BOTTOM SEDIMENT DISTRIBUTION IN CERTAIN INSHORE WATERS OF HONG KONG

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INTRODUCTION

The continental shelf in the vicinity of Hong Kong is about 100 miles wide, trending northeast-southwest roughly parallel to the Chinese coast. The bottom slope averages 0° 02′ seawards, increasing to 1° 50′ near the shelf break. Several extensive studies of the area have been carried out (SHEPARD *et al.*, 1949; KLENOVA, 1958; NIINO and EMERY, 1961; WANG, 1961; CHING, 1963; and USNOO, 1968), but none of them extended into the inshore waters of Hong Kong. In 1964, a programme to study the bottom sediment distribution in these inshore areas using a side-scan sonar was initiated by the Department of Physics at the University of Hong Kong. Results of the early phases of the work have already been reported (CHESTERMAN *et al.*, 1967). This paper summarizes the findings of the latter part of the study.

HISTORICAL BACKGROUND ON THE GEOLOGICAL USE OF SIDE-SCAN SONARS

Since the first successful attempt to use the side-scan sonar for seabed survey (CHESTERMAN *et al.*, 1958), repeated applications of the method to the study of the shallow sedimentary environment have been made. In the Celtic Sea and the seas around southern Britain, studies on the redistribution of sediments by tidal streams have been carried out (STRIDE, 1959; STRIDE, 1963; BELDERSON and STRIDE, 1966). Acoustic surveys have been made south of Dorset, where major fold and fault patterns were recognized (SRIDE, 1960; DONOVAN *et al.*, 1961 a). Similar work on the continental rise off the eastern seaboard of north America has revealed the occurrence of sets of parallel ridgelike features in waters in excess of 2 400 m (CLAY *et al.*, 1964). By mapping the crest length and sinuosity of some marine sand waves on the European continental shelf, the genetic relationship between different shapes of these waves was established (KENYON and STRIDE, 1968). In ecological research, the side-scan sonar has been used as an aid to herring spawning ground investigations at Ballantrae Bank (STUBBS and LAWRIE, 1962). In addition, geologic, topographic and sedimentary distribution studies have been made on a few submarine canyon heads between Ireland and West Africa (BELDERSON and STRIDE, 1969), on the Bristol Channel and the Atlantic continental margins of Europe (DONOVAN *et al.*, 1961b; STRIDE *et al.*, 1969), on certain shelf areas between New York and Nova Scotia (SANDERS *et al.*, 1969), in the vicinity of the Magdalen Islands (LORING *et al.*, 1970), on an area of the northern Hawaiian arch (SPEISS *et al.*, in press) as well as on part of a coral bank in the South China Sea (WONG *et al.*, 1970) and around the coastal waters of Hong Kong (CHESTERMAN *et al.*, 1967).

EXPERIMENTAL METHOD

The present work employed a side-scan sonar system tuned to 48 kHz and pulsed at a rate of 1 pps. Normal range athwartships was 2 400 feet. The transducer, used both as a sound projector and listening hydrophone, was a 27-element magnetostrictive device housed in a fibre-glass tow body. The beam pattern had a polar distribution that was very narrow in the horizontal plane (being only 1.8 degrees between 3 dB points) and relatively wide in the vertical plane (7.5 degrees between 3 dB points). The receiver included a time-varied gain amplifier (TUCKER and STUBBS, 1961) and the processed output was presented on a facsimile paper recorder. The reverberation signal was also tape-recorded for additional processing and analysis.

Navigation was executed by making simultaneous sextant angle readings to charted landmarks on shore. Radar ranges and bearings were also used to provide supplementary information. Absolute positioning was generally better than ± 50 feet in the areas to be discussed.

The survey lines consisted of two sets of parallel courses at right angles, each line being traversed in both directions. The distance between adjacent lines varied from 900 feet to 1800 feet, so as to allow for a generous overlap between adjacent runs. A ship speed of 6 knots was used throughout, except during one cruise over an area west of Ma Wan Island in the northeast Lantao Channel, where a speed overground of 2.4 knots was employed for better resolution.

Bottom samples were collected on a regular basis by means of a Phipps underway sampler.

RESULTS

Regional Discussion

Four inshore areas of Hong Kong (outlined in figure 1) have been repeatedly studied with a side-scan sonar and a Phipps underway bottom sampler. The results are presented in four bottom sediment distribution charts, and bottom notations on British Admiralty charts have been consulted during their compilation.

(i) ***Southeastern Approaches to Hong Kong***

Much of the southeastern approaches to Hong Kong is covered by a very soft, grey organic clay, containing fragments of shell and other debris derived from marine life (figure 2). This type of clay is the most commonly encountered form of marine sediments in Hong Kong waters (HOLT, 1962). Protruding slightly above this clayey bottom over most of Lamma Channel are a number of rock ridges. They range in width from 10 feet or so to well over 100 feet, and at least two of them appear to be partially buried.

Patches of sand-and-mud occur in the northwestern portion of Lamma Channel, between Taitam Peninsula and Stanley, in several enclosed bays, and a few other locations where the mode of deposition is affected by tidal currents or by the general topography (figure 3).

The marine clay of the southeastern approaches shows a fairly large variation in textural parameters. They range from silty-clay to sand-silt-clay, and are usually quite well-sorted (figures 4 and 5). The average grain size decreases in a southeasterly direction, in agreement with the movement of the tidal current, thus suggesting that here transport by the flood stream is largely responsible for the pattern of sediment distribution.

(ii) ***Lantao Channel***

Lantao Channel lies in the Pearl River estuary. Its bottom sediments consist mostly of river-borne material in the form of fine-grained sand, silt and marine clay. Local variations do occur, and are mainly controlled by the form of the coastline, bottom topography and strength of tidal currents (figure 6). Thus, in areas where streams reach the sea soon after a downward descent from nearby uplands, the Recent alluvial deposits consist largely of sand and sometimes appreciable quantities of gravel and cobble. Down the central deeper portions, which must have been an alluvial flood plain during periods of low sea level, they are more clayey and silty, with the coarser particles concentrated at places where the tidal currents are stronger. The sand particles are rather sharp and angular, particularly when they are found close to shore, suggesting that they are locally derived. In certain localized patches, particularly toward the east,

