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LATE QUATERNARY GEOLOGY
OF THE CANTERBURY CONTINENTAL TERRACE

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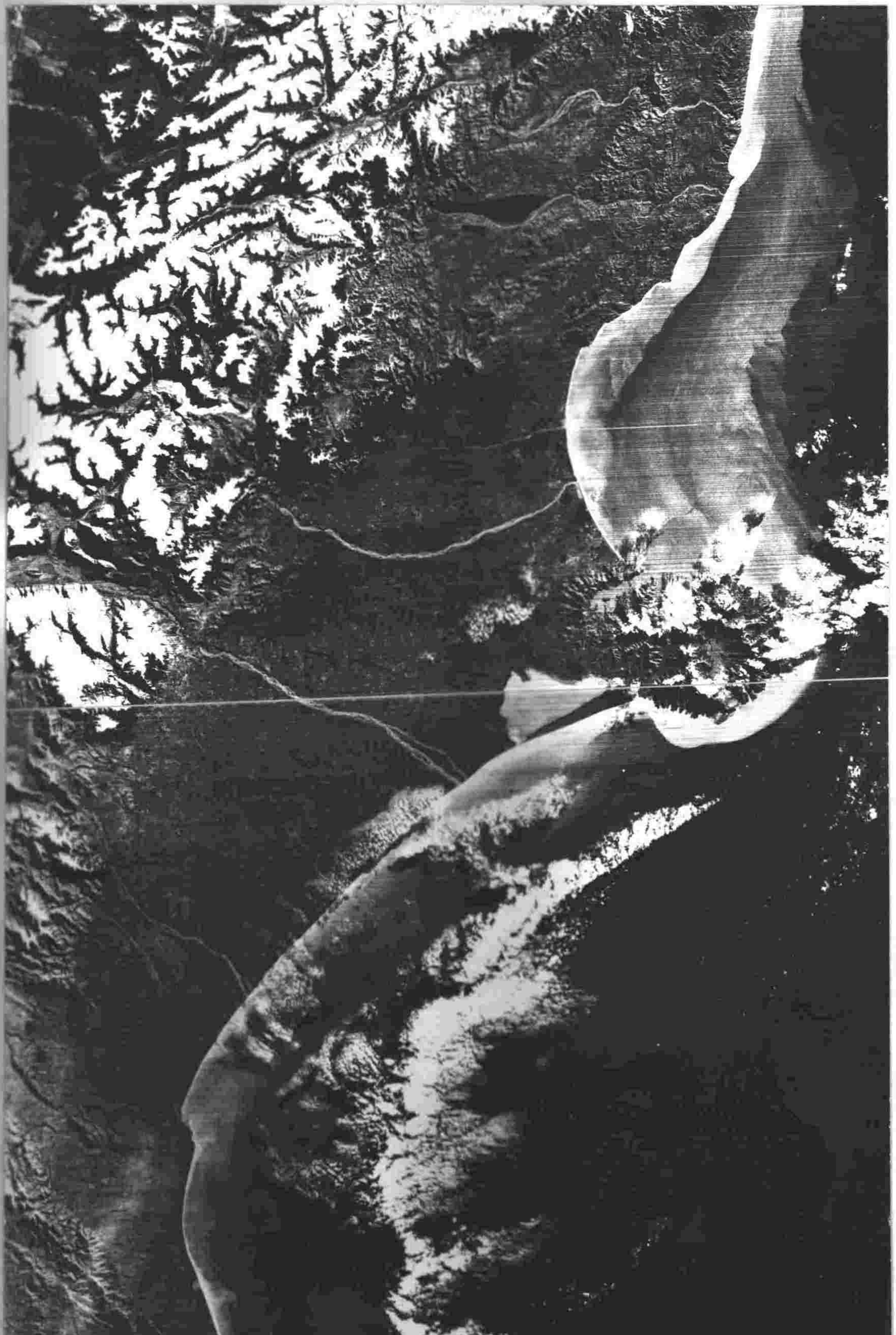

Frontispiece Plate A1. Landsat II image of Pegasus Bay and Canterbury Bight taken on 2 August 1975 Band 4. Photograph by courtesy of NASA.

PREFACE

The study of Quaternary sedimentation on the continental shelf and slope is an area of geological research where the present and past come together. For instance, surface sediments in dynamic equilibrium with the present shelf hydraulic regime may be either Pleistocene or modern in origin; shoals formed in shallow water near past shorelines may either persist as active submarine ridges in deep water, or be buried by younger sediment; submarine canyons, once fed by Pleistocene littoral drift, may now either be fed by spillover of palimpsest sand from the shelf, or be completely inactive. To decipher the complex problems, marine geologists must examine many facets of the sea floor sediments and of the forces that move them.

This thesis represents the first comprehensive directed research into the Quaternary geology of a large portion of New Zealand's continental shelf and slope for which little data was previously available. It is presented as a collection of scientific papers in which each successive paper draws on the conclusions of the preceding ones. For the sake of brevity, repetition of conclusions from preceding papers is avoided as far as possible in the introduction of following papers, and references are combined in a single list at the end of the thesis. The papers bring together the processes (hydrology and sedimentation) and products (stratigraphy and geomorphology) of the Pleistocene and modern continental terrace.

ACKNOWLEDGEMENTS

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ABSTRACT

The Late Quaternary stratigraphy and sedimentary processes are interpreted for an area of continental shelf and slope on the eastern side of the South Island, New Zealand, between latitudes 43°00'S and 44°50'S.

Two formations are recognised in the Late Quaternary stratigraphy of the shelf: the Canterbury Bight Formation of mainly Last Glacial age and, locally overlying it, the Pegasus Formation of mainly Holocene age. The formations are distinguished by shelf-wide unconformities (visible in seismic profiles), by geomorphology, by grain-size modes, and by macrofauna.

Ridge-and-swale topography occurs on two scales on the shelf. Very large ridges and troughs are interpreted from microbathymetry, stratigraphy, sediments and macrofauna to be the remains of Pleistocene barrier/lagoon complexes. With the aid of radiocarbon dates, four well developed shorelines between 28,000 yr and 15,000 yr old are recognised. The smaller ridges are submarine features, formed by strong currents. Those ridges that are in a zone of constricted and accelerated currents near Banks Peninsula are active, while those well removed from the peninsula constriction are fossil and date from times of lower sea level.

Sedimentation on the continental shelf has reached a state of equilibrium with the modern hydraulic regime. Relict sediments of the deglacial transgressive sand/gravel sheet are being reworked in zones of high energy, principally in the region of constricted flow around Banks Peninsula. Modern-input sand (distinguished by its grain-size mode) is restricted by currents mainly to an active belt near shore, but locally it has replaced palimpsest sand on the middle shelf. The modern mud facies, being confined by zones of higher energy, has reached its maximum areal extent; its greatest thickness is in Pegasus Bay.

Sea-bed drifter studies, and studies of sediment texture and provenance show that net sediment movement on the shelf and along shore during both Pleistocene and modern times has been northwards.

The continental slope is dissected by submarine slide scars in the south and by submarine canyons in the north. Streams of fine sand, transported from the continental shelf to the upper slope by north-flowing currents during Pleistocene lowered sea levels, initiated the erosion of submarine canyons. Interception of littoral-drifted gravel by established canyons reaching Pleistocene strand lines probably accelerated canyon erosion. The canyons are thought to be now effectively dormant. Deposition of fine sediment from suspension has dominated the development of the southern slope. This slope is consequently free of deeply corrasional features like submarine canyons but is prone to failure by gravity sliding. The youngest slides are less than 18,000 yr old.

The history of growth of Pegasus Submarine Canyon is investigated in detail. The course of the canyon across the shelf is not fault controlled. As well as growing landwards, the canyon and its tributaries have, during Pleistocene sea level stillstands, grown southwards along shore towards the supply of littoral drifted gravel and sand. A buried tributary, of Penultimate Glacial age or older, on the canyon's west side, once brought the canyon 7 km closer to the present shore. The relative ages of the south-trending arms of the canyon are inferred from their relationship to known Last Glacial shorelines that are preserved on the shelf, and by their position with respect to a regional subsurface unconformity of Penultimate Glacial age. Canyon erosion was concentrated in the largest arm during the last deglacial rise of sea level, and shallow channels, interpreted as feeders, are common around its rim.

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CHAPTER A

THE CIRCULATION OF CONTINENTAL SHELF WATER OFF CANTERBURY AND SOME IMPLICATIONS FOR SEDIMENT TRANSPORT

ABSTRACT

Drift card, sea-bed drifter and hindcast studies show that the net flow of water along the bottom on the open continental shelf off Canterbury is northwards. Part of the flow, previously attributed entirely to the Southland Current, is, in fact, sometimes partly due to wind drift and barotropic currents caused by southerly gales and storms.

The northward flow along the bottom of the inner shelf is deflected landwards by these currents, and that along the middle shelf is deflected seawards. The northward flow on the surface is readily deflected (but not reversed) by wind drift currents.

The combined Southland Current, tidal current and storm-induced (wind and wave) currents should move bottom sediment frequently on the inner shelf and infrequently on the middle shelf. The net movement will be northwards.

The currents around Banks Peninsula are constricted and accelerated, surface velocities between 2 and 3 knots being common. Bottom sediment movement on the middle shelf off Banks Peninsula is predicted to be frequent.

The strong northward flow bypasses Pegasus Bay, which is sheltered by Banks Peninsula. Within the bay currents are slack and sediment movement on the bottom should be very infrequent

INTRODUCTION

A basic requirement for the realistic interpretation of present and past sediment distribution patterns on any part of the continental shelf is a knowledge of the local hydrology and meteorology. Until recently, sedimentologists in New Zealand have related sediment dispersal patterns to the mean flow (Summerhayes 1969; van der Linden 1969; Andrews 1973; Schofield 1976). However with increasing knowledge of the hydrology and meteorology of the New Zealand region, and with new methods of study, mean flow is now only one of the effective factors that can be applied to sediment dispersal studies. Carter & Heath (1975) have evaluated the respective roles of mean flow, tidal currents and waves in the movement of sediment on the continental shelf of New Zealand. The various components of the hydraulic regime of the portion of the continental shelf lying off Canterbury (Fig. A1) are examined here, and their predicted effect on sediment dispersal is tested by direct observations. This chapter is based on a recently completed joint study by the author and Dr L. Carter of the N.Z. Oceanographic Institute. Dr Carter has investigated the way in which wind and waves affect the currents on the Canterbury Shelf, and has inferred the net effect of the combined currents on the bottom sediments of the inner and middle shelf. Those parts of this chapter that incorporate Dr Carter's results are indented.

DRIVING MECHANISMS

The movement of water over the continental shelf is controlled by : the Southland Current, tides, swell, locally generated wind waves, wind drift and wind-induced barotropic flow. Longshore currents and beach drifting are caused by waves and swell.

Winds

McIntosh (1958) has summarised wind persistence records over a 20-year period, concluding that in the

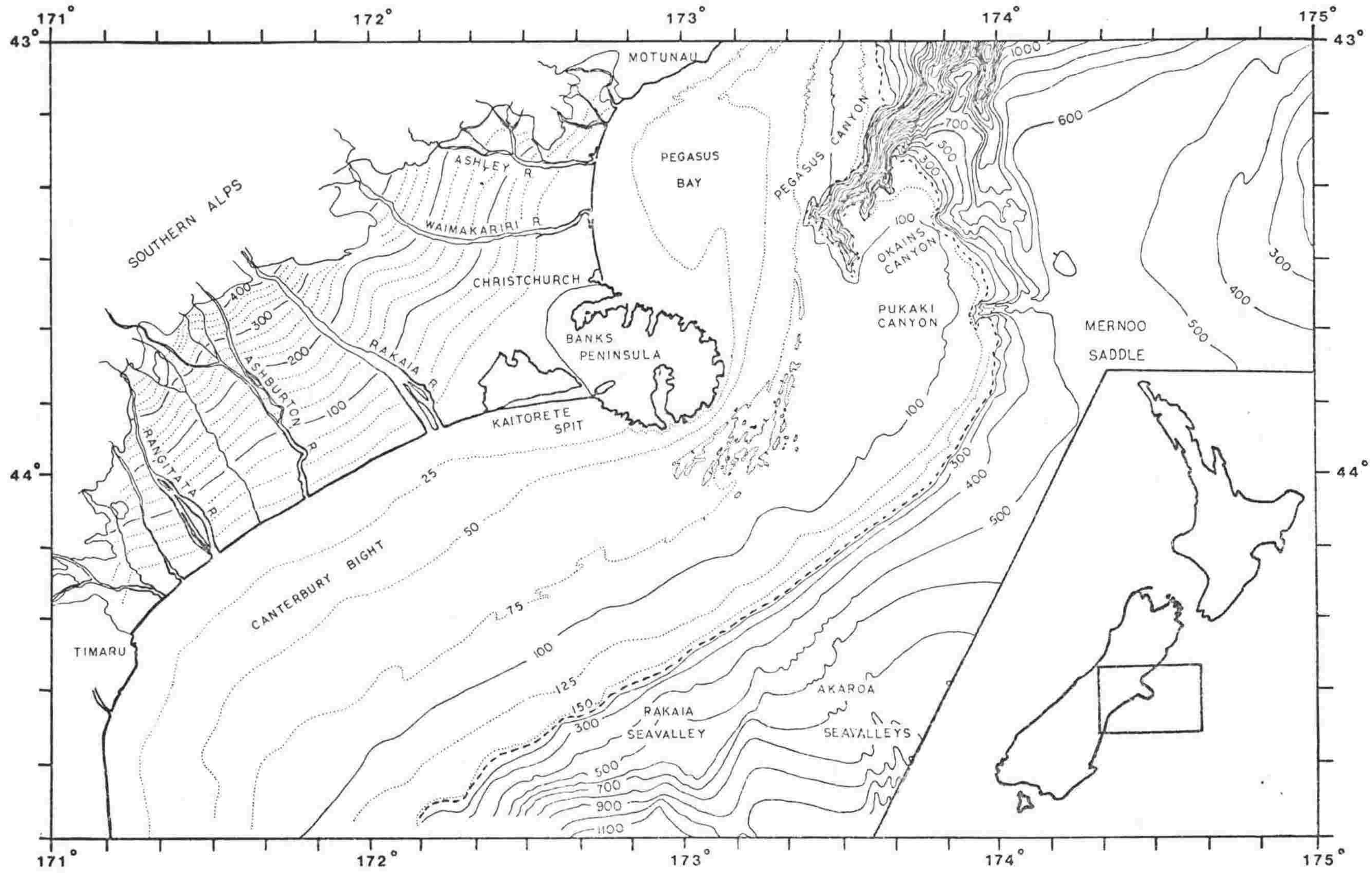


Figure A1. Locality map. Contours in metres.

lowland Canterbury area, the prevailing winds blow from the opposite directions - from the northeast or from the southwest. The same conclusion has since been reached independently by Dingwall (1974), Burgess (1968) and others. A.A. Neale (N.Z. Meteorological Service, pers. comm.) has pointed out that the NE-SW polarity is enhanced by the local physiography, there being a tendency for winds to be deflected by the NE-SW front of the Southern Alps and channelled between the front and the hills of Banks Peninsula. The wind distribution offshore is likely to be somewhat more variable. On the other hand the strength of the wind offshore recorded on ships, is generally double that of the wind recorded at weather stations onshore.

Hindcast studies by L. Carter (N.Z. Oceanographic Institute, pers. comm.), based on analysis of 15 years of local wind records from Christchurch Airport and the wind records from stationary drilling rigs offshore, showed that the winter southerlies generate the highest waves offshore.

Longshore Transport

In response to the dominant southerly swell (Elliott 1958; Hodgson 1966; Dingwall 1974, and others) the net sediment movement alongshore in Canterbury Bight is northwards. In Pegasus Bay, which is sheltered by Banks Peninsula, longshore transport is more variable, but there is a southward trend due to the influence of swell from the northeast and to refraction of the southeasterly swell (Blake 1964; Burgess 1968).

