kimura, and McCoy, 1968; Fan and Grunwald, 1968).

The brown clay south of the islands is olive gray in color and consists of abundant glass fragments which are mostly unaltered and contain crystal and bubble inclusions. Plagioclase, pyroxene, magnetite, and olivine mineral grains are also present. *Ethmodiscus* fragments and radiolarians, along with minor quantities of sponge spicules, are occasionally important constituents of the pyroclastic silt. The abundance of volcanic glass shards in this region is indicative of the volcanic activity of the Hawaiian area. The fact that the region lies in the trade wind lee of the islands, that the grain size of the shards decreases from shore, and that gas-bubble inclusions are present in most of the glass, all suggest that most of the material was derived from subaerial volcanoes in the Hawaiian Islands.

Some of the brown clay has been derived from island detritus. This sediment, however, is characterized by a high quartz content of about 14 percent (Rex and Goldberg, 1958), indicative of the large contribution by continental eolian debris.

There are occurrences of diatomaceous ooze in the Hawaiian Deep, east of the island of Hawaii, and in a few isolated sampling locations south of the islands. This ooze is less than 40 percent detrital mud and greater than 70 percent organic silica (Belshe, 1968), the latter composed almost exclusively of skeletal remains of the giant tropical marine diatom, *Ethmodiscus rex* (Rattray) Hendey. Radiolarians and sponge spicules are only very minor constituents of the ooze. The diatomaceous sediments are buried beneath 10 to 20 cm of detrital mud in the Hawaiian Deep and are very similar to the *Ethmodiscus* oozes from the western Pacific described by Hanzawa (1933), Wiseman and Hendey (1953), and Anikouchine and Ling (1967). In color, the diatomaceous sediments are generally light yellowish-brown, with darker yellowish and olive-brown bands approximately 1 centimeter thick occurring at various depths, occasionally interspersed with thin layers of volcanic glass shards. When wet, the sediment is very soft, with a peculiar "curdy" texture. On drying, the sediment shrinks to a very light, fluffy, white powder. The larger *Ethmodiscus* individuals may attain a size somewhat greater than 1 millimeter, but all the diatom frustules in the sediment have been broken and they resemble thin platelets of mica. Consequently, they are extremely mobile and can be moved about by the gentlest current.

Ethmodiscus sediments characteristically accumulate in depressions in the sea floor. Lisitsyn (1967) has regarded the presence of this type of deposit as indicative of a very calm environment.

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