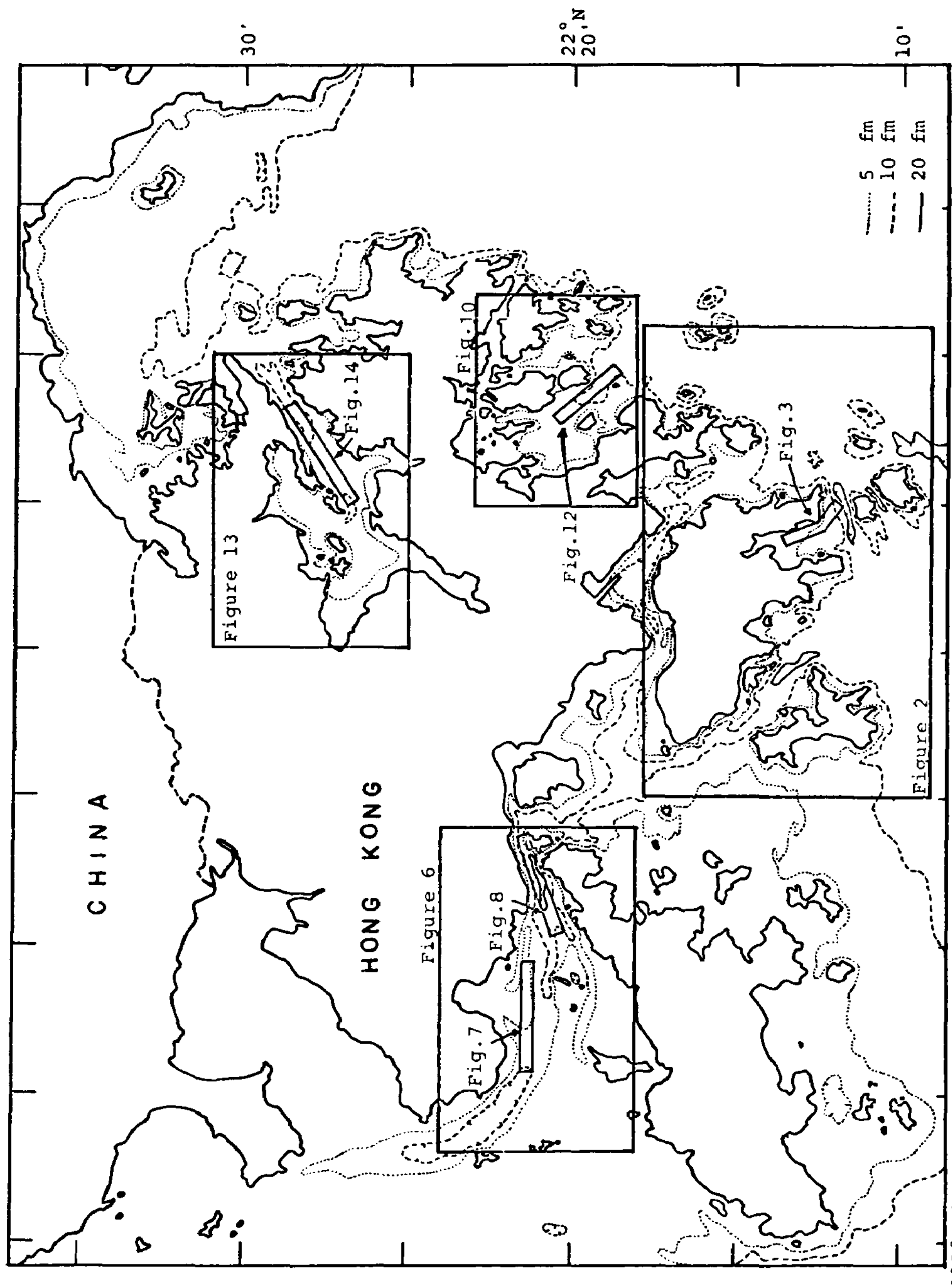

FIG. 1. — Bathymetric chart of Hong Kong. Rectangles indicate the locations of subsequent figures.

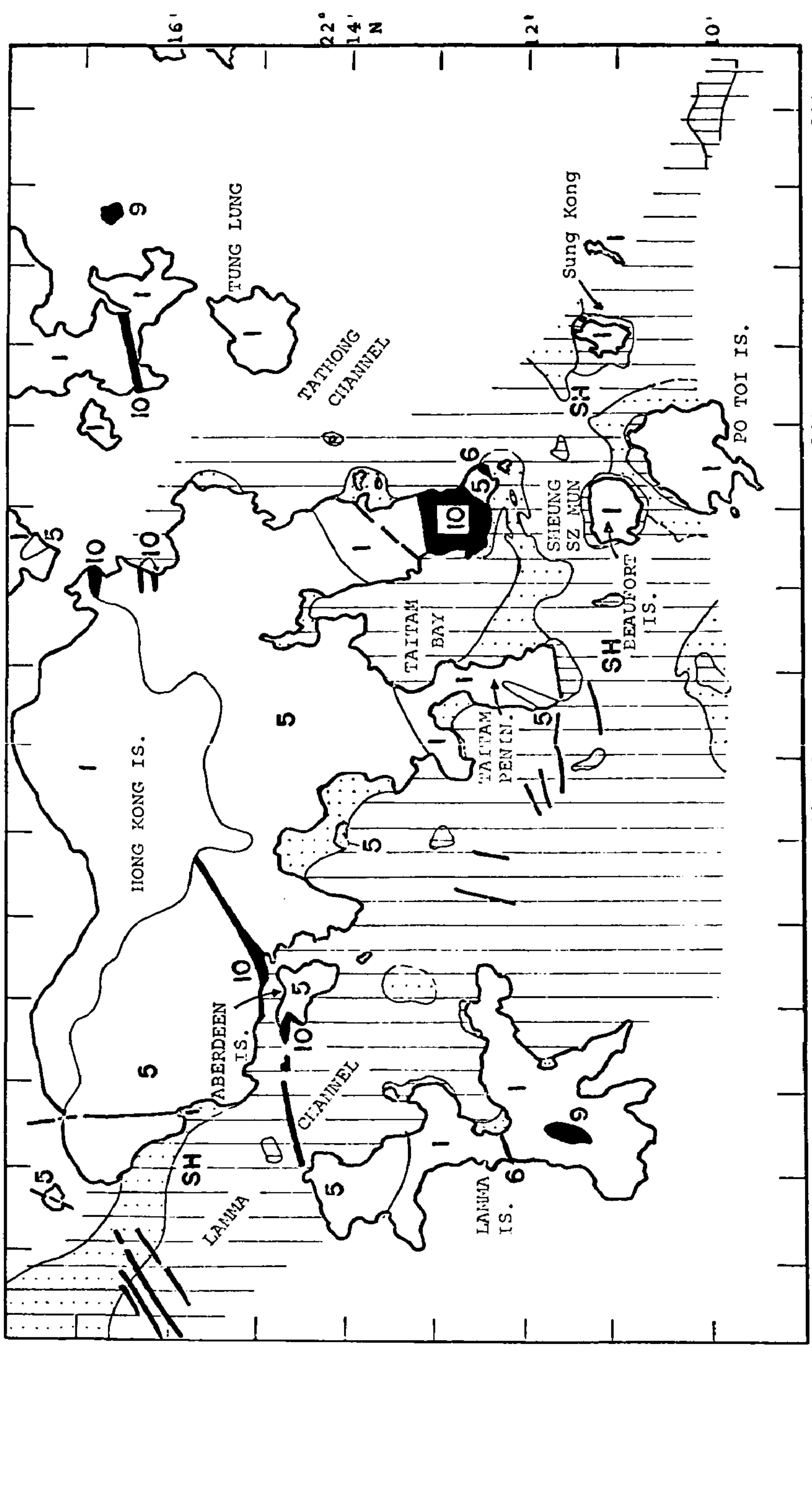

FIG. 2. — Bottom sediment distribution in the southeastern approaches to Hong Kong. Land geology after RUXTON (1960). Dots represent sand, sparse vertical shading represents clays and silt, and dense vertical shading represents exposed rocks or boulders. Submarine rock ridges are shown as thick lines. sh = shells, 1 = granite, 5 = volcanics, 6 = porphyries, 9 = quartz porphyry and porphyrite, 10 = porphyritic syenite.