Southland Current

The main coastal current of the oceanic circulation in the area is the Southland Current. Drift cards were used by Brodie in 1960 and other methods have been used since to establish its pattern (Garner 1969; Heath 1972a, 1973a). It travels from the south of New Zealand northeastwards along the continental shelf and slope off Canterbury. Near Kaikoura it branches : one branch continuing north parallel to the coast and the other heading east with the

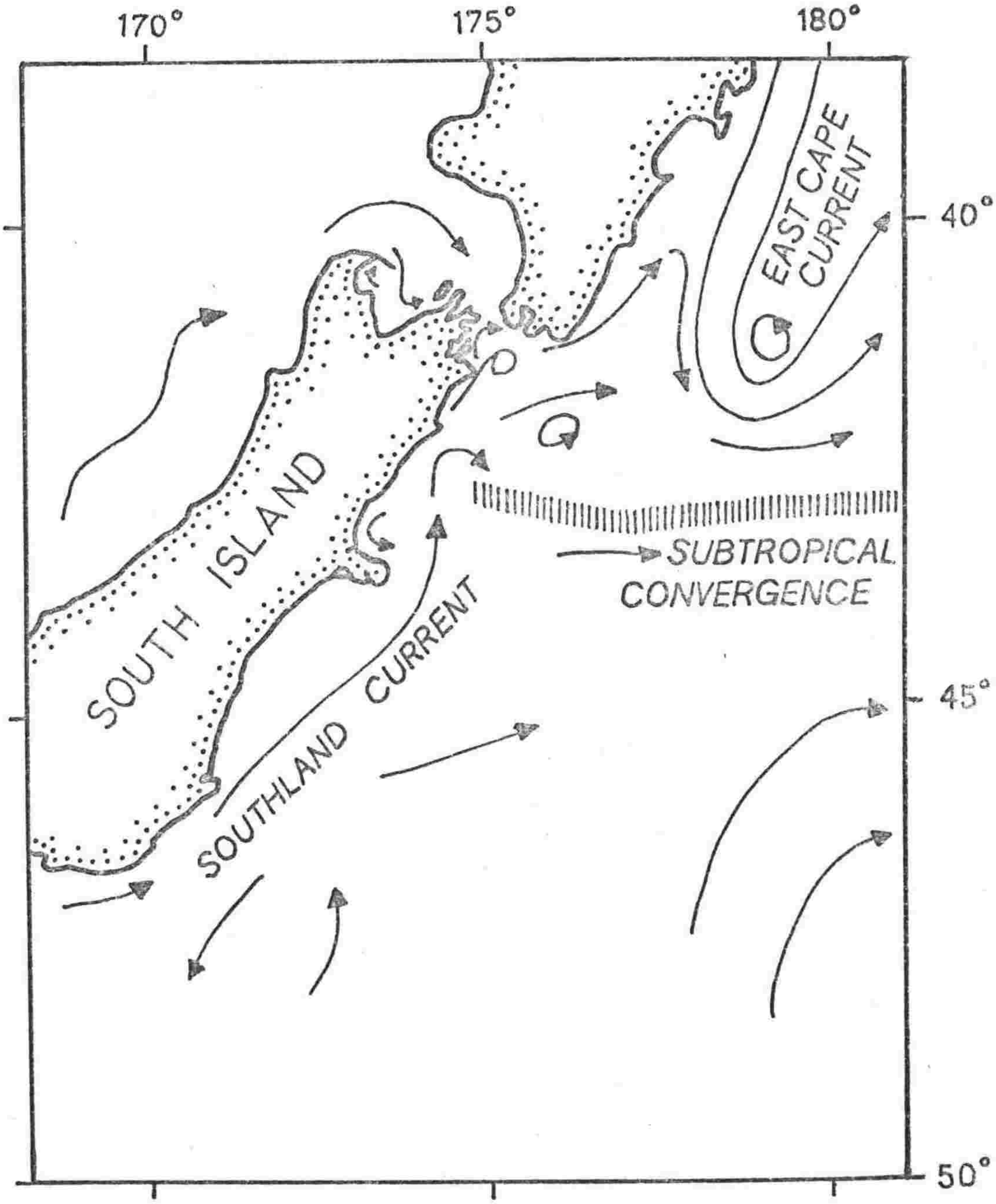


Figure A2. The oceanic circulation off eastern South Island. (After Heath, 1973a).

East Cape Current towards the Chatham Islands (Fig. A2). A minimum velocity of 13 cm/sec. for the Southland Current on the Canterbury Shelf was obtained by the author from a drift card study presented later in this thesis.

Brodie (1960) discovered that off North Canterbury, drift cards released in the Southland Current always travelled north in spite of opposing prevailing winds. Drift cards released within Pegasus Bay, however, generally moved west on to the beaches of the bay, suggesting the presence there of an anticlockwise eddy. Observations by Dawson (1959), however, imply that the current within the bay is superficial and wind-controlled.

So far two Landsat II photographs are available which show that the circulation within Pegasus Bay is indeed complex and variable. One shows a positive northward flow of suspended sediment on the surface throughout the bay (Plate A1), and the other a confused pattern which may represent an eddy, with northward flow off the northeastern tip of Banks Peninsula and again north of the bay, and a diffuse southward flow nearshore in the southwestern part of the bay (Plate A2).

Tides

The tides are semi-diurnal with a measured range at Lyttelton of 1.9 m, springs and 1.6 m neaps and at Akaroa of 1.8 m springs and 1.6 m neaps (Hydrographic Chart NZ63). The tidal wave advances in an anticlockwise direction around the New Zealand coast. It thus proceeds northeast along the east coast of the South Island (Bye & Heath 1975). The tide on the continental shelf therefore floods twice daily in a northerly direction, followed each time by a southerly ebb. Tidal reference station B (Fig. A3) on Hydrographic Chart NZ10 indicates that in Pegasus Bay the surface tidal streams are weak. Station A near Banks Peninsula on Hydrographic Chart NZ63 (Fig. A3), however, illustrates the polarity of the tidal cycle (Fig. A4) which is probably greatly accentuated by the peninsula and

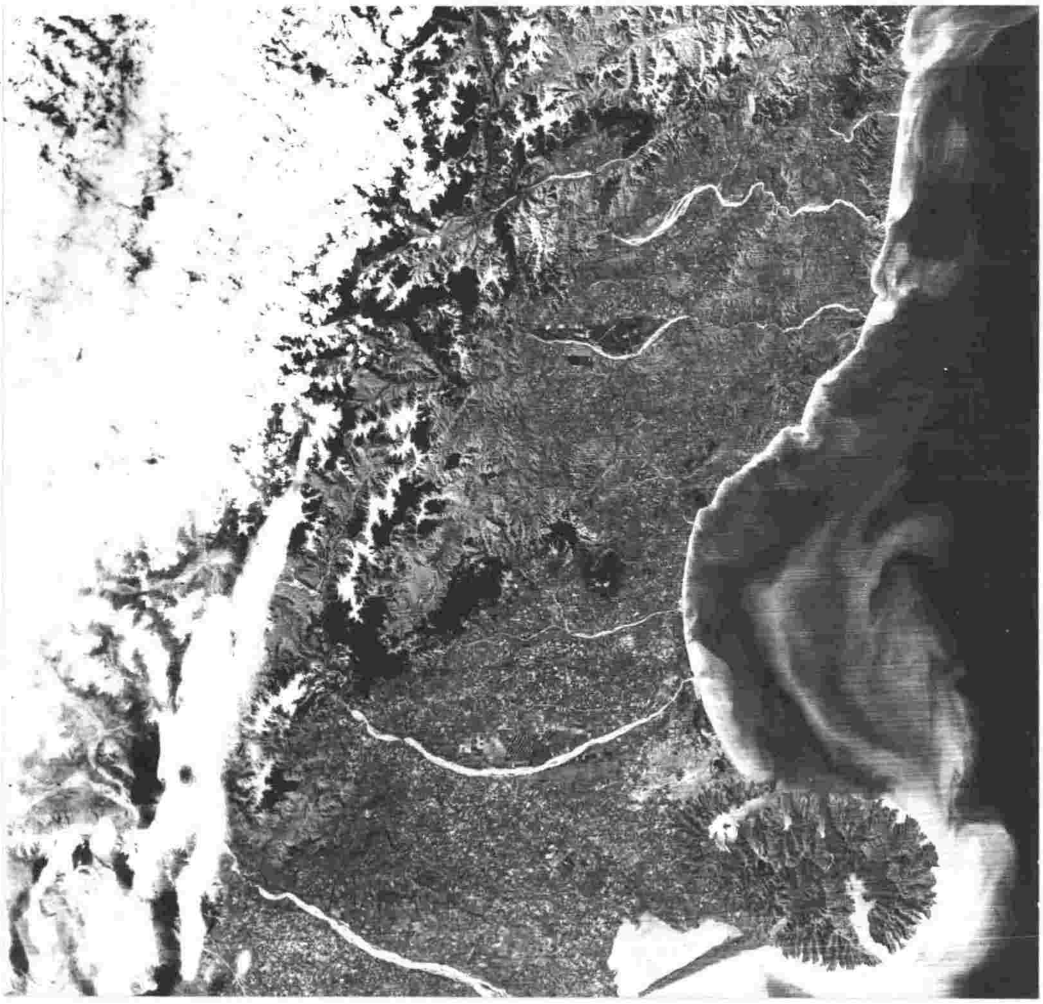


Plate A2. Landsat II image of Pegasus Bay taken on 31 October 1975 Band 4. Photograph by courtesy of NASA.

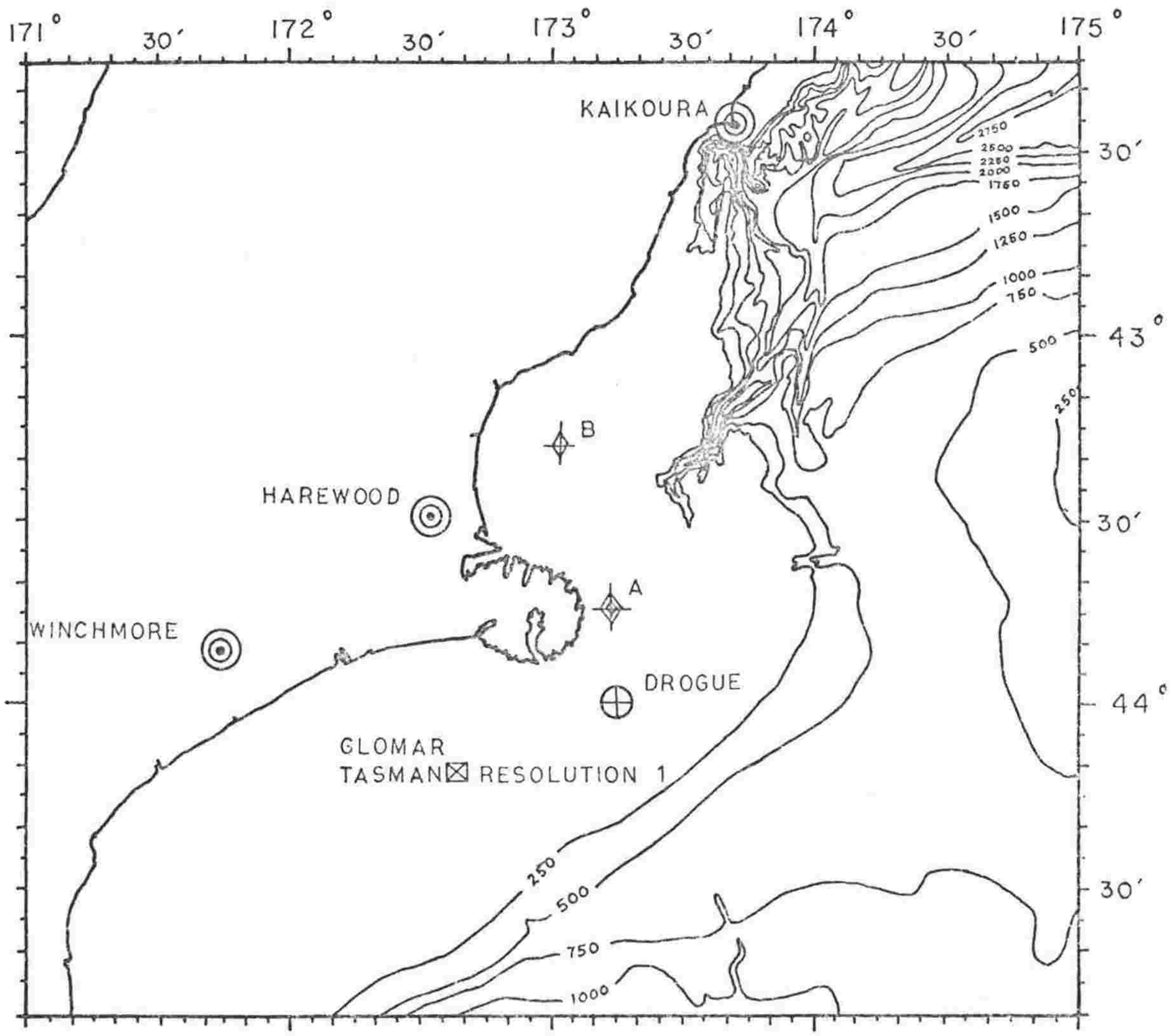


Figure A3.
Location of weather stations on land, Glomar Tasman drillship from which wind and wave data was obtained, tidal reference stations on N.Z. Hydrographic Charts, and the parachute drogue station monitored in this study.

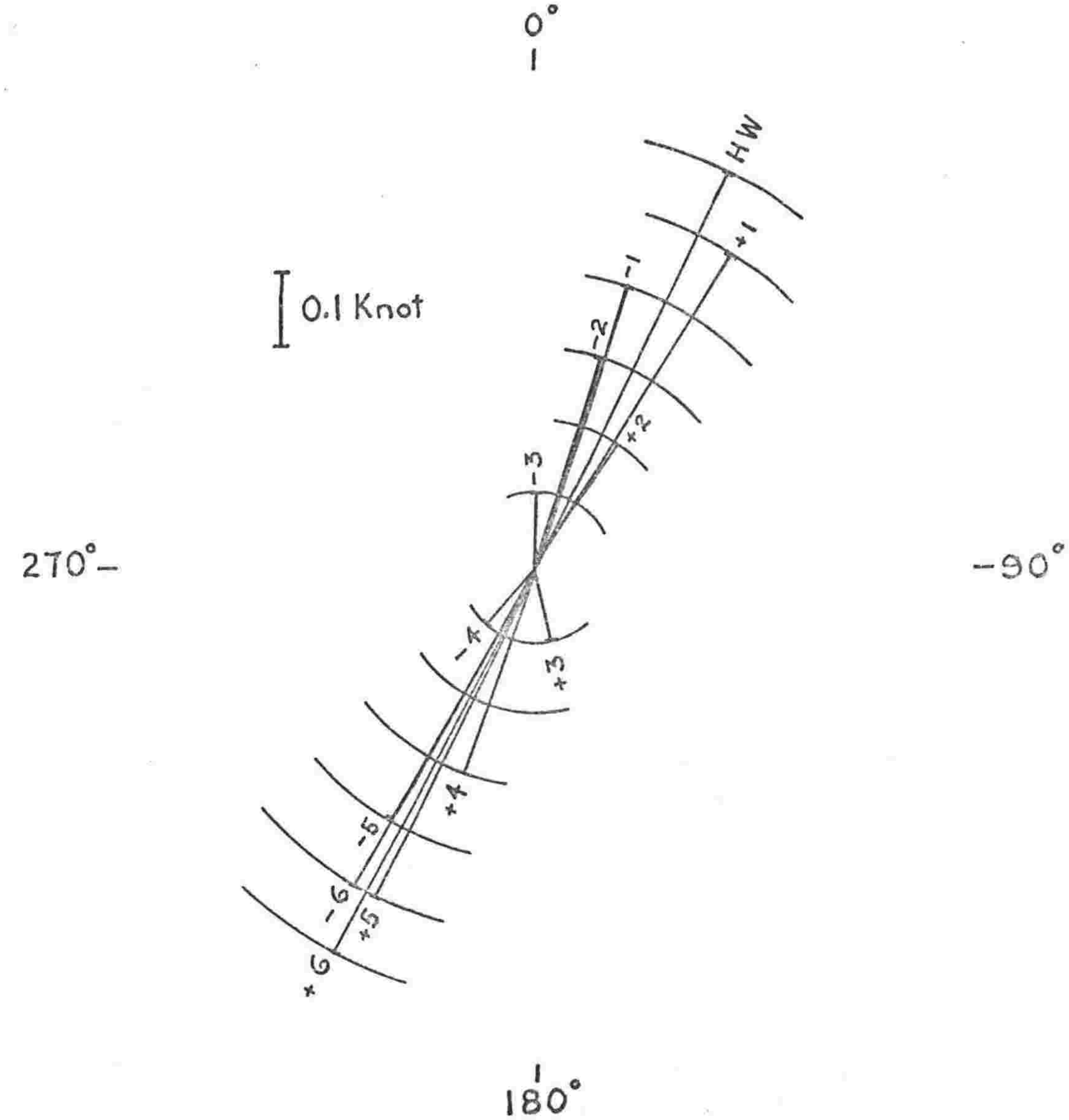


Figure A4. Tidal current rose for Tidal Reference Station A on Hydrographic Chart NZ63 (with reference to high water at Lyttelton).

the more widespread bathymetric obstacle presented by the Chatham Rise. At this latter station the flood and ebb tides each flow for approximately five hours, reaching a maximum surface velocity in either direction of 31 cm/sec. (0.6 knots). The flow is extremely dipolar, with no prolonged slack water and little divergence from the two main flow directions.

The track taken over a 5-hour period by a parachute drogue set out by the author at 30 m depth near 44°00'S, 173°15'E southeast of Banks Peninsula (Fig. A3) suggests that the polarity of the tidal stream is less pronounced away from the peninsula. However, the maximum computed velocity of 41 cm/sec. (0.8 knots) towards 180°T implies that the current speed is greater than at the coast. Measurements by Heath (1973b) at a depth of 300 m, in 460 m of water just beyond the shelf break in Mernoo Saddle indicated a maximum speed there of 44 cm/sec. with a residual speed of 8 cm/sec. Surface currents of up to 80 cm/sec. were measured on the shelf nearby.

Little is known of the tidal current speed at depth, especially near the bottom. A drogue set out at 60 m depth (15 m above the bottom) was tracked simultaneously with the 30 m drogue southeast of Banks Peninsula. It did not diverge significantly from the track of the shallower one, indicating that the tidal velocity at depth matches that near the surface.

Swell and Wind-generated Currents

The weather-generated hydrologic phenomena in the area have been recently investigated by L. Carter (N.Z. Oceanographic Institute) in order to determine the extent to which they may transport bottom sediments. His conclusions, as yet unpublished, are incorporated here. They represent the conditions that are likely to occur on an exposed, unconstricted portion of the shelf such as Canterbury Bight.

Swell rolls in from the Pacific virtually all the time. The dominant swell is from the southerly quarter and is generated by storm centres in the southern ocean. It has a modal period of 10-11 seconds. Although active the year round, it is most prominent in winter. Calculations reveal that on the open shelf in winter, wave surge associated with the swell is generally strong enough by itself to move fine sand on the bottom in depths of less than 30 m (inner shelf), and contributes a less frequent horizontal oscillating component of up to 18 cm/sec. at depths of 75 m (middle shelf). During the summer, the threshold velocity for fine sand movement on the inner shelf is exceeded only rarely by swell-induced surge. The threshold velocity following the suggestions of Sternberg (1971, 1972) is taken to be that required to erode fine sand from the bottom - approximately 34 cm/sec. (cf. Hjulstrom 1939; Sundborg 1967).

The effect of locally generated wind waves was determined from hindcasts based on Christchurch Airport wind records. These imply that during periodic gales or storms, which occur about 14 times per year at Christchurch and probably twice as often offshore, frequent wave surges of 76-190 cm/sec. (well above threshold for sand movement) may be expected at a depth of 30 m (inner shelf), and infrequent surges of 6-34 cm/sec. (well below to barely threshold) may be expected at a depth of 75 m (middle shelf). Wind-induced unidirectional flows are generated on the shelf in addition to the relatively high velocity oscillating currents mentioned above.

Wind drift currents are set up in response to wind shear during sustained periods of wind from a constant direction. Velocity is greatest at the surface and decreases exponentially downwards. Under gale and particularly under storm conditions, significant velocities are to be expected at the bottom on the inner shelf (11 cm/sec. for gales and 40 cm/sec. for storms, at 30 m depth) and on the middle shelf (only 2 cm/sec. for gales but 18 cm/sec. for storms at 75 m depth).

The resultant direction of the wind drift current combines the direction of actual wind shear and the left-hand deflection of the Coriolis force. The strongest and most frequent winds are from the southwest, hence the dominant wind drift is northwards. On the inner shelf it acts alongshore and onshore. During northeasterly winds the wind drift is offshore.

Heath's observations (1970, 1972b, c) imply however, that the offshore wind drift layer caused by the weaker northerly winds does not extend very deeply and is compensated at the bottom by a net shoreward flow. Hence with both northerly and southerly winds there is a persistent shoreward component of water movement on the bottom of the inner shelf.

Onshore/offshore mass transport of water produces other currents below the wind drift layer in the deeper water of the middle shelf. In response to the build up of water against the shore by southerly winds there is a seaward return flow along the bottom and a northward moving barotropic current in mid-water. The reverse is true when northerly winds prevail. Because southwesterly winds are dominant, annual net transport by this current system is offshore and northwards. The velocity of the current system is small but significant - 6 cm/sec. in gale conditions, and 13 cm/sec. in storm conditions.

A significant finding of the study is that the net northward movement of water on the Canterbury continental shelf attributed to the Southland Current, is, from time to time, considerably enhanced by wind drift and barotropic currents which flow predominantly in the current direction.

Heath (1970, 1972b, c) in a similar study reached the same conclusion about the effect of wind-derived water transport on the Southland Current off northeastern South Island.

It is not clear at this stage if there are currents of significant strength on the outer shelf. Heath (1972a) has located the core of the Southland Current on the upper slope just beyond the shelf edge in Mernoo Gap. He has recorded a maximum water speed (including the tidal component) of 44 cm/sec. in the area at depth and 80 cm/sec. on the surface (Heath 1973b). Hadley (1964) and Draper (1967) have indicated that waves affect sediment on the outer shelf off northwestern Europe and Komar et al. (1972) have observed the effect of waves on the sediments of the Oregon outer shelf. The outer shelf is thought to be influenced by internal waves which may even break, expending considerable energy on the substrate (Cartwright 1959; LaFond 1961; Southard & Cacchione 1972; Cacchione & Southard 1974). Stride & Tucker (1960) have suggested a relationship between internal waves (detected in the deep scattering layer in echograms) and sand waves. The deep scattering layer is frequently well developed in this region but efforts to detect a clear wave form in it have not been entirely successful (e.g., Plate A3). On the outer shelf the current regime is still unknown.

SUMMARY OF CURRENTS AND INFERRED EFFECTS ON SEDIMENT MOVEMENT

Cater has made some preliminary inferences about the effect of these currents on the bed load sediment of the shelf. These inferences apply mainly to the exposed, unconstricted shelf of Canterbury Bight. Pegasus Bay and the constricted shelf off Banks Peninsula are exceptional because of their geography.

> The routine hydrologic regime on the inner shelf during calm weather is one of frequent stirring of bed load sediment by the constant swell, lateral transport of the suspended sediment by the ebb or flood tide, with a net

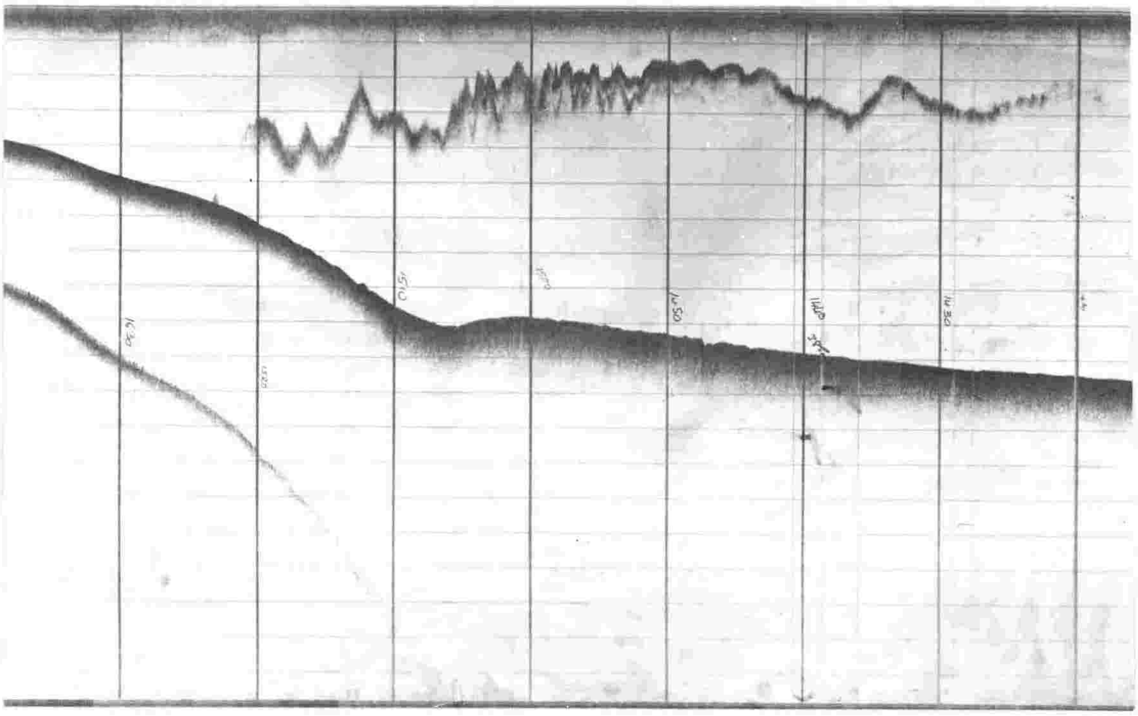


Plate A3. Vertical variation in the deep scattering layer observed in Mernoo Saddle southwest of Mernoo Bank on September 28, 1973.

northward transfer due to the mean flow (Southland Current). This occurs only sporadically on the middle shelf.

During gales or storms which blow most frequently from the south, the swell may be reinforced to produce continual stirring of inner shelf sediment and frequent stirring of middle shelf sediments. The flood tidal current and the mean flow (Southland Current) are, under these conditions, reinforced by wind drift currents and barotropic currents. On the inner shelf, the wind drift current will dominate and should tend to deflect the northward moving sediment towards shore. The wind drift and barotropic flow produce a combined velocity between 8 and 31 cm/sec. at 75 m (depending on the severity of the weather disturbances), which is added to the speed of the tidal current and Southland Current.

It is stressed that, only when travelling in the same direction do all the forces enhance each other to the greatest extent. The direction is northwards. The Southland Current flows continually northwards, wind-induced currents, when they occur usually flow northwards, and the tides flow apparently with equal strength in either direction. Swell and wind waves both predominantly move north. Net sediment movement is therefore northwards.

Unidirectional currents and opposing wind waves set up by northeasterly winds temporarily interfere with the net northward flow.

A shoreward component acts on the sediment of the inner shelf during both southerly and northerly winds. In deeper water, during southerly winds, a seaward component acts on the sediments.

These conclusions apply to the open unrestricted shelf - in this case Canterbury Bight. Pegasus Bay and the shelf east of Banks Peninsula are rather special cases.

Pegasus Bay is partly sheltered from these northward-acting forces by Banks Peninsula. The Southland Current apparently bypasses the inner bay (see below); wind drift currents and waves set up by southerly winds are limited by the sheltering effect of Banks Peninsula and by short fetch. Wind drift, swell and waves from the northeast enter the bay unimpeded but as mentioned above, they are less powerful than the southerly system that affects Canterbury Bight. The overall regime in Pegasus Bay is therefore quieter than elsewhere on that part of the shelf studied here and is not subject to a dominant northerly flow. The movement of bed load sediment should be less directional and less frequent than elsewhere on the shelf.

East of Banks Peninsula the situation is reversed. This region is exposed to the open shelf regime described above but the current velocities, particularly those of the tide, the Southland Current and the occasional wind-induced unidirectional flows, are accelerated by the constrictions created by the peninsula and the Chatham Rise. The degree of acceleration is still very much an unknown quantity. As mentioned above the tidal flow is known to be strongly polarised in this area, and strong unidirectional currents flow even in calm conditions. The Hydrographic Chart NZ63 reports a surface current of up to about 103 cm/sec. (2 knots). A strong northerly set with a minimum velocity of 128 cm/sec. (2.5 knots) and a possible maximum velocity of 170 cm/sec. (3.3 knots) was encountered by R.V. Tangaroa during the study while on a slow west-to-east traverse of this area. The wind at the time was blowing at 9 knots from 020°T against the set. The empirical data illustrate that high velocity currents routinely flow over the constricted shelf off Banks Peninsula. In this area frequent movement of bed load sediment can consequently be assumed to be taking place over a much wider portion of the shelf and to greater depths.

OBSERVED NET TRANSPORT FROM SURFACE AND SEA-BED DRIFTERS

The results of a programme of drift card and sea-bed drifter releases carried out during work on the Canterbury shelf in 1973 and 1975 are relevant to the foregoing discussion and are discussed below.

Drift Cards

In May and October 1973 about 2,000 drift cards were released during the course of two geological cruises by the author in the Canterbury area. Approximately 13% of these were recovered. A further 450 cards were released from 7-28 July 1975, from the rig drilling the Resolution I exploratory well for B P Shell Todd south of Banks Peninsula. The recovery from this group was very small and is discussed below.

The vectors between all release and recovery points are shown in Fig. A5. The pattern of drift that emerges corresponds closely to that discovered by Brodie (1960). As a rule, cards released on the continental shelf ultimately washed ashore while most of those beyond or near the shelf edge were lost to the coastal system (several reaching Chatham Island). With few exceptions the cards were carried north. Of those released in outer Pegasus Bay a large number moved west on to the beach. More were found on the beaches to the west (5%) than to the north (0.5%).

Since significant minimum velocities were obtained for the north-going cards (viz. 18.3 cm/sec.; Table A1) it is important to know the contribution of the wind.