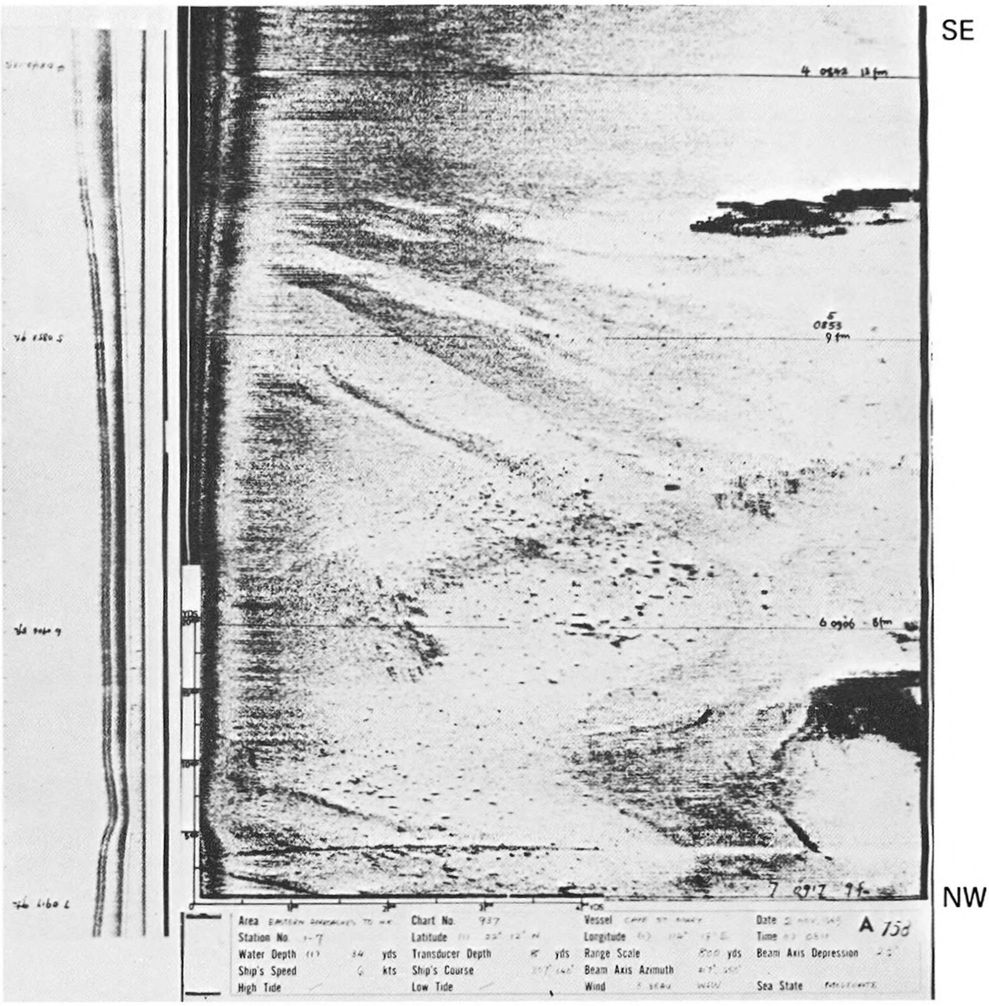

FIG. 3. — A side-scan sonar record of an area from the southeastern approaches to Hong Kong. Location shown in Figure 1. Vertical exaggeration approximately 7 times.

heterogeneous mixtures of clay, sand and shells are found, indicating the abundance of marine life. A typical acoustic record in the western part of the channel is shown in figure 7, which is somewhat marred by image interference fringes at near ranges.

Sediments carried down by the Pearl River originate from regions of relatively high relief and heavy rainfall. The supply of terrigenous material is therefore abundant. Thus, the Recent alluvial sediments reach an average depth of 30 feet in the west (Hong Kong Public Works Dept, 1963). They are thickest near Urmston Road and Castle Peak Bay (fig. 6), and thin progressively as Ma Wan Island on the east is approached, where the channel narrows and the winnowing effect of currents must become stronger. In the stretch of seafloor just west of Ma Wan Island, the surficial sediment veneer is either absent or very thin, and there are extensive bedrock exposures some of which appear as pinnacles (figures 8

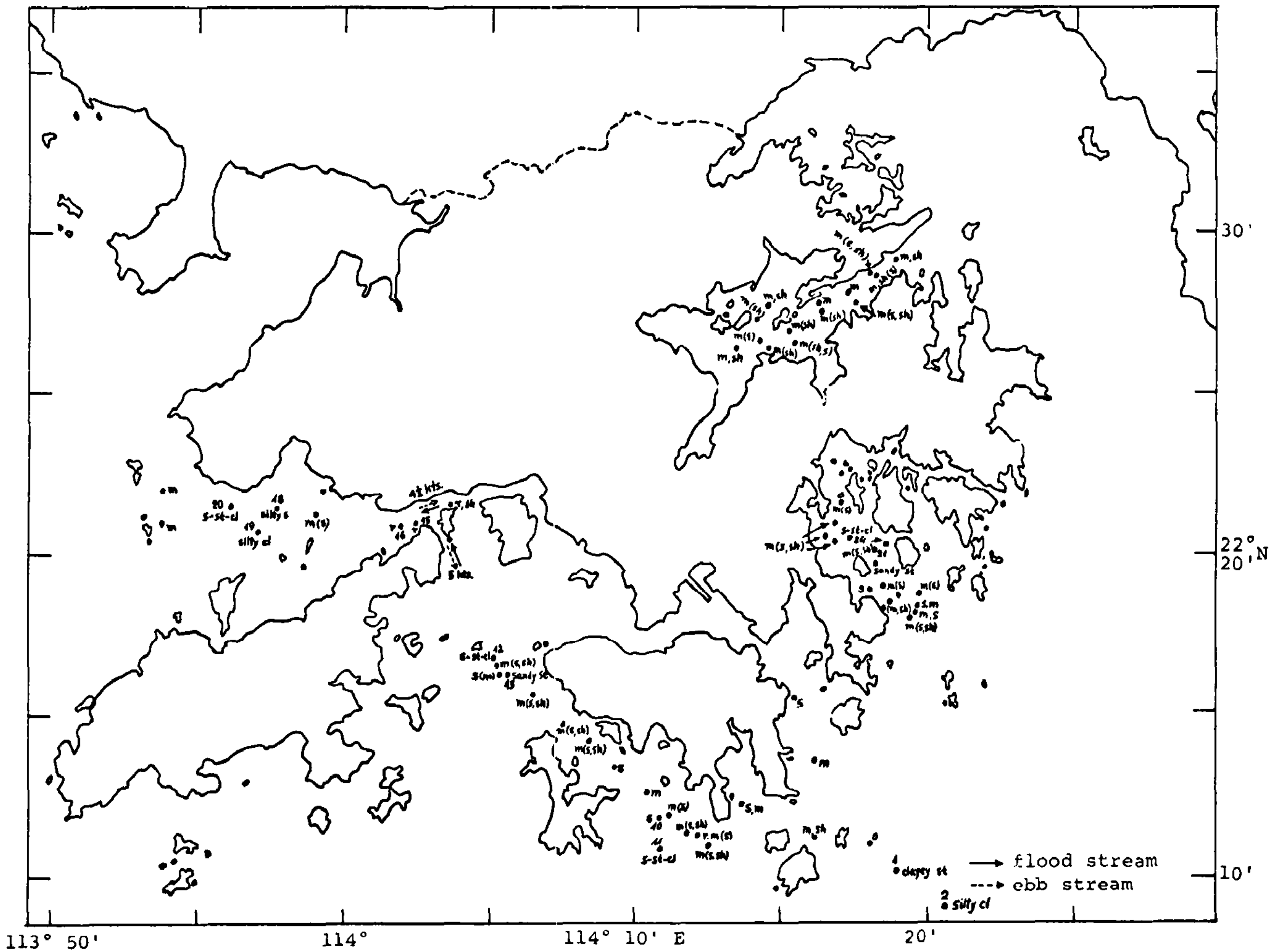

FIG. 4. — Some bottom samples collected in the study areas. Numbers refer to stations of Table 1. s = sand, m = mud, st = silt, cl = clay, sh = shell, r = rock (cutting nose of sampler bent or indented). Materials in brackets occur in small quantities.

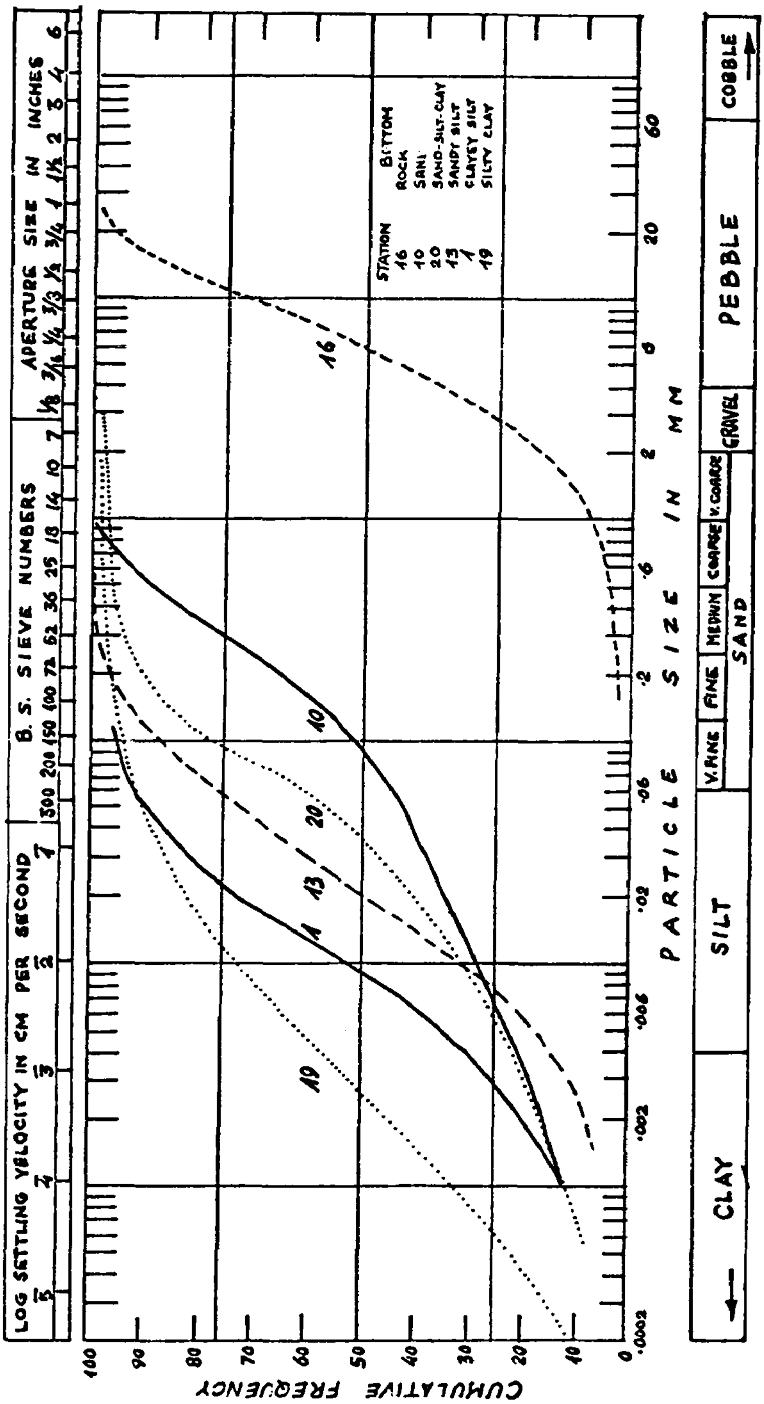

FIG. 5. — Averaged grain-size frequency distribution curves for 5 of the samples in Table 1.

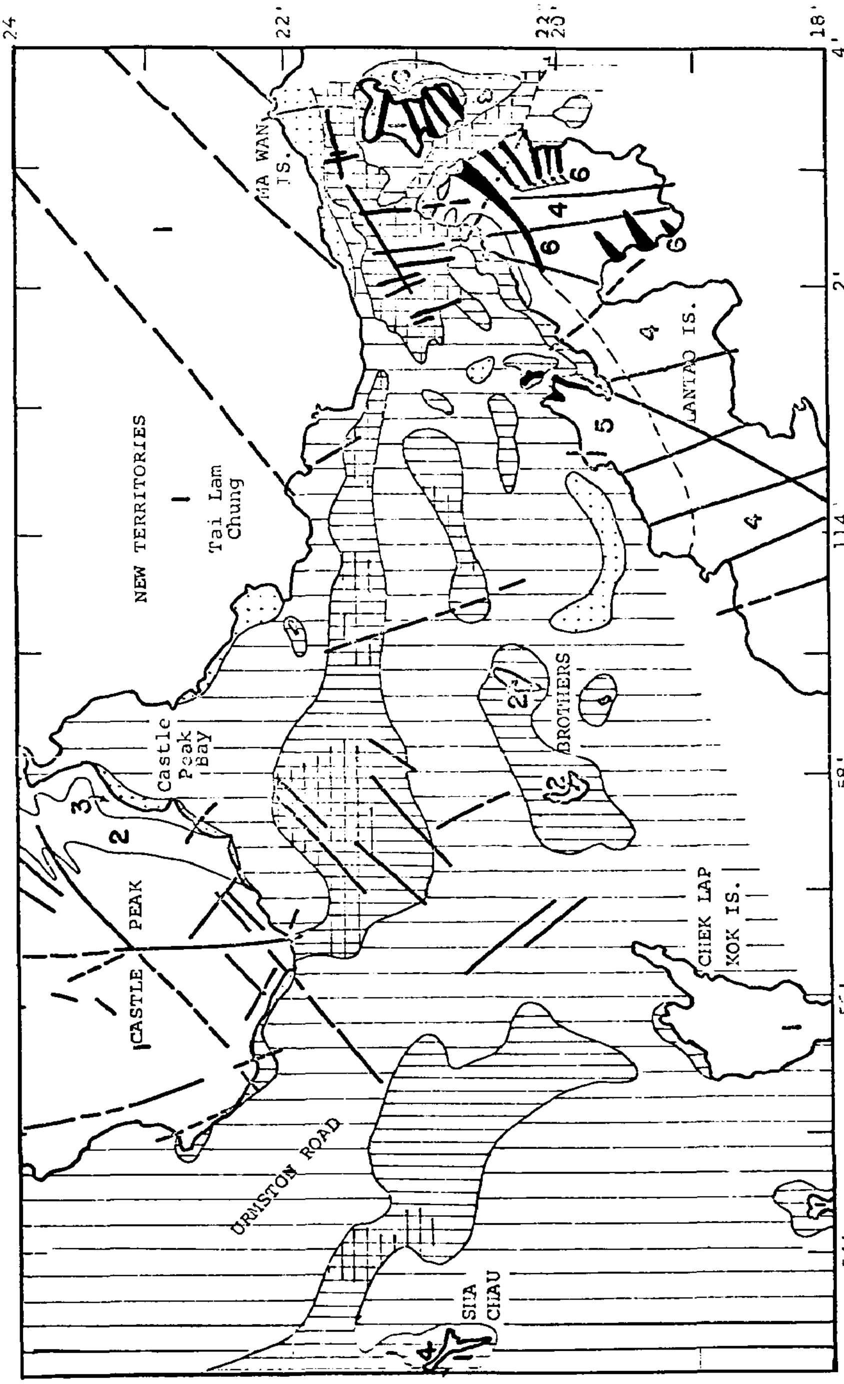

FIG. 6. — Bottom sediment distribution in the Lantao Channel. Land geology after RUXTON (1960). Heavy solid and broken lines indicate faults. Squares show areas of exposed bedrock or concentrations of rock. Horizontal shading indicates particularly dense rock exposures. 2 = metamorphosed sedimentaries, 3 = regolith, 4 = porphyritic granite. Other symbols same as in Figure 2.