The following method was used. Wind vectors, derived from hourly wind data at three N.Z. Meteorological Service weather stations in north, central and south Canterbury, are presented for the period during which the fastest ten cards of the present survey were in the water (Fig. A6). Wind speeds were cumulated within each separate octant of the compass and the total wind run for each octant was

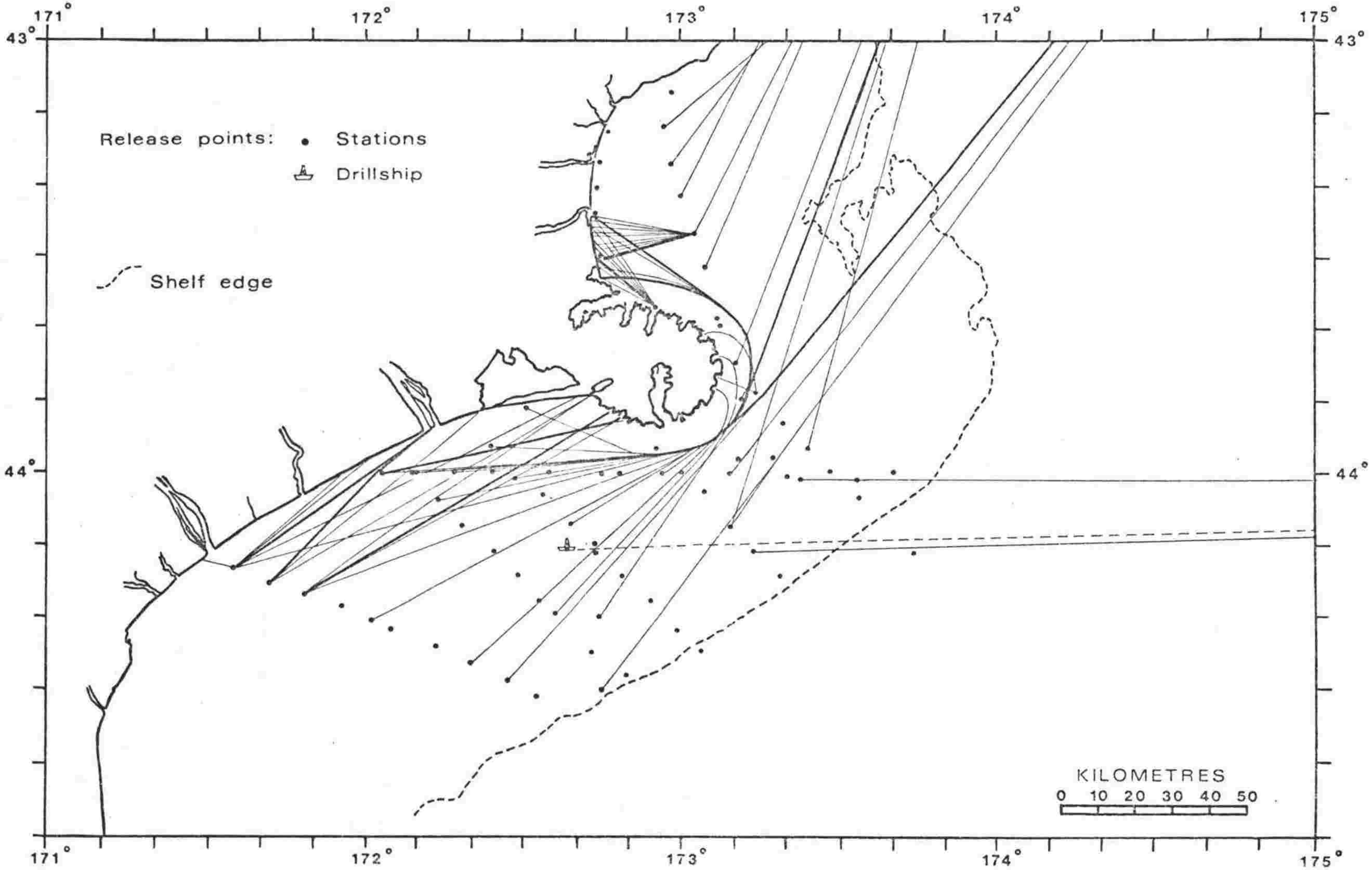


Figure A5. Vectors between release and recovery points of drift cards. Thin lines represent the vectors followed by one or two cards. Thick lines represent the dominant drift vectors.

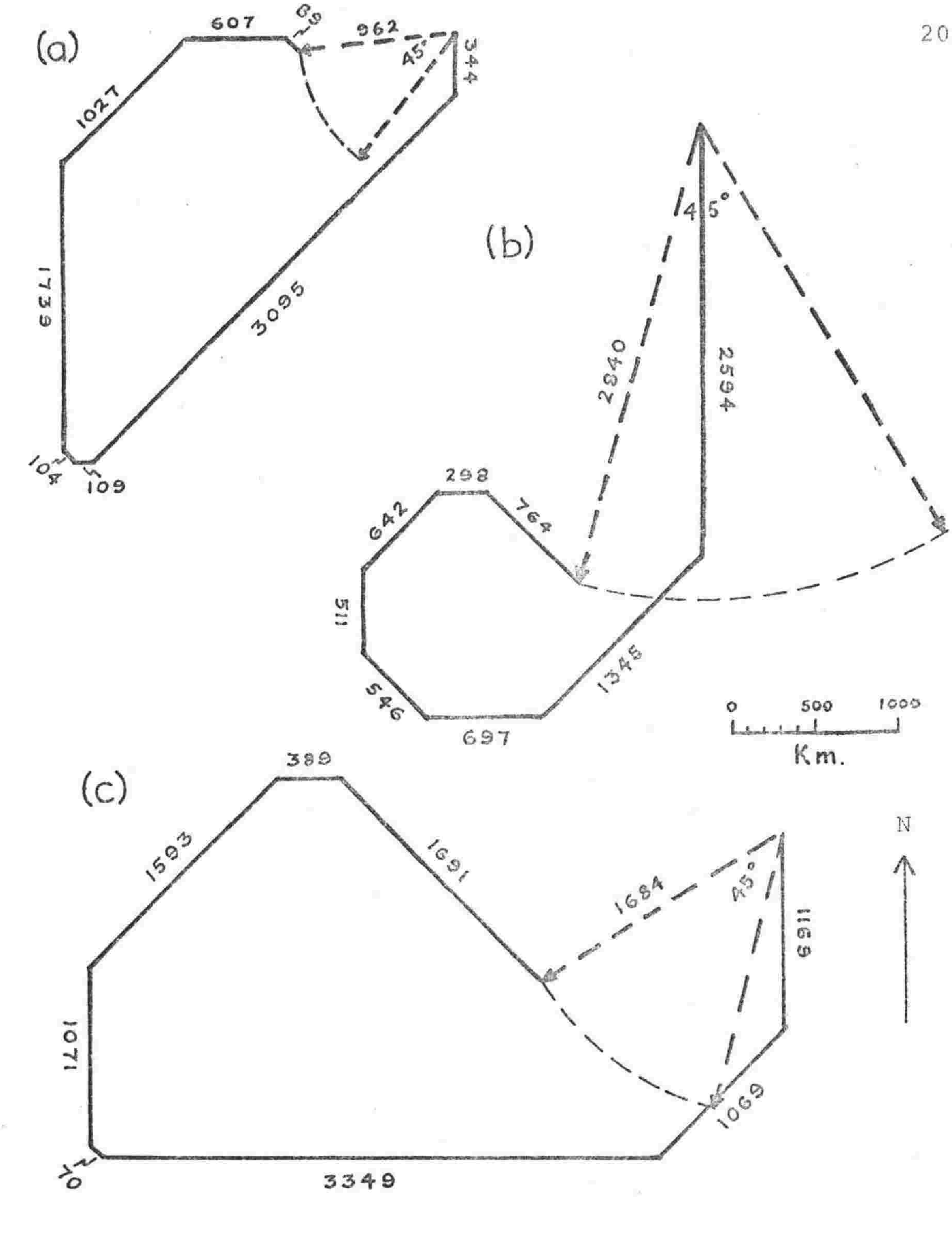


Figure A6. Progressive vector diagrams for wind run cumulated by octants during the period of travel of the ten fastest drift cards; 1000 hrs 9-10-73 to 1000 hrs 7-11-73. Observations from meteorological stations (a) Kaikoura; (b) Winchmore; (c) Harewood.

plotted as a vector. The resultant wind run vector is taken to represent the direction in which the net effect of the wind has acted on the card. Allowance is made in the diagrams for up to 45° of lefthand deflection of the induced water current by the Coriolis force (cf., Bowditch 1966). Because a drift card floats in the top centimetre or less of water, where response to wind shear is rapid, it is felt that this simplistic approach is justified.

The resultant wind run vectors, even allowing for the maximum possible Coriolis deflection of the induced current, in each case ran strongly counter to or obliquely counter to the direction taken by the cards. This agrees with Brodie's observations (1960).

The minimum velocities of the cards therefore represent the speed of the oceanic current without reinforcement from the wind. With the wind running against the oceanic current, the minimum velocities are, if anything, low. The two highest minimum velocities (Table A1) represent cards that travelled as far as Cape Campbell. Since part of their itinerary was outside the study area, their speeds are not, strictly speaking, valid for this study. However the third highest velocity, 12.9 cm/sec., and several of the others in the table were obtained entirely within the confines of the study area and can therefore be taken as the minimum velocity of the Southland Current in this region.

It is important to note that of the fastest ten cards, all but one were released south of Banks Peninsula. The single fast card released in Pegasus Bay was in the south-eastern part of the bay where it was easily entrained by the northward flowing current. The minimum velocities of these cards are all significantly higher than those obtained for the fastest cards within the bay (Table A2).

Anomalous drift patterns were individually investigated in the light of the available wind data. The vectors and arrival times of the west-travelling cards in Pegasus Bay do not suggest an obvious gyre. Wind vector diagrams

TABLE A1 - MINIMUM VELOCITIES OF 10 FASTEST DRIFT CARDS

Station No.	Release Point Latitude S	Release Point Longitude E	Card No.	Minimum Velocity cm/sec.	Release Area	Direction of Travel
H367	44° 07.1'	172° 38.8'	N1803	9.4	Canterbury Bight	Northeast
J404	43° 31.8'	173° 04'	I1214	10.3	Pegasus Bay	"
J414	44° 00'	172° 59'	U1343	11.6	Canterbury Bight	"
J416	44° 00.5'	172° 45'	U1393	14.4	" "	"
J427	44° 20.5'	172° 01'	U1842	12.9	" "	"
J430	44° 15.0'	171° 42'	U1957	10.7	" "	"
J430	"	"	U1990	8.7	" "	"
J431	44° 13'	171° 35.5'	X1006	9.9	" "	"
J434	44° 00'	172° 10'	X1079	9.0	" "	"
J440	"	172° 35'	X1241	18.3	" "	"

TABLE A2 - MINIMUM VELOCITIES OF DRIFT CARDS RELEASED IN PEGASUS BAY

Station No.	Release Point Latitude S	Release Point Longitude E	Card No.	Minimum Velocity cm/sec.	Release Location in Bay	Direction of Travel
J400	43° 12.3'	172° 56.8'	I1060	5.5	Northern	Northeast
J401	43° 17.3'	172° 57.9'	I1088	3.4	North central	"
J402	43° 21.9'	172° 59.9'	I1130	0.7	Central	"
J403	43° 26.9'	173° 02.1'	I1168	1.5	South central	West
J403	43° 26.9'	173° 02.1'	I1177	3.2	" "	North east
J404	43° 31.8'	173° 04'	I1214	10.3	South eastern	"
J454	43° 37.4'	172° 55.2'	X1281	7.1	Southern	Northwest

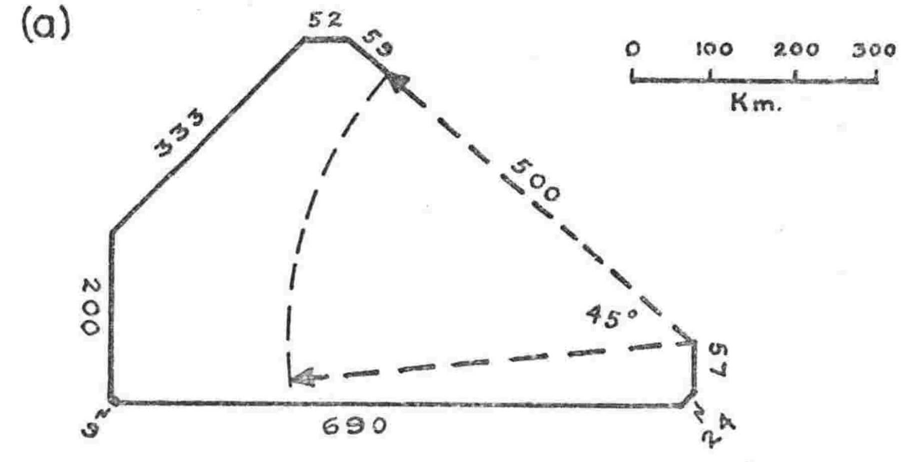
(drawn from the data from Harewood, the closest weather station) for the fastest card from each of the two west-going groups offshore (Fig. A7) indicate that a significant westward wind component was active at the time.

Cards released along the western side of the bay less than 2 km from shore moved onshore within hours along westerly to south-southwesterly vectors. Recovery rates were 70-90%. The wind recorded at the time on the ship was blowing at 7 knots from 050°T, suggesting that their motion was also wind influenced.

Both the drift card and Landsat data complement Brodie's (1960) and Dawson's (1954) observations about circulation in Pegasus Bay. The Southland Current flows generally past the mouth of the bay with a minimum velocity of 13 cm/sec. while nett circulation within the bay remains slacker. Although an eddy system may be set up, it is not premanent and the slow moving surface water in the bay shows a significant response to the force of the wind.

An interesting situation developed in the case of the cards released over a 21-day period from the stationary oil rig in Canterbury Bight (Fig. A5). The rig was located in an area from which previously good card returns had been obtained along the beaches to the north yet of the 450 cards released, only one was found - on Chatham Island. Wind vector diagrams (including one drawn from data recorded on the drilling rig) covering the period from the first card release to seven days after the last card release (Fig. A8) indicate a strong resultant wind run vector and wind-induced surface current towards the east, which suggests that the cards were deflected eastwards out of the coastal Southland Current system.

It is interesting to note that the wind runs obtained from the offshore rig data were approximately double those from the land based stations, confirming that wind speeds offshore tend to be twice as high as those onshore.



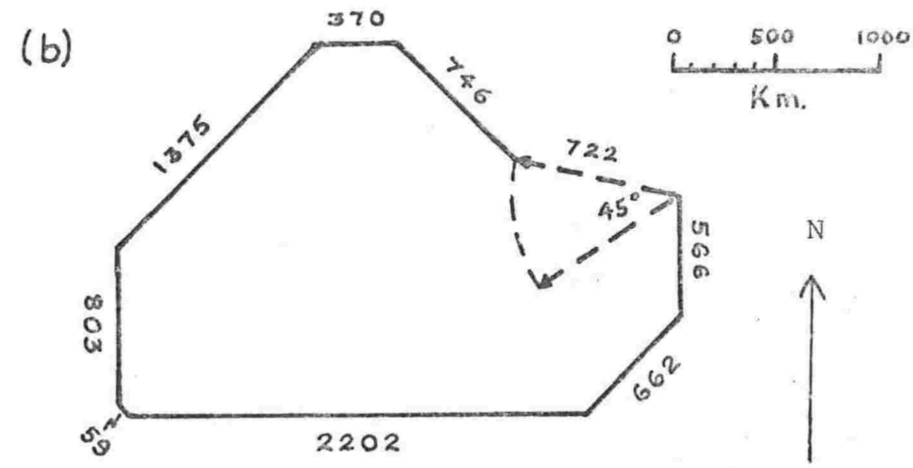


Figure A7. Progressive vector diagrams for wind run cumulated by octants during the periods of travel of the fastest card in each of the two west-going groups in Pegasus Bay.
(a) J403, 1000 hrs 9-10-73 to 0700 hrs 29-10-73.
(b) J454, 0900 hrs 13-10-73 to 1600 hrs 16-10-73.