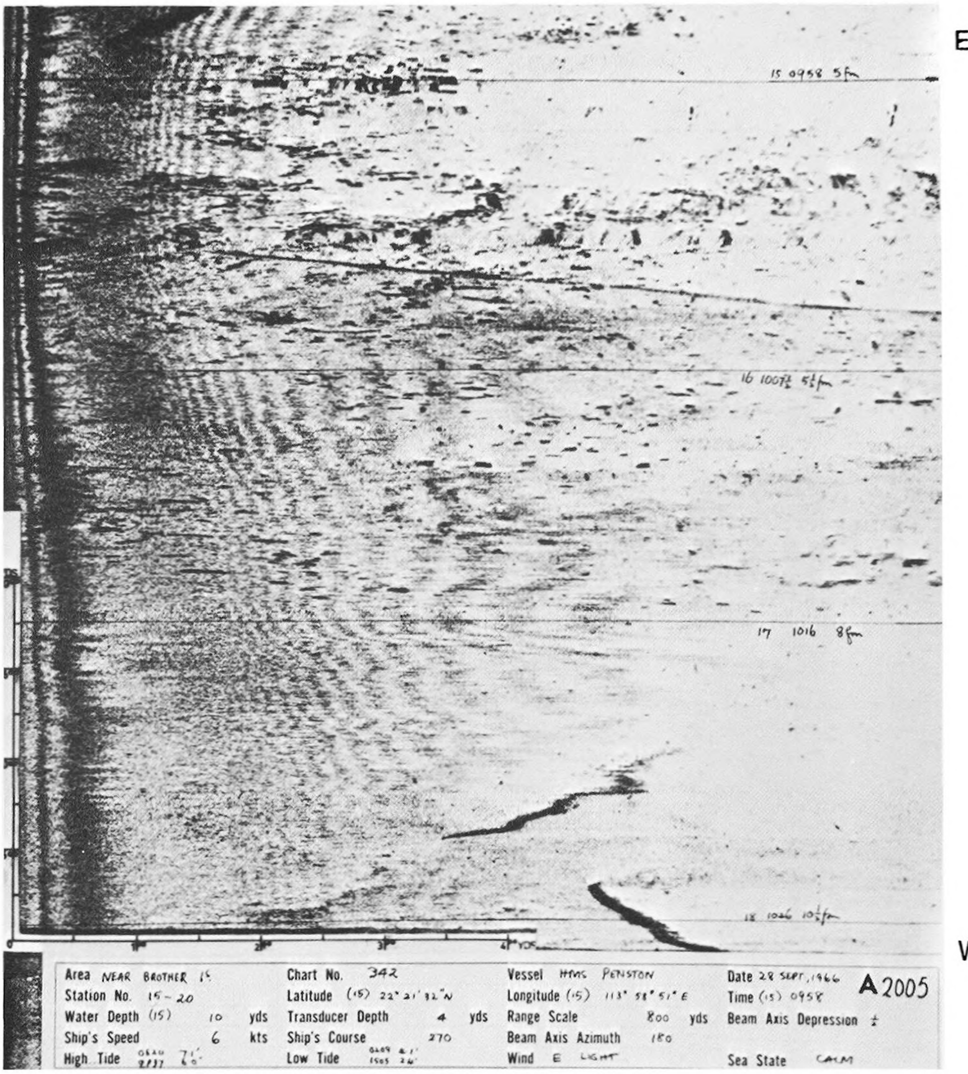

FIG. 7. — Acoustic record of an area north of the Brother Islands, Lantao Channel, showing rocks and gravels on finer material. Horizontal exaggeration about 7.5 times. Location shown in Figure 1.

and 9). Here the tidal currents reaching up to 5 knots (figure 4) are sufficiently fast to prohibit the deposition of clay and silt particles, and where sediments do exist, sand and shell fragments are dominant. The edges of the depositional zones coincide roughly with the place where the two incoming sets of currents from the east and west mix. Here the water velocity is checked and the loads of traction and suspension are dropped.

(iii) ***Port Shelter and Rocky Harbour***

Port Shelter and Rocky Harbour lie along the eastern coast of the mainland portion of Hong Kong. They include a large number of rocky,

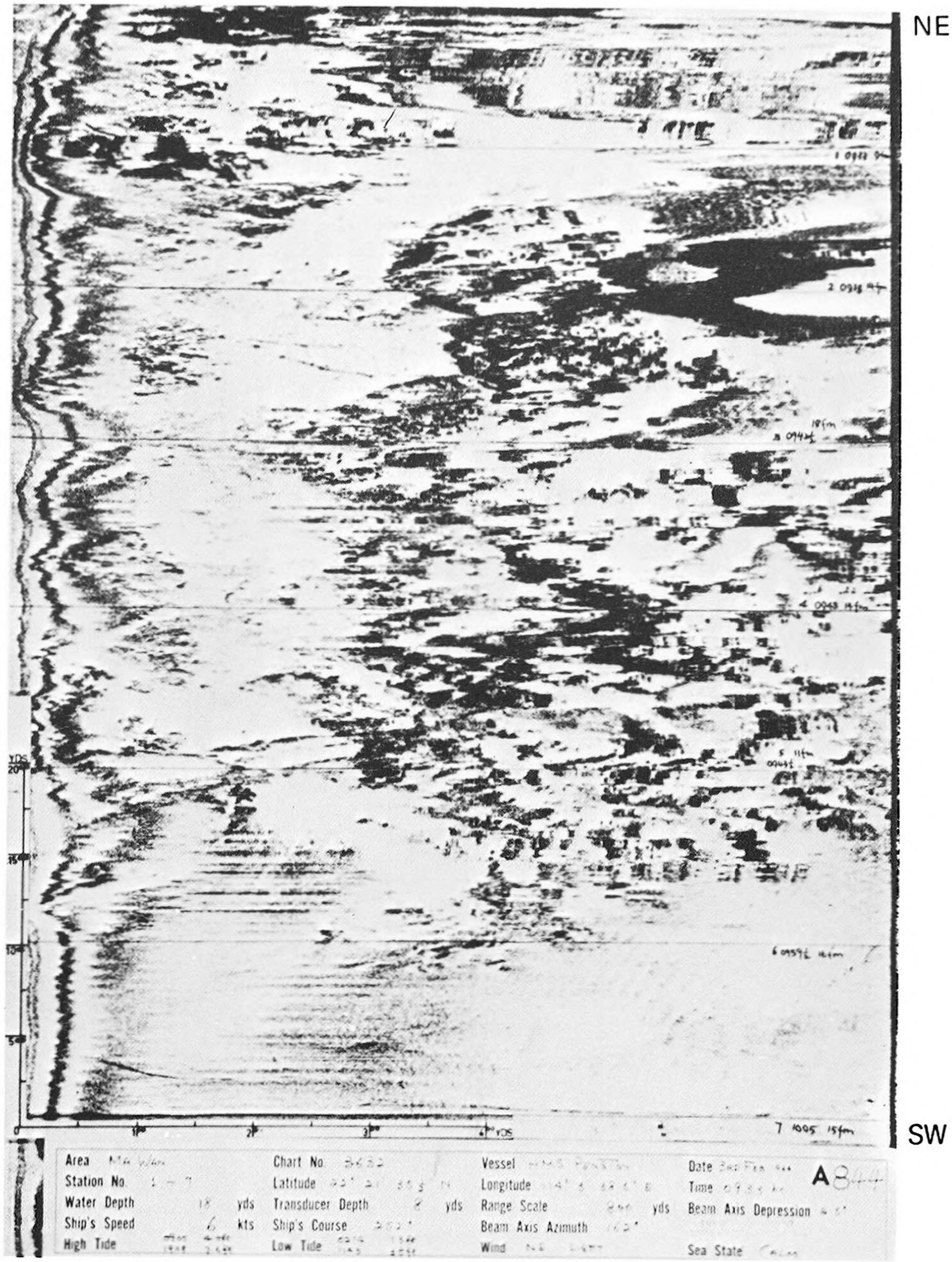

FIG. 8. — Acoustic record of an area west of Ma Wan Island (location shown in Figure 1). Note the transition from faulted rock exposures to sediment-covered regions. Horizontal exaggeration approximately 7 times.

rugged islands. The western coast of Port Shelter, including Shelter Island and Kiu Tsu Chau, are of volcanic origin (figure 10). Tuffs and coarse agglomerates with boulders reaching 6 feet in dimension are very common. The volcanic succession is crossed by closely spaced columnar joints, leaving pillar-like joint blocks in many places.

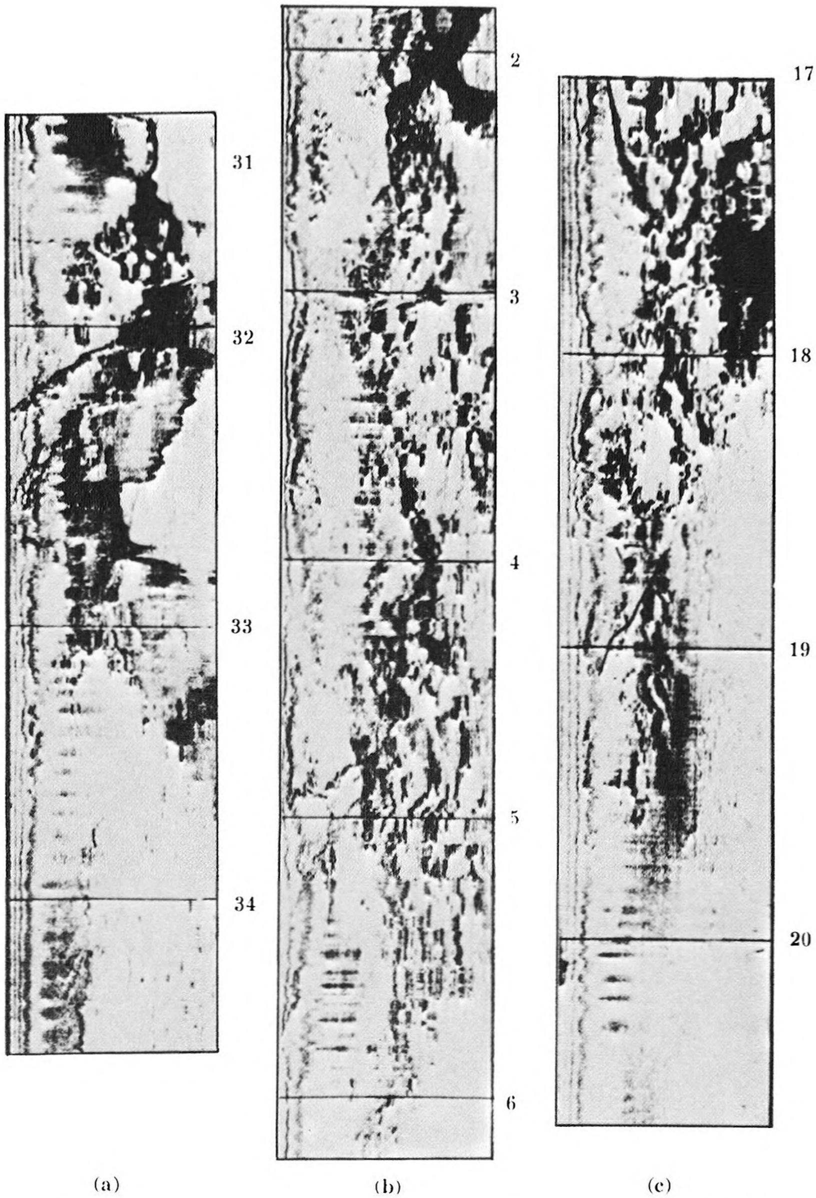

FIG. 9. — Three isometric side-scan sonar records of areas west of Ma Wan Island. Section (b) covers the same area as Figure 5.

The water-covered portion is largely floored with rock, with a thin, patchy veneer of mud and shells. Figure 12 is a typical acoustic record, in which the black dots are interpreted as joint blocks similar to those observed on land. Individual dots average 10-15 feet, but the joint blocks themselves are probably smaller because of the effect of acoustic blending (COLEMAN, 1968).

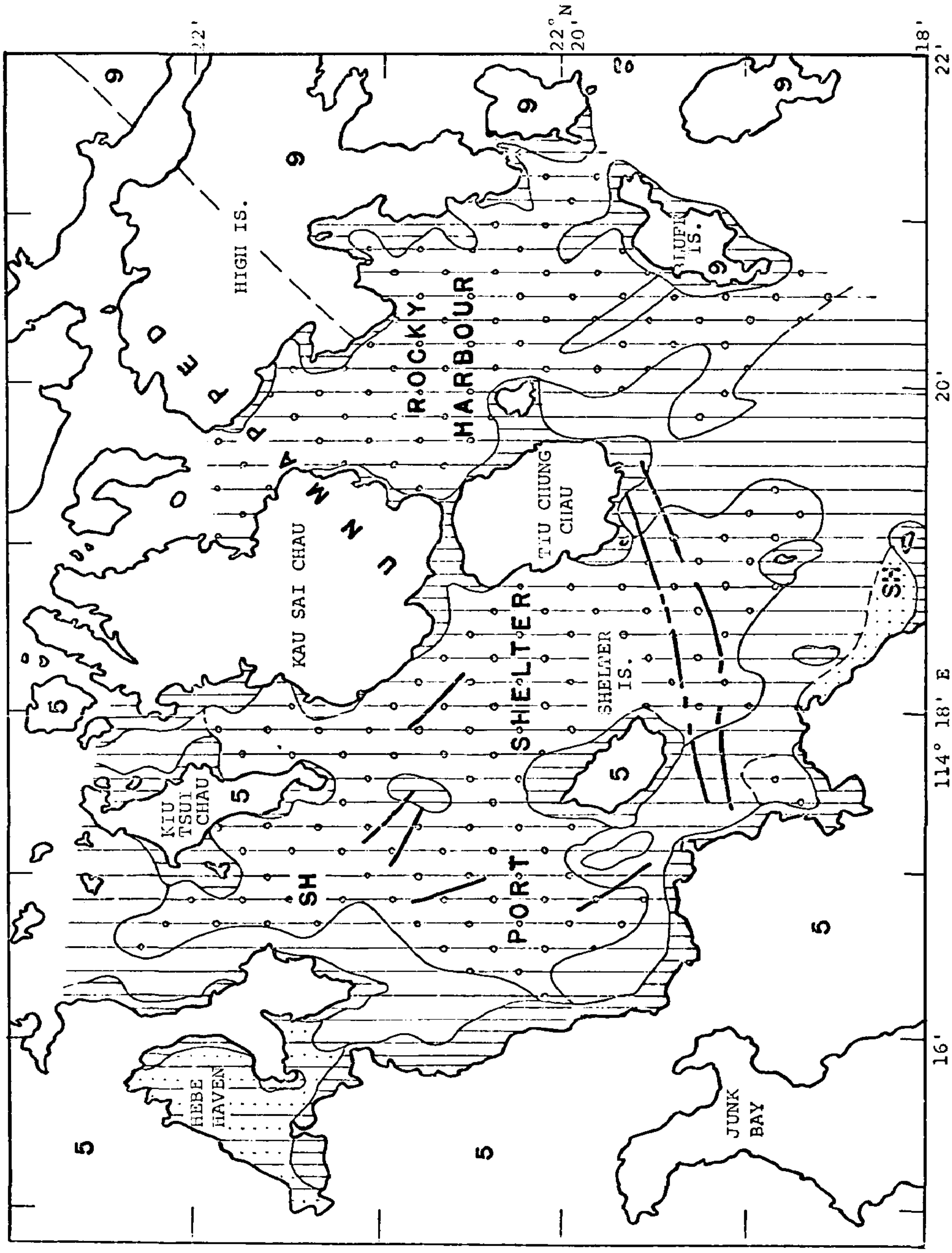

FIG. 10. — Bottom sediment distribution in Port Shelter and Rocky Harbour. Land geology after RUXTON (1960). Submerged joint blocks are found in the circled areas. Other symbols same as in Figure 2.