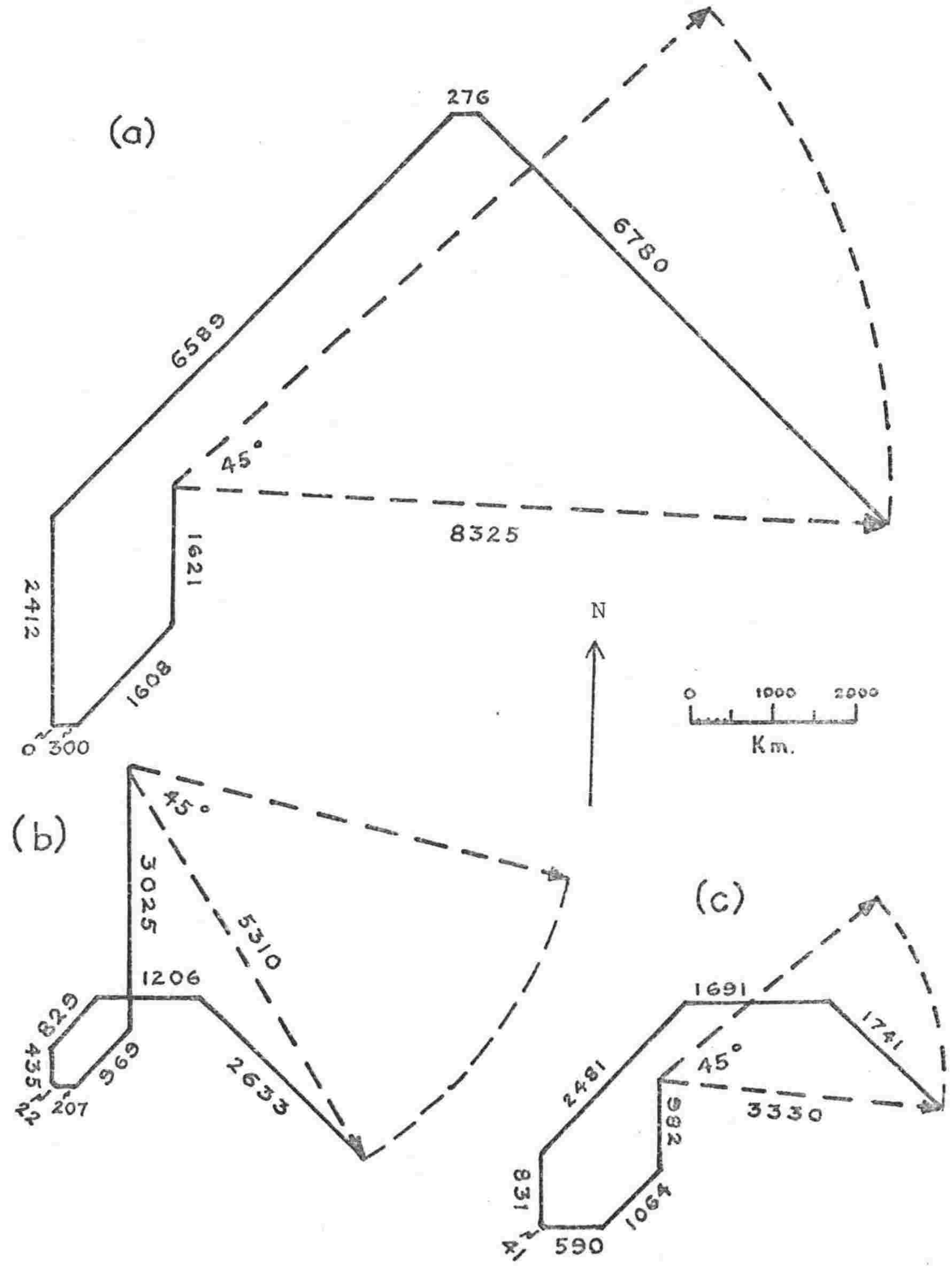


Figure A8. Progressive vector diagrams for wind run cumulated by octants during the period from the first card released from the stationary drillship to seven days after the last card release; 0000 hrs 8-7-75 to 2400 hrs 4-8-75. Observations from (a) Glomar Tasman drillship; (b) Winchmore meteorological station; (c) Harewood meteorological station.

The effect of wind on the surface water of the Southland Current is evidently important. Although not strong enough to reverse or stop the current at the surface, it readily deflects the northward flowing surface water to one side or another and can therefore be counted on to slow or accelerate the surface water when blowing from the north or south quarters.

Sea-Bed Drifters

The movement of water at the sea bed on the Canterbury shelf was investigated by using sea-bed drifters. Eight hundred and sixty Woodhead drifters (Woodhead & Lee 1960) were released at the points shown in Fig. A8. The drifters were tagged with standard N.Z.O.I. drift cards, additional weight being added to compensate for the added buoyancy of the most buoyant of the cards. The negative buoyancy of the drifters thus ranged from 1-5 grams. They were released on the bottom in bunches of ten from soluble anchors made of 1.5 kg blocks of agricultural salt. Although drifters were released in much smaller numbers than cards, their rate of recovery was as good as that for cards.

The interpretation of sea-bed drifter returns is not simple and several factors have to be taken into account. The most obvious factor is the friction between the drifter stem and the sea bed. Harden Jones et al. (1973), using data published by Ramster (1965) and Phillips (1970), suggested that at water velocities between 20 cm/sec. and 103 cm/sec. a Woodhead drifter moves at 70-90% of the water velocity and that at water velocities below 20 cm/sec. it will move at a progressively smaller fraction of the water velocity. As pointed out by Ramster (1965) the direction taken by the drifter will thus tend to be the direction of the highest velocity currents and not that of the low velocity residual current.

Abberations in the flow of water at high velocities will also affect the behaviour of drifters. Experiments

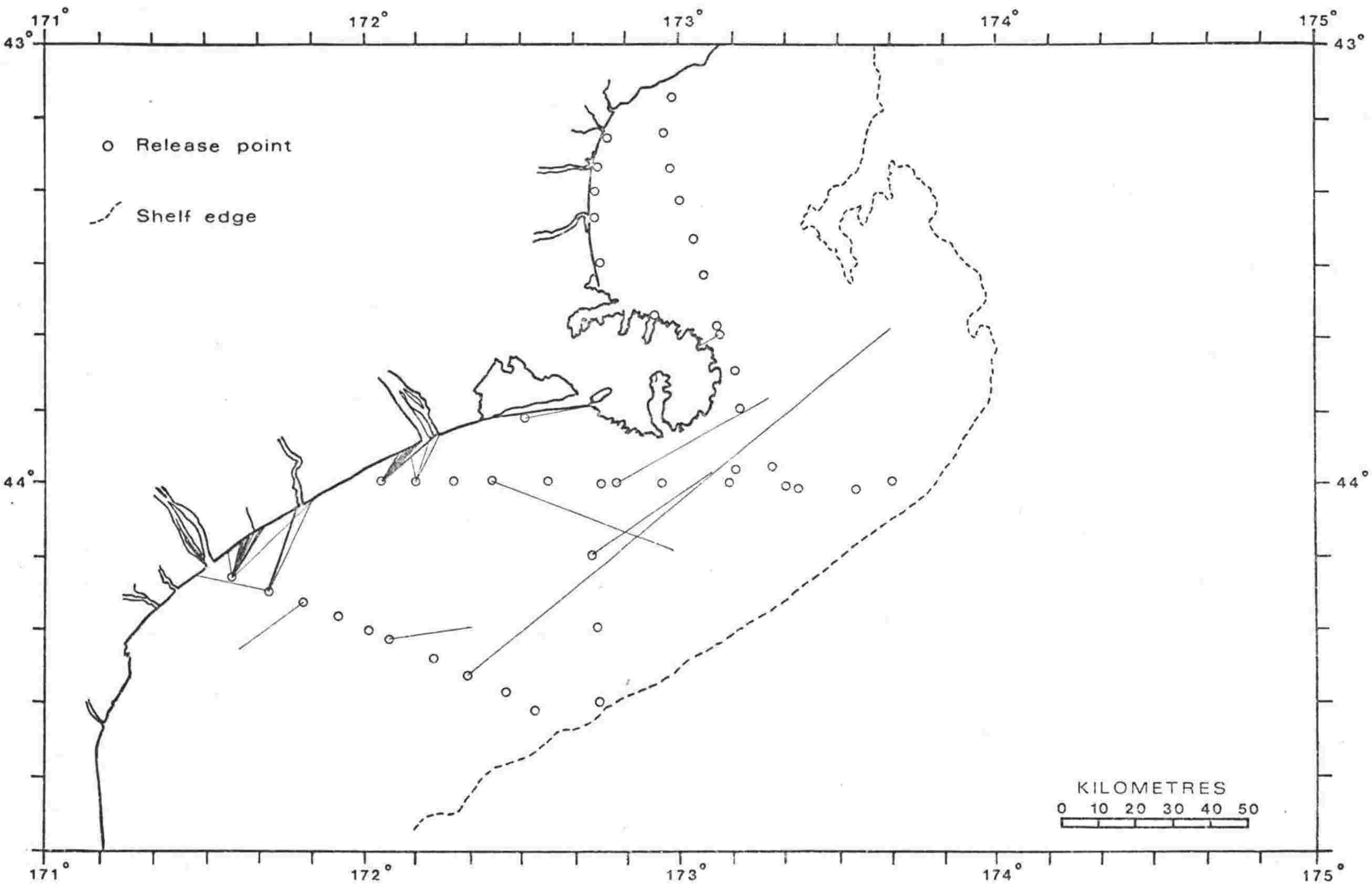


Figure A9. Vectors between release and recovery points of sea-bed drifters. Thin lines represent the vectors followed by one drifter. Thick lines represent the dominant drift vectors.

by Harden Jones et al. (1973) on a drifter with a negative buoyancy of 1 gm moving freely in an area of strong tidal currents (over 1 cm/sec.), revealed that the drifter spent a significant proportion of each tidal cycle off the bottom. Both the extent and the duration of these excursions into midwater appeared to be related to water velocity. At slack water and low velocities the drifter was on the bottom. As velocity increased, off-the-bottom movements began as a series of hops which increased in amplitude and duration until the drifter was in the middle of the water column for periods of up to 15 minutes. The drifter rose up to 12 m off the bottom and travelled at speeds as high as 94 cm/sec. while suspended in the water column. They suggested that these movements reflected the scale of turbulence near the sea bed. The important thing to note here is that once off the bottom, the drifter is no longer restrained by friction with the sea bed. It will therefore tend to travel further in high velocity currents than in low velocity ones.

Hence, in a regime of frequently conflicting flows, the net path of sea-bed drifters will be that of the intermittent high velocity component and not that of the slow but steady mean flow.

The effect of wave surge, however, cannot be ignored. Although shallow water wave transport may by itself significantly affect the movement of sea-bed drifters (Morse et al. 1968; Halliwell 1973) this factor has yet to be properly investigated. The role of waves in stirring sediment at substantial depths so that it is subsequently transported by weaker currents is, however, recognised. Given calm weather and a heavy swell (frequently the case off Canterbury) the momentarily high surges generated by the passing swell may lift the sediment, and therefore a drifter, off the bottom whereupon it is carried a short distance by the tidal current and weak mean flow before being set down again. In this case, the path of the drifter will approximate that of the mean flow.

It was concluded in the first part of this paper that the highest velocity unidirectional flows on the Canterbury shelf act most frequently in the same general direction as the mean flow. The problem of reconciling the major trend of the drifters to that of the current regime on a broad scale is, therefore, simple. Although the tides flow with equal velocity in either direction, both the mean flow and the dominant storm currents flow northwards and this is reflected in the vectors of the sea-bed drifters (Fig. A9).

The highest minimum velocity of the sea-bed drifters was 2.5 cm/sec., only 20% of that obtained for drift cards (Appendix 1). An unknown but substantial proportion of this difference will be due to friction with the bottom as discussed above.

Besides the general northward trend of the vectors, another important trend is obvious and that is the divergence between the onshore direction taken by the inner shelf drifters and the offshore direction taken by the middle and outer shelf drifters. This trend agrees remarkably with the divergent sediment transport directions predicted earlier in the paper. As well as wind drift, the onshore component followed by the inner shelf drifters may be due to direct wave transport (cf. Morse et al. 1968; Halliwell 1973) since these drifters were all released in less than 30 m of water, a zone that has been demonstrated to be frequently agitated by wave surge. It may also be due to a density gradient (cf. Halliwell 1973; Heaps 1972) caused by the spring season freshwater runoff in the area (Heath 1972a)

A lack of returns can be as significant, indirectly, as the result of returned drifters. Although 160 drifters were released in central and outer Pegasus Bay, there were no returns. This could mean either that the drifters were carried eastwards out of the bay into deep water by strong currents, or, more likely, that bottom currents in the mud-floored bay are too feeble, sporadic or random to move the drifters to a site where they are likely to be found.

A small number of drifters in the southwest corner of Canterbury Bight showed a tendency to follow a more southward component in the overall pattern of northward drift. One drifter did in fact travel ten miles southwest over a period of 25 days. It seems likely, therefore, that a significant southward flow exists due either to locally faster ebb tide currents, occasional southward flowing, wind-induced currents, or an eddy in the Southland Current system.

CONCLUSIONS

The net travel vectors of sea-bed drifters and drift cards have provided a practical confirmation of the theoretically predicted path of mass transport on the Canterbury continental shelf. The observed mass transport path, including trends revealed in Landsat II imagery, is presented in Fig. A10.

Net flow on both the surface and the bottom on the open shelf is northwards and is in response to the Southland Current and the dominant strong winds from the south.

The wind is also responsible for deflecting the water masses either seaward or landward both on the surface and on the bottom. Bottom water on the inner shelf is deflected landwards in both southerly and northerly wind conditions. On the middle shelf, southerly winds accelerate the northward bottom flow and may deflect it seawards.

High velocity surges caused by the passage of southerly swell or storm waves take place frequently in inner shelf depths of less than 30 m and much less frequently in middle shelf depths of 75 m.

The flow around Banks Peninsula is constricted and accelerated. Unidirectional flows in this region may reach 2 Or 3 knots. In Pegasus Bay, the current regime is much

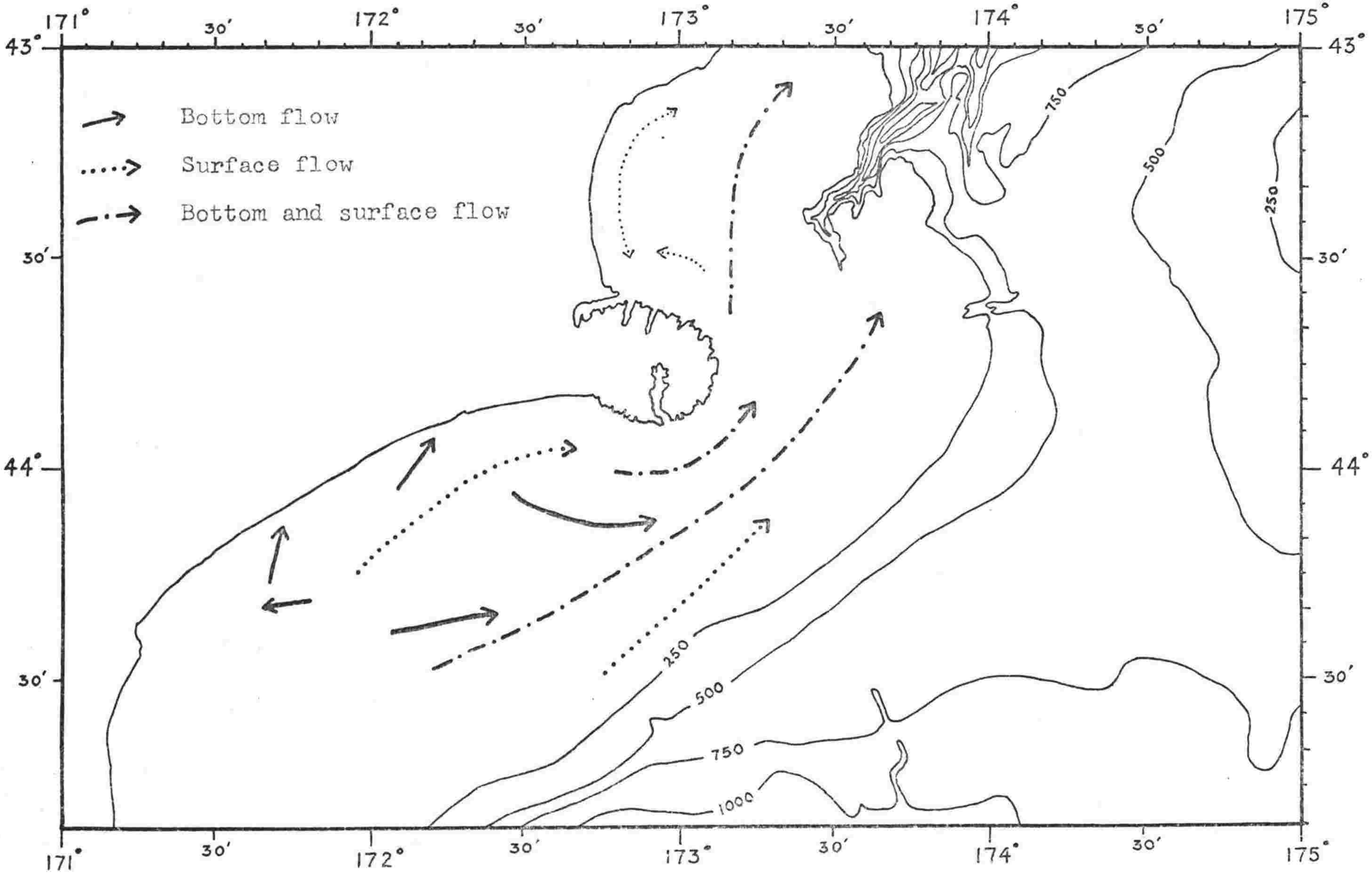


Figure A10. Direction of net water flow on the Canterbury shelf, based on drift card, sea-bed drifter and Landsat II information.

slower and more erratic.

The implications for sediment transport are clear. The currents will continually transport the mud and fine sand supplied to the inner shelf of Canterbury Bight northwards along a belt close to the shore. They will agitate the sediment of the middle shelf infrequently and transport it also northwards and seawards as well. The energy available to move sediment in this system should increase with proximity to Banks Peninsula and Mernoo Saddle, where high velocity currents are known to occur even in calm weather. In Pegasus Bay, where the energy conditions are lower and less directional, sediment transport will be less effective.

CHAPTER B

STRATIGRAPHY, SEDIMENTATION AND LATE QUATERNARY HISTORY OF THE CANTERBURY CONTINENTAL SHELF.

ABSTRACT

The Quaternary stratigraphy and sedimentary processes are interpreted for an area of continental shelf on the eastern side of the South Island, New Zealand. The area extends from latitude 43°00'S to latitude 44°50'S and includes Pegasus Bay, the shelf around Banks Peninsula, and Canterbury Bight.

Two formations are recognised in the late Quaternary stratigraphy: the Canterbury Bight Formation of mainly Last Glacial age and, locally overlying it, the Pegasus Formation of mainly Holocene age. The formations are distinguished by shelf-wide unconformities (visible in seismic profiles), by geomorphology, by grain-size modes, and by macrofauna.

Ridge-and-swale topography occurs on two scales on the shelf. Very large ridges and troughs are interpreted from microbathymetry, stratigraphy, sediments and macrofauna to be the remains of Pleistocene barrier/lagoon complexes. With the aid of radiocarbon dates, four well developed shorelines between 28,000 yr and 15,000 yr old are recognised. The smaller ridges are submarine features, formed by strong currents. Those ridges that are in a zone of constricted and accelerated currents near Banks Peninsula are active, while those well removed from the peninsular constriction are partly buried by muddy sediments, and date from times of lower sea level.

Studies of sediment texture and provenance show that net sediment movement on the shelf and along shore during both Late Pleistocene and modern times has been northwards. The submarine canyons of the northeastern shelf were probably the main Pleistocene sediment sinks. The present day flow of sediments is mainly into Pegasus Bay.

Sedimentation on the continental shelf has reached a state of equilibrium with the modern hydraulic regime. Relict

sediments of the deglacial transgressive sand/gravel sheet are being reworked in zones of high energy, principally in the region of constricted flow around Banks Peninsula, into lag gravels, sand ridges, sand ribbons and sand waves. Modern-input sand (distinguished by its grain size mode) is restricted by currents mainly to an active belt near shore, but locally it has replaced palimpsest sand on the middle shelf. The modern mud facies, being confined by zones of higher energy, has reached its maximum areal extent; its greatest thickness is in Pegasus Bay.

INTRODUCTION

The eastern continental margin of the South Island of New Zealand comprises a rather narrow continental shelf flanked to seaward by a system of large submarine plateaus and troughs which intersect the landmass at high angles. The continental shelf is almost linear and is exposed to the open ocean for its whole length.

The portion of the South Island continental shelf dealt with in this paper lies off central Canterbury between 43°00'S and 44°50'S (Figs. B1, B2). It includes Pegasus Bay, the shelf around Banks Peninsula, and Canterbury Bight. The South Island shelf reaches its greatest width in this area. It descends very gently to a shelf break at a depth of 150-180 m, the shelf break being approximately 90 km offshore. The shelf lies off a 40 km wide Pleistocene fluvio-glacial outwash plain, the Canterbury Plains, behind which rises a high mountain front, the Southern Alps. An extinct volcanic complex, Banks Peninsula, rising to over 500 m, divides the shelf into Pegasus Bay to the north and Canterbury Bight to the south. East of the continental shelf, the Chatham Rise extends over 160 km out to the east with a crestal depth of less than 500 m, shallowing locally to as little as 32 m. North and south of the rise, the sea is over 2000 m deep. Separating the rise from the continental shelf is Mernoo Saddle with a minimum depth of 550 m.

Rivers entering the sea along the east coast of the

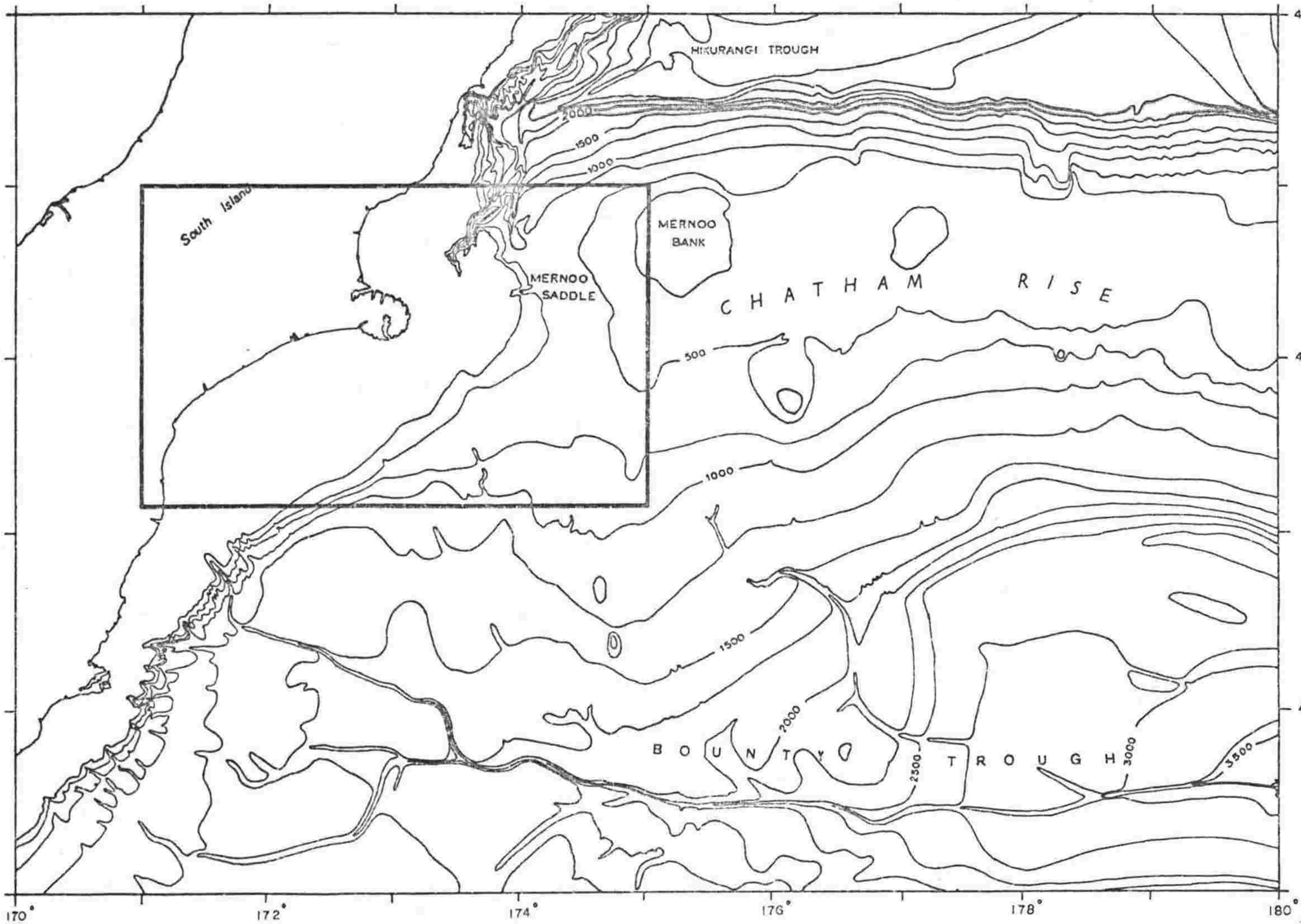


Figure B1. Regional bathymetry (after Krause and Cullen, 1970) of part of the ocean off the eastern South Island. The study area is outlined in black. Contours in metres.

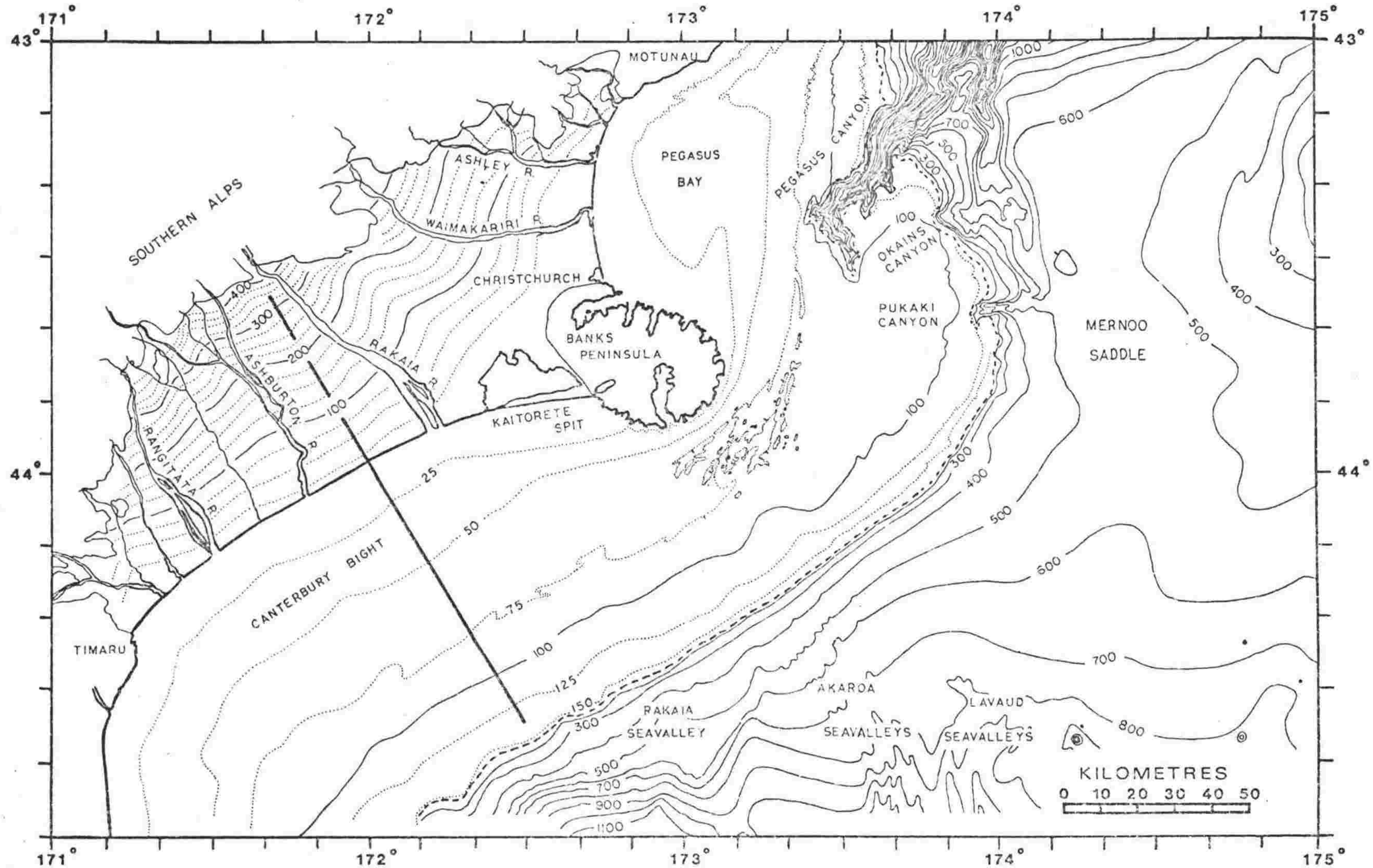


Figure B2. Bathymetry of the continental shelf and slope, and simplified physiography of the adjacent land area. The location of the profile in Figure B16 is shown. Contours in metres.

island drain a hinterland composed mainly of greywacke and argillite in the north, and chlorite zone, quartzo-feldspathic schist in the south (Fig. B3). Small areas of basic and intermediate volcanics and limestones are also present.

With the exception of a published N.Z. Oceanographic Institute sediment chart (Cullen & Gibb 1966) and a near-shore survey of Pegasus Bay by Campbell (1974), there has been no research on the Quaternary geology of the Canterbury shelf. By contrast, the literature relating to the onshore geology is voluminous (Jobberns 1926, 1927; Speight 1930, 1950; Gage 1958; Suggate 1958, 1963, 1965, 1968; Oborne & Suggate 1959; Blake 1964; Raeside 1964; Kear et al. 1967; Burgess 1968; Soons 1968; McLean & Kirk 1969; Kirk 1969; Armon 1970; Dingwall 1974; Brown 1975; to name but a few).

The currents affecting the area have been discussed in detail in Chapter A.

BATHYMETRY

Methods

The first step in the geologic investigation of any piece of sea bottom is bathymetric mapping. All available bathymetric data were accordingly compiled (Fig. B4) and contoured (Figs. B2, B5, B6).

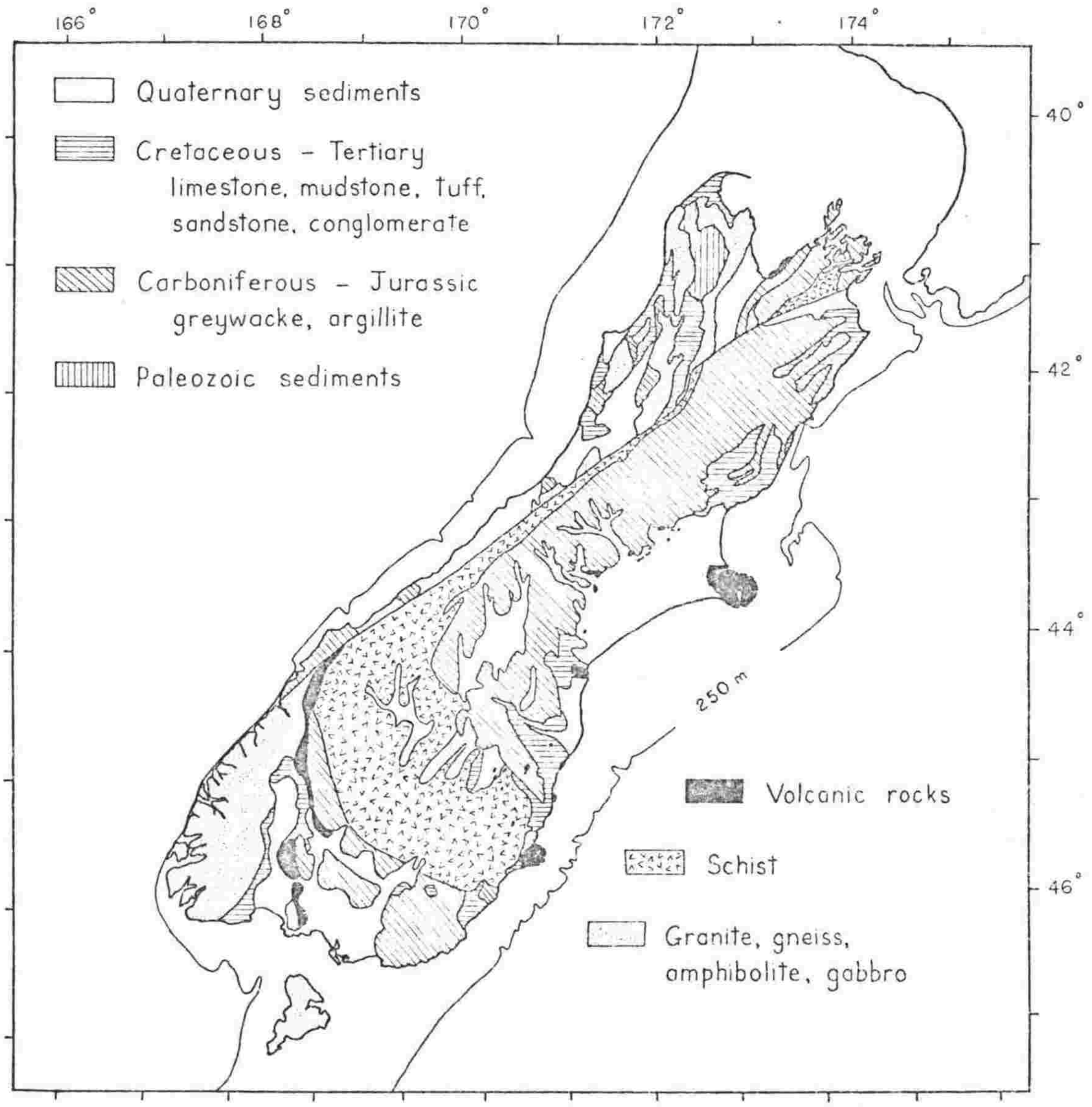


Figure B3. Simplified geology of the South Island. Modified from Grindley et al. (1959).