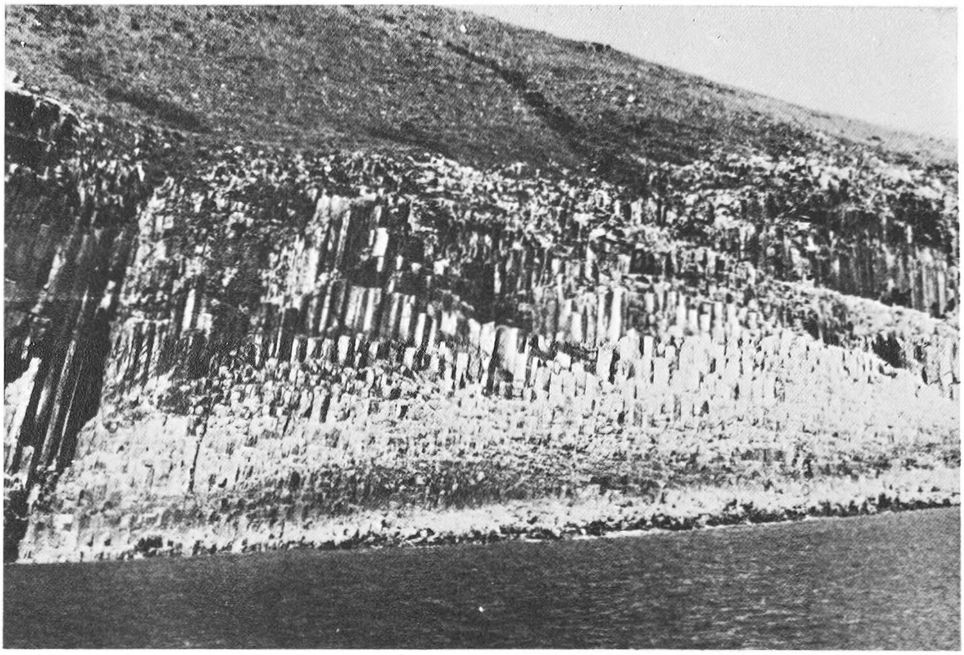

FIG. 11. — Joint blocks on the coast of High Island.

(iv) ***Tolo Channel***

Tolo Channel has an average depth of 50 feet sloping from 25 feet in the southwest to 70 feet in the northeast. The seafloor itself is thickly clay-laden, sand and shell fragments occurring only in small quantities (figure 13). Occasional rock outcrops emerge as "reefs" (figure 14). The central part of the channel is crossed by a few ridges, which may represent rock contacts or the dipping beds of older sedimentaries.

ACKNOWLEDGEMENTS

We wish to thank Dr. A.H. STRIDE of the British National Institute of Oceanography for his valuable criticisms on this paper during the course of its preparation.

This work, carried out at the University of Hong Kong, was supported by the British Inter-University Council for Higher Education Overseas, and the Colonial Development and Welfare Fund held by the United Kingdom Treasury. We are very grateful to the Director of the Fisheries Research Station (Hong Kong Government Department of Fisheries and Agriculture) for allowing us the use of the *FRV Cape St. Mary*, and to the Commodore-in-charge (British Royal Navy, Hong Kong) for permission to use the following naval vessels : *H.M.S. Dampier, H.M.S. Lanton, H.M.S. Penston, H.M.S. Dufton, HMS. Wilkieston*, and *H.M.S. Fiskerton*. The fine cooperation of the captains, officers, and crew of the above ships is gratefully acknowledged.

We are indebted also to Y.L. CHAN, I.W. McLEAN, K.L. YAU, and D.H. SHUN for their assistance in data collection at sea.

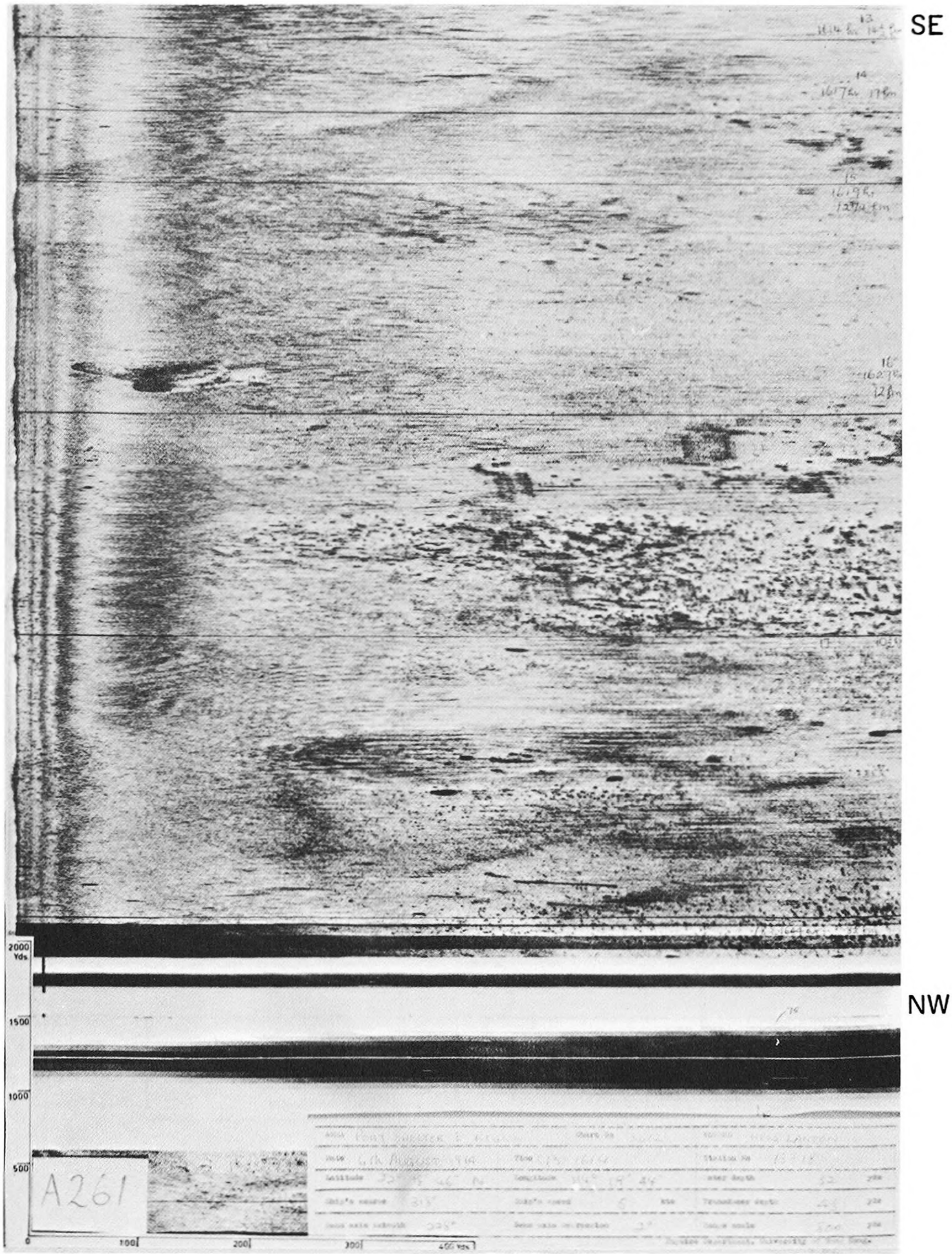

FIG. 12. — A side-scan sonar record covering the southern part of Port Shelter. Black dots are interpreted as joint blocks. Horizontal exaggeration about 6 times.