In areas where detailed surveys have been done, such as Pegasus Bay and west of Banks Peninsula, the microbathymetry was contoured from the collector sheets of the Hydrographic Branch, Royal N.Z. Navy. A fairly systematic surveying error along some of the sounding lines on the collector sheets created a spurious bathymetric trend parallel to the lines. The error was one of depth and not one of position, since a large displacement of contour lines (generally in the order of 1-2 km) occurred where the slope is gentle - on the continental shelf - and no displacement occurred where the slope is steep - in submarine canyons or on the continental slope. The error was approximately ± 0.5 m, and when allowed for, it became possible to contour with a 2 m vertical interval.

South of Banks Peninsula no detailed survey had been made. In order to deduce the geomorphology, every available echo sounding profile (Fig. B4) was examined, and features such as slight changes of slope, areas of smooth or undulating sea bed, highs, depressions, terrace-like features etc. were plotted. It was found that most features could be correlated from profile to profile and tied in with those shown by the microbathymetry to the north.

Geomorphic Zones of the Continental Shelf

The morphology of the shelf surface shown in Figs. B5 and B7 is described below. Its probable mode of origin is discussed later.

It consists of a series of zones which are generally parallel to the strike of the shelf.

Zone A:

Zone A includes almost all of Pegasus Bay plus a narrow band extending south around Banks Peninsula and into Canterbury Bight as far south as the Rakaia River.

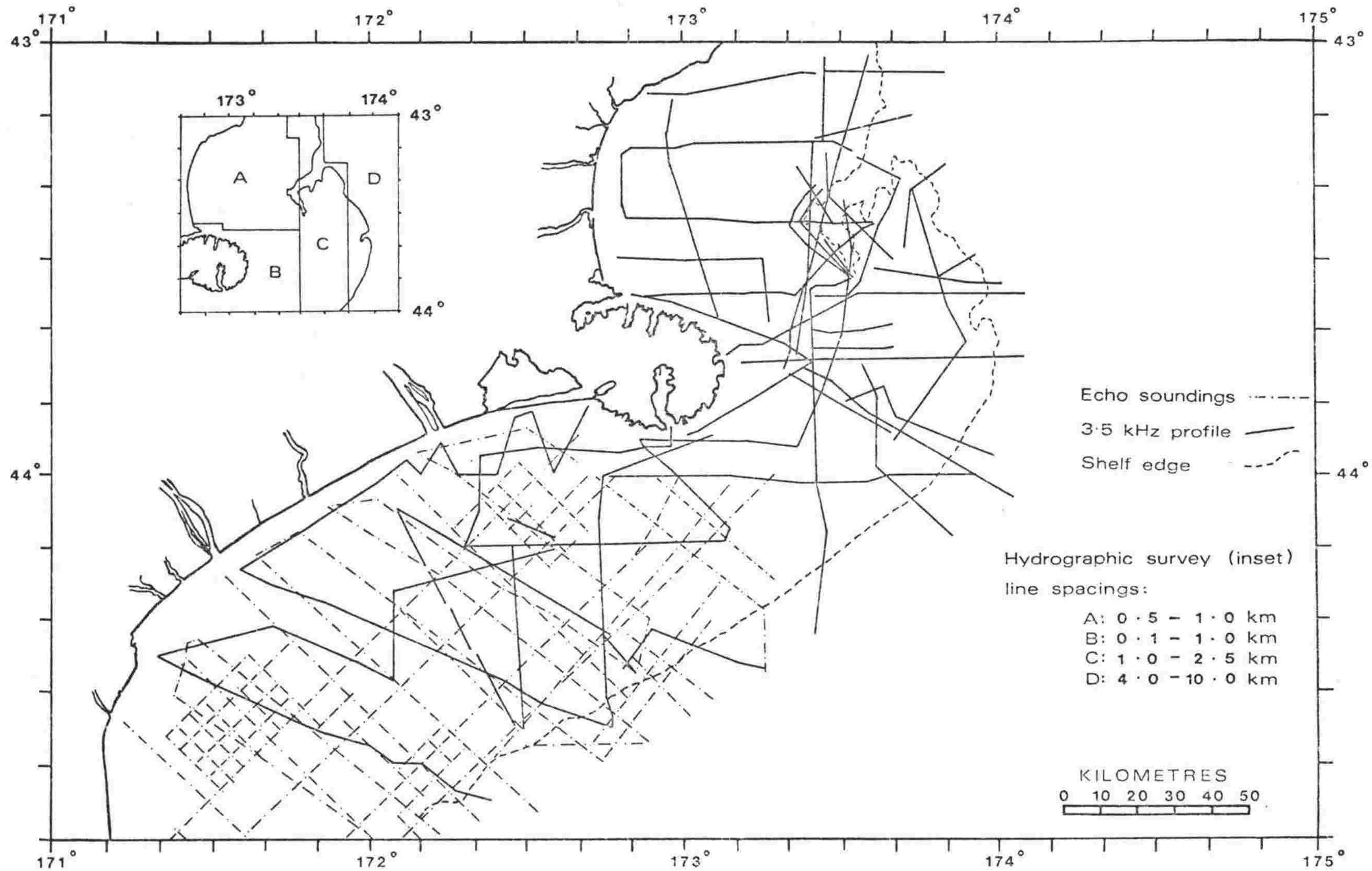


Figure B4. Echo sounding coverage of the continental shelf. Reliability diagram (inset) shows area covered in detail by hydrographic surveys (echo-sounding lines not shown).

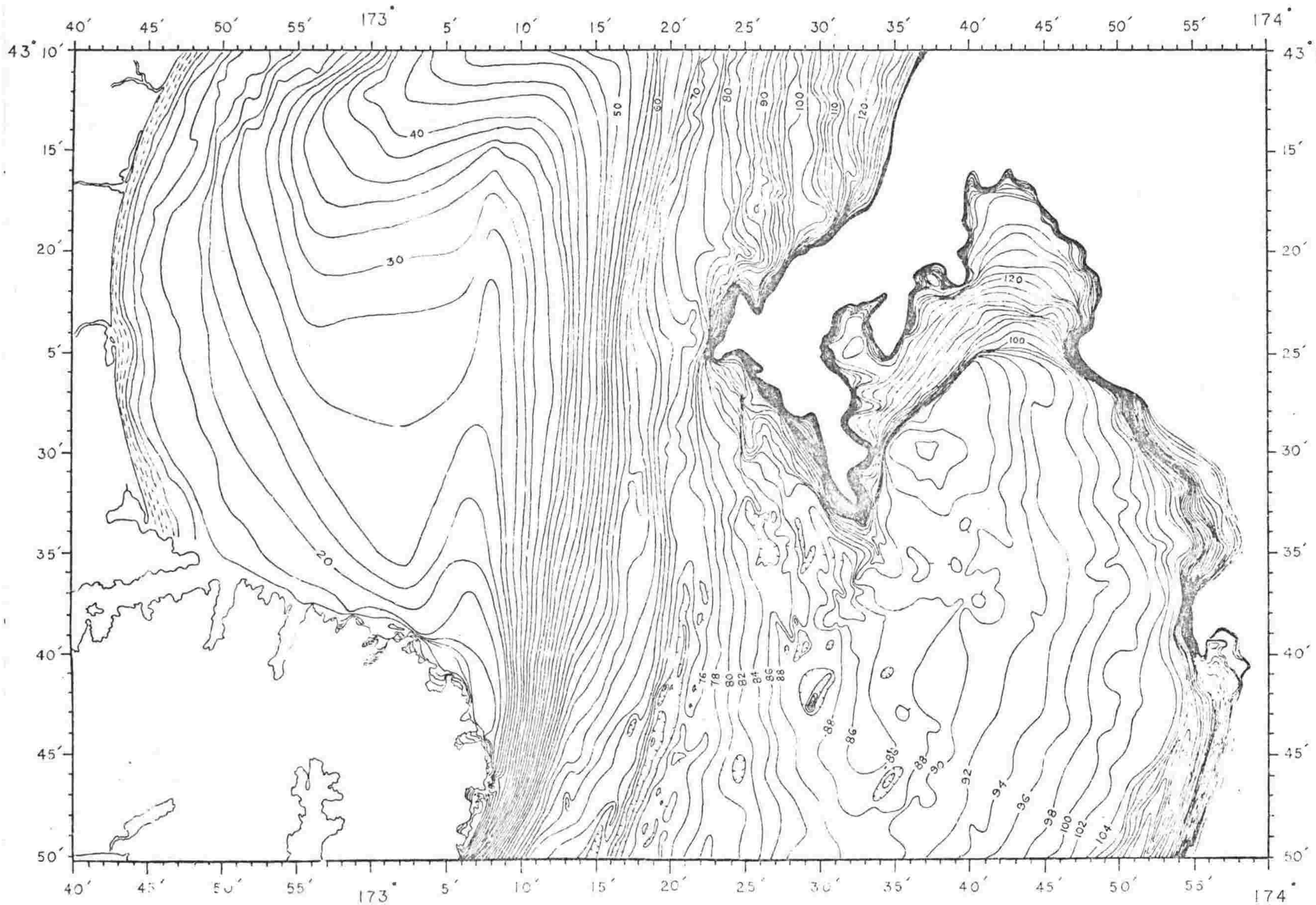


Figure B5. Microbathymetry of Pegasus Bay and the shelf off Banks Peninsula. See Figure B4 for reliability diagram. Contours in metres.

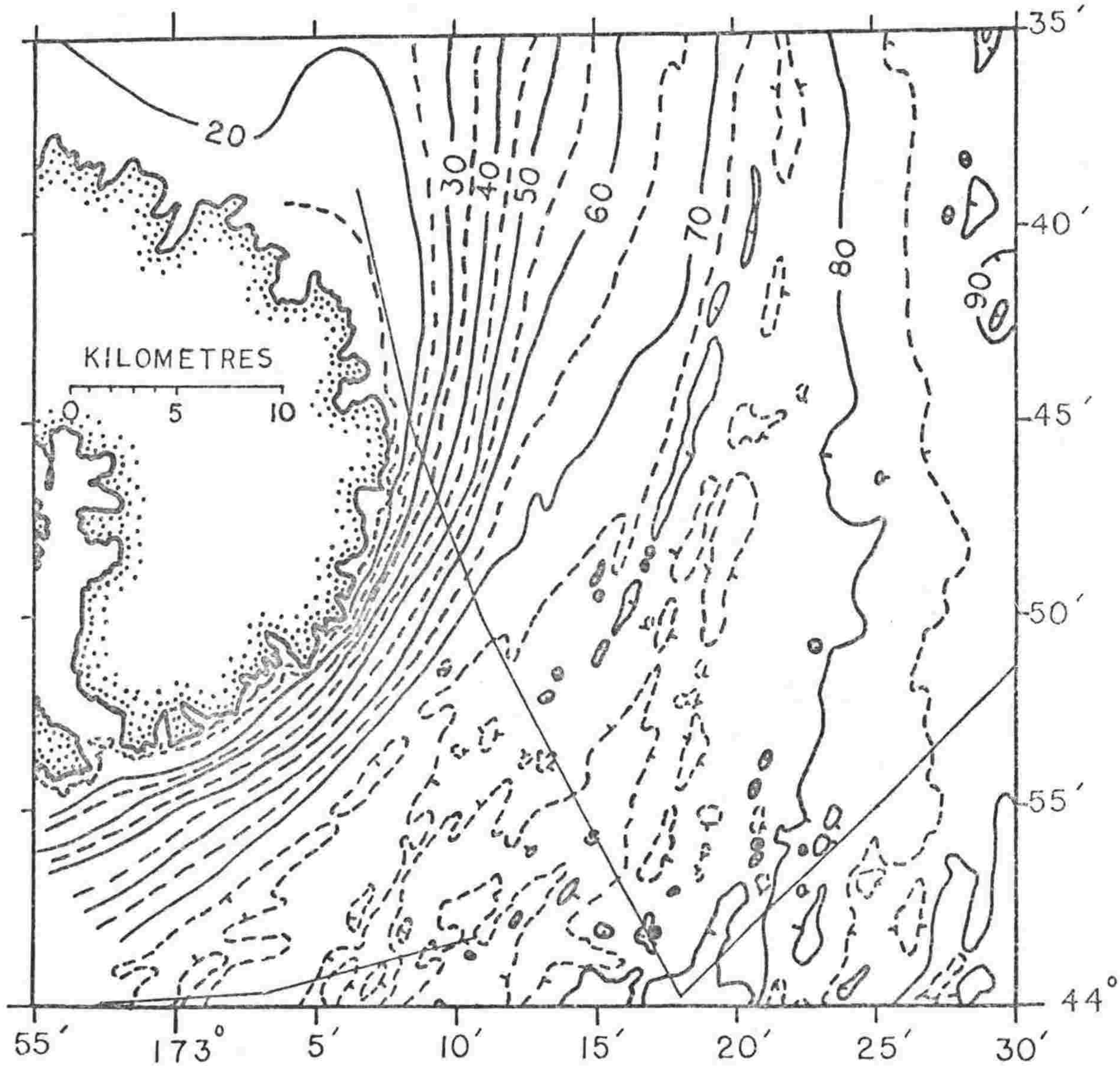


Figure B6. Bathymetry of a portion of the second order ridge-and-swale topography off Banks Peninsula. Locations of side-scan lines are shown. Contours in metres.

It generally stands above the rest of the continental shelf, its seaward limit being easily recognised along much of its length by a relatively steeply sloping, convex surface terminating abruptly against the more level shelf to the east. Within Pegasus Bay, the zone comprises a broad, very shallow trough, open to the north, and bounded on the east by a long, low bank, projecting north from the northeastern extremity of Banks Peninsula. Around Banks Peninsula it consists of a narrow, sloping apron 7 km wide. It widens in Canterbury Bight to a shallow platform 20 km wide. The surface on echograms is smooth and even.

Zone B:

In the northwestern corner of Pegasus Bay, where the coastline is rocky, a rough surface of low relief (Zone B) occupies a coastal belt about 10 km wide.

Zone C:

South of the Rakaia River, where the coastline is cliffed, Zone C lies adjacent to the coast. Zone C does not stand high above the rest of the shelf as does Zone A. Its slope is slightly steeper than the more level shelf to seaward, but merges imperceptibly with it at a depth of approximately 60 m. Bathymetric contours within the zone (Fig. B2) describe two adjacent, broadly convex, arcuate surfaces with a slope of 4-5 ft (1/700-1/800) lying offshore from the two great alluvial fan surfaces of the southern Canterbury Plains. It shows on echograms as a smooth surface with local wave-like features superposed. The wave-like features are asymmetrical, with steep slopes facing north to northwest; they have an amplitude of approximately 1 m and a wave length of approximately 2 km.