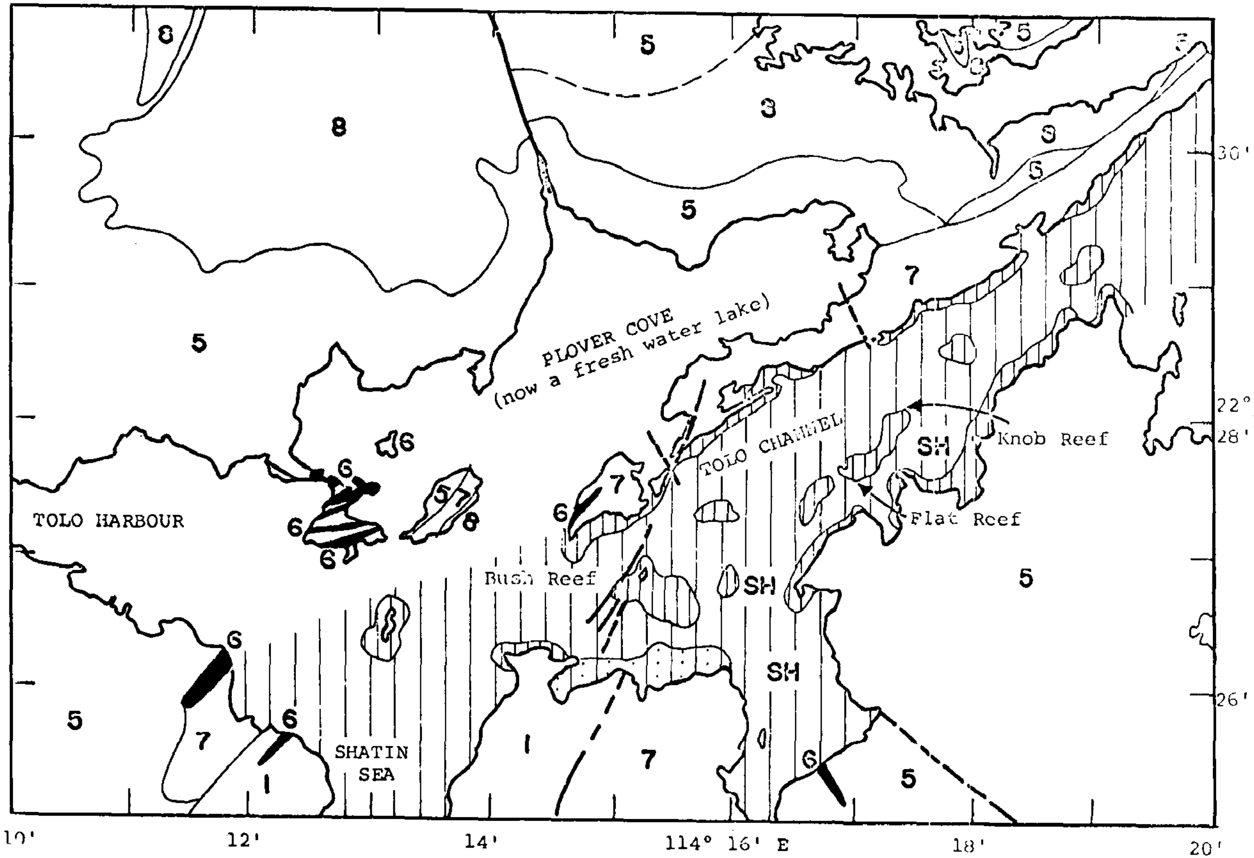

FIG. 13. — Bottom sediment distribution in the Tolo Channel. Land geology after RUXTON (1960). 7 = sedimentaries, 8 = red beds. Other symbols same as in Figure 2.

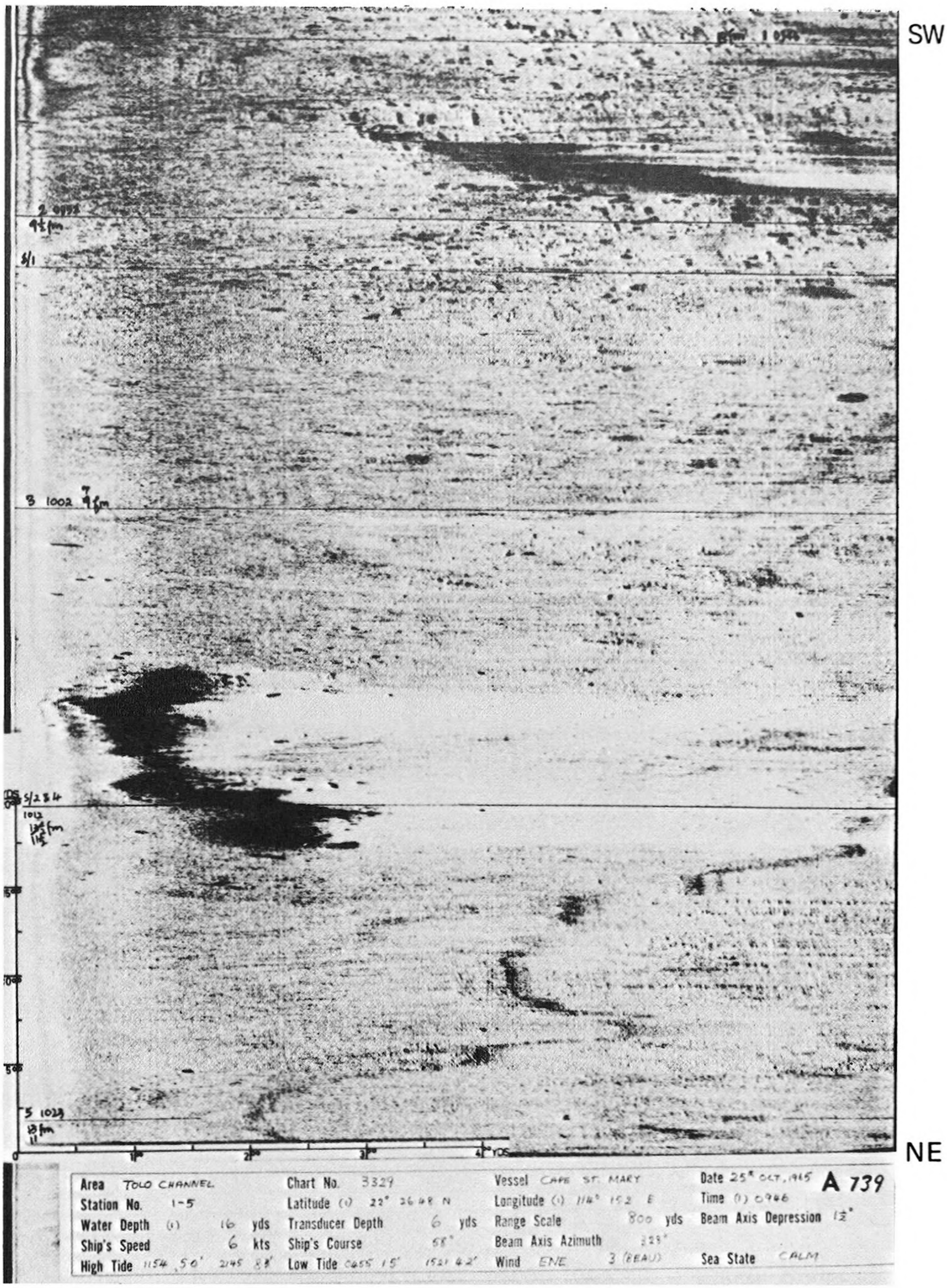

FIG. 14. — Acoustic record of an area in the Tolo Channel, showing a clayey bottom with occasional rock outcrops. Location shown in Figure 1. Horizontal exaggeration approximately 7 times.

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