Zone D:

Zone D occupies a midshelf position and stretches from about 44°30'S northwards to Pegasus Canyon. Zone D generally has a much gentler slope than the landward zones (with the exception of Zone A in Pegasus Bay) and it terminates seaward at the line where the slope of the shelf again increases.

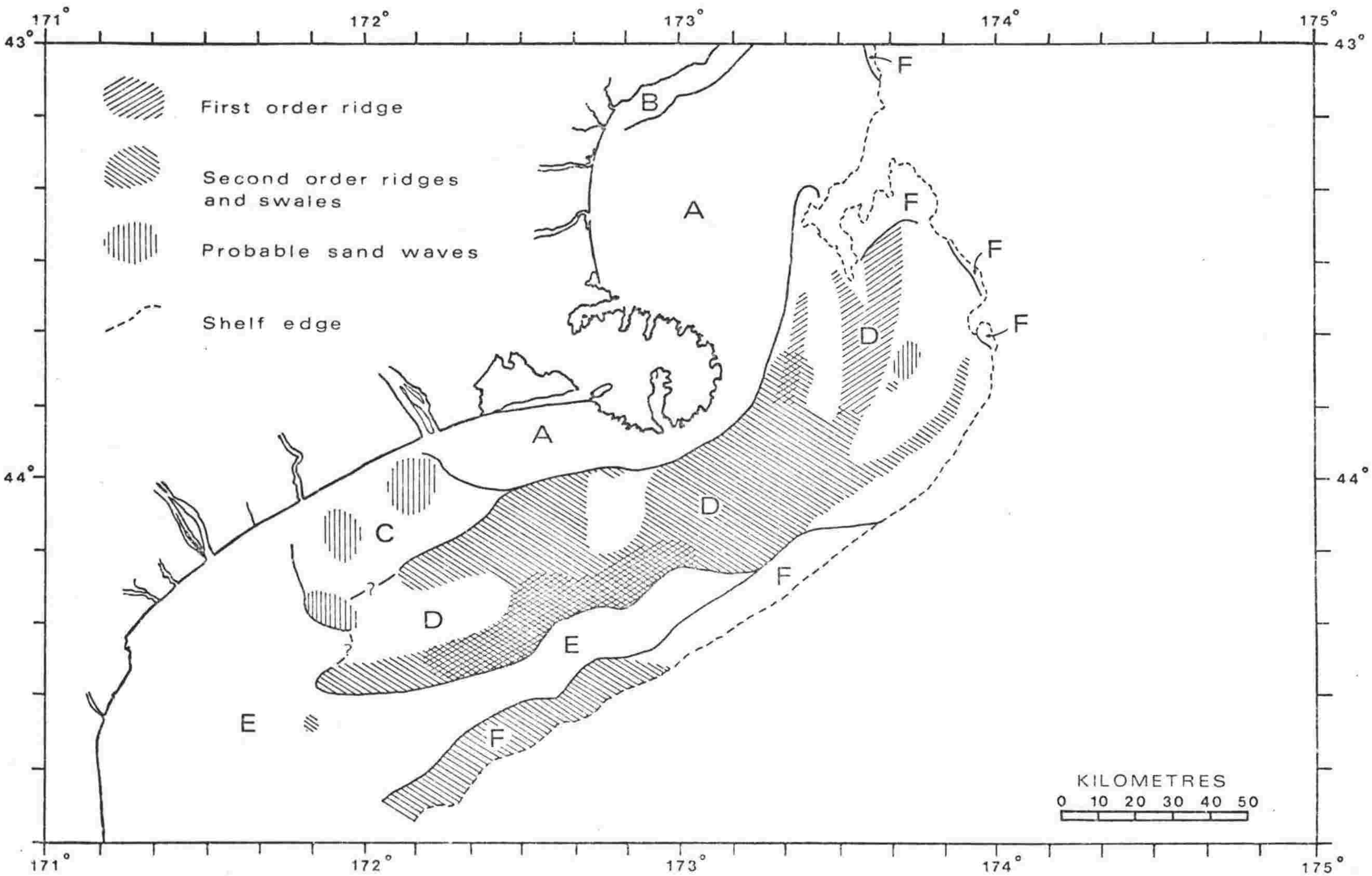


Figure B7. Geomorphic zones of the Canterbury continental shelf.

The surface of this zone is uneven and echograms display a gently rolling profile that is characteristic of ridge-and-swale topography. Echograms and microbathymetry show that the ridge-and-swale topography is made up of two distinct types of ridges : small ridges with heights of 1-14 m, widths of 1-2 km and lengths of 10 km or more; and very large ridges of generally similar height, but with widths of 9-13 km and lengths of 30-80 km. The large ridges are termed here "first-order ridges", and the small ridges, "second-order ridges". Second-order ridges are frequently superimposed upon first-order ones.

In Canterbury Bight, second-order ridges are concentrated in two long, roughly parallel bands, incompletely separated by patches of smooth bathymetry (Fig. B7). The bands run parallel to the general trend of the bathymetric contours, the landward band occurring along the southeastern margin of the nearshore Zone A, and the seaward one occurring at the line where the bathymetry again steepens seawards at about 80-90 m. A single first-order ridge underlies most of the outer band of second-order ridges. Where the continental shelf is narrow southeast of the peninsula, Zone D occupies most of the width of the shelf. Within it, neither a 2-fold areal distribution nor first-order ridges are evident and the zone is dominated from east to west without interruption by high second-order ridges with amplitudes up to 14 m.

North of latitude 43°55'S the second-order ridges become abruptly sparser, and within 10 km, virtually disappear. Two parallel first-order ridges, each with a trough on its landward side continue north to Pegasus Canyon (Fig. B5).

The eastern ridge of the pair lies just inside the 90 m isobath and is broad and indistinct (Figs B5, B7). Its crest is 84-86 m below sea level and its associated landward trough is, on average, 90 m below sea level. There are several relatively small closed basins in the trough, the deepest being 100 m below sea level. The ridge branches at about 43°40'S, the eastern branch appearing as a very subdued high east of the head of Pegasus Canyon and the western branch forming a narrower but more pronounced ridge which trends into the western side of the canyon head.

The western ridge has a depth of 74-76 m below sea level along its crest and its landward trough has a fairly consistent depth of 80 m below sea level. Ridge and trough both terminate at 43°35'S where they merge with steeper bathymetry off eastern Pegasus Bay. However, very low second-order ridges, persist to 43°30'S, beyond which point canyon-head valleys dominate the bathymetry.

East of the two first-order ridge systems just described, the shelf slopes gently eastwards for 25 km as a broad platform with an uneven surface, before steepening towards the shelf edge.

Zone E:

In Canterbury Bight the ridge-and-swale zone passes seaward and southward into a zone of smooth, even bathymetry. The seaward change is marked by an increase in slope; the southward change simply by a gradual disappearance of the ridges. The region of smooth bathymetry is designated Zone E. It forms a relatively steeply sloping (1/400) belt about 11 km wide running parallel to the shelf trend and extending only as far north as latitude 44°13'S. To the south it widens westward to include most of the shelf but undergoes subtle changes of slope which reflect the slopes of the distinctive zones to the north. From the coast down to a depth of 40 m, 20 km offshore, the slope is approximately (1/500), slightly convex and reminiscent of Zones A and C in central and northern Canterbury Bight. There are no wave-like features on the echograms, however, to suggest a link with adjacent Zone C, the slope becomes more gentle seaward, approximately (1/750) south of adjacent Zone D but is free of ridges. It then steepens again 40 km offshore at 70 m to approximately (1/400) with a northeastward extension forming the abovementioned belt to seaward of the ridge-and-swale zone.

Zone F:

Zone F is a terrace 4-9 km wide, that skirts most of the shelf edge of the study area. North of 44°25'S, the surface of the terrace is smooth and even; to the south it has a gentle second-order ridge-and-swale topography.

The depth of the terrace is variable. The depth of the lower limit of the terrace (the shelf break) ranges from about 130-180 m, and that of the nick point at the upper edge of the terrace from about 110-150 m. The greatest depths are found along the distal portions of the shelf east of Banks Peninsula, and the shallowest, on the narrow shelf at the northern edge of the study area and in the upper reaches of Pegasus Canyon. Intermediate depths prevail off southern Canterbury Bight.

The terrace is slightly anomalous in the region of Pegasus Canyon. It is 9 km wide along the southeast side of the main trunk of the canyon but is absent on the canyon's west and north sides. The terrace is also absent on the narrow portion of the shelf adjacent to Banks Peninsula.

SEDIMENTS

Sampling

A total of 332 surface samples and 23 cores were studied (Fig. B8). The cores and 224 of the surface samples were obtained during three cruises by the author on R.V. Tangaroa in 1973 and 1975. The remaining samples came from the N.Z.O.I. collection. The bulk of the surface samples were obtained with a modified Hayward orange-peel grab and a small number with a Deitz-Lafond grab. Cores were obtained with a 6 m Kullenberg-type piston corer.

The shipboard processing of samples was as follows. A representative subsample (to be used later for textural analysis) was taken from each grab sample. For sandy and muddy sediments, about 400 ml were taken; for very gravelly

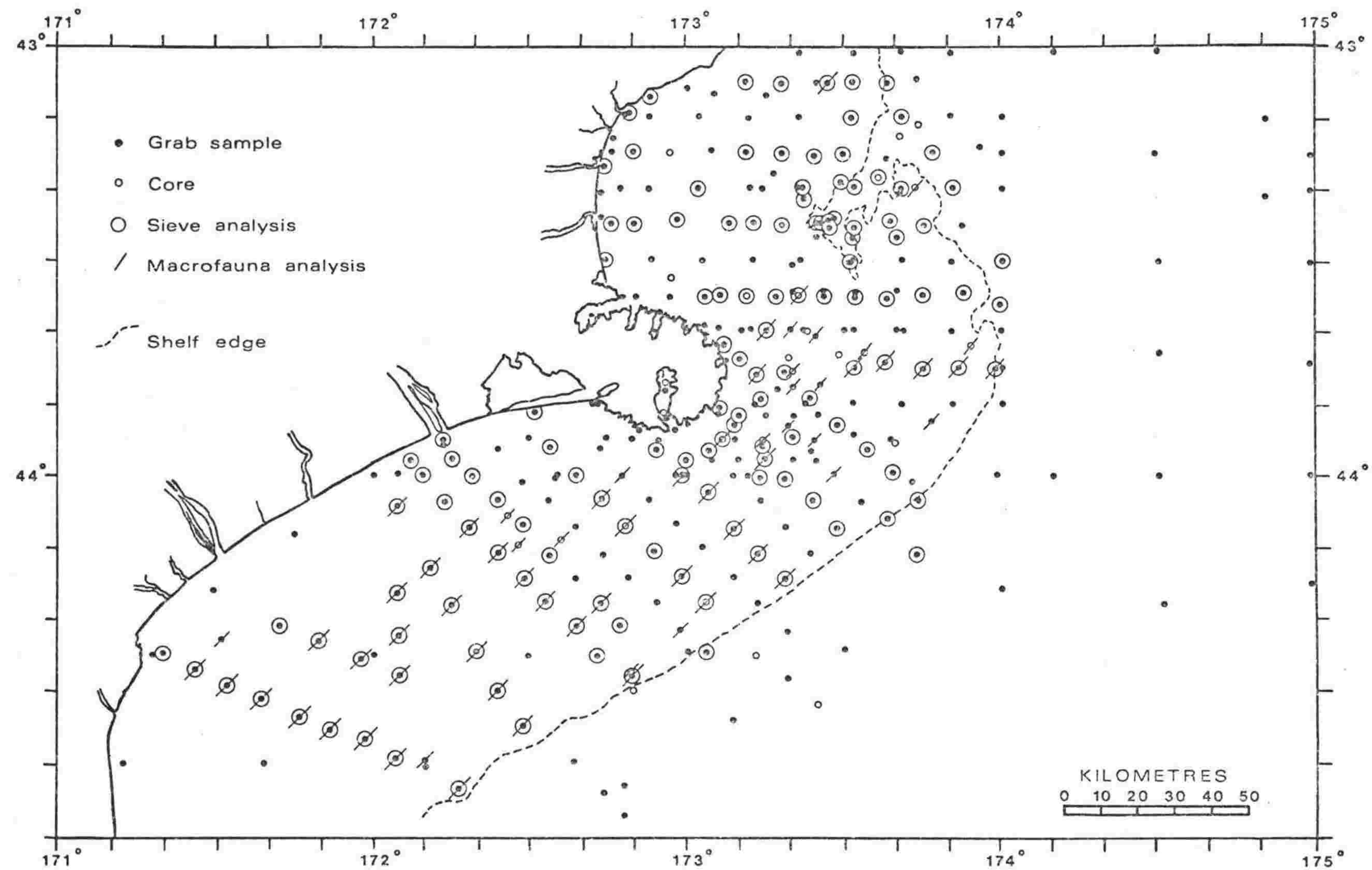


Figure B8. Locations of sample stations.

sediments, several litres were taken. The remainder of the grab sample was washed through a screen and the pebbles and shells retained were bagged. Living specimens were preserved in alcohol. Cores were stored vertically aboard ship in their plastic liners. On shore they were cut to storage size and stored horizontally prior to analysis.

Surface sampling was mostly on a grid pattern with a spacing of about 10 km. Coring was restricted to sites deemed important.

Analytical Methods

All the surface sediment samples obtained on the three Tangaroa cruises plus any relevant samples in the N.Z.O.I. collection were wet sieved with a 62 μ (4 ϕ) sieve. The relative amounts of lithic gravel, shell gravel, and sand (including carbonate) were determined by dry weight. The amount of mud was determined by the replicate method of Folk (1968). The colour of the dry sand fraction was noted (Geological Society of America, 1963). Pipette analyses were performed for a small number of samples only. A complete sieve analysis using the following mesh sizes (in ϕ units) was carried out on approximately half of the samples (Fig. B8; Appendices II, III) : -1, -0.5, 0, 0.5, 1.0, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, 3.00, 3.25, 3.50, 3.75 and 4.00 ϕ.

This sieve distribution was adopted after trial runs using a complete 1/4 ϕ interval on a number of representative samples had revealed the dominant grain-size populations. Material smaller than -1.0 ϕ was brushed through the large sieve with a paint brush to avoid abrasion of the commonly shelly and delicate gravel sized material. The 16 sand sizes (-0.5 to +4.0 ϕ) were sieved for 15 minutes on an Endecotts shaker which could accommodate 8 sieves at a time. Each sieve fraction was examined under a binocular microscope and the relative proportions of clastic shell sand, foraminifera and terrigenous sand were estimated. The carbonate sand content was low and did not significantly affect the fraction weights.

The pebbles that had been washed from the remainder of each grab sample after subsampling on board ship, were examined. The relative abundances of visually determined rock types in each of two size classes (-2 to -3 ϕ, and > -3 ϕ) were recorded (Tables B1, B2; <u>see</u> Fig. B9 for sample locations). Where there was sufficient gravel in a sample, 100 pebbles were identified; but in many samples, gravel was rare and smaller numbers had to be used.

The shells washed from the remainder of each total grab sample at 54 stations along selected sample lines (Fig. B8) were identified and the relative abundance of each species noted (Table B4).

Cores were split, logged and photographed (Appendix IV), those obtained on the first cruise (H347 - H474) being X-radiographed prior to splitting; shell horizons were sampled, the fauna identified (Table B5), and selected material submitted for radiocarbon dating (Table B3). In most cases, only a single species was submitted for dating. Where two species had to be used in order to make up the required sample weight, they were from closely related environments. Wherever possible shells of species restricted to shallow water were selected. The material submitted for dating was apparently free of borings and of biological or chemical encrustations.

In order to obtain an onshore reference collection for provenance study, 38 river, beach, and cliff grab samples were taken along the coast from the Waipara River south to Dunedin. River bed samples were collected where possible from midstream bars and beach samples from the wet shoreface below the most recent high water mark. The lithology of the gravels was determined visually. The modes in the sand fraction of selected samples were determined by standard sieving techniques with a 1/4 ϕ sieve spacing.

The textural size classes used are those of Wentworth (1922) and Folk (1968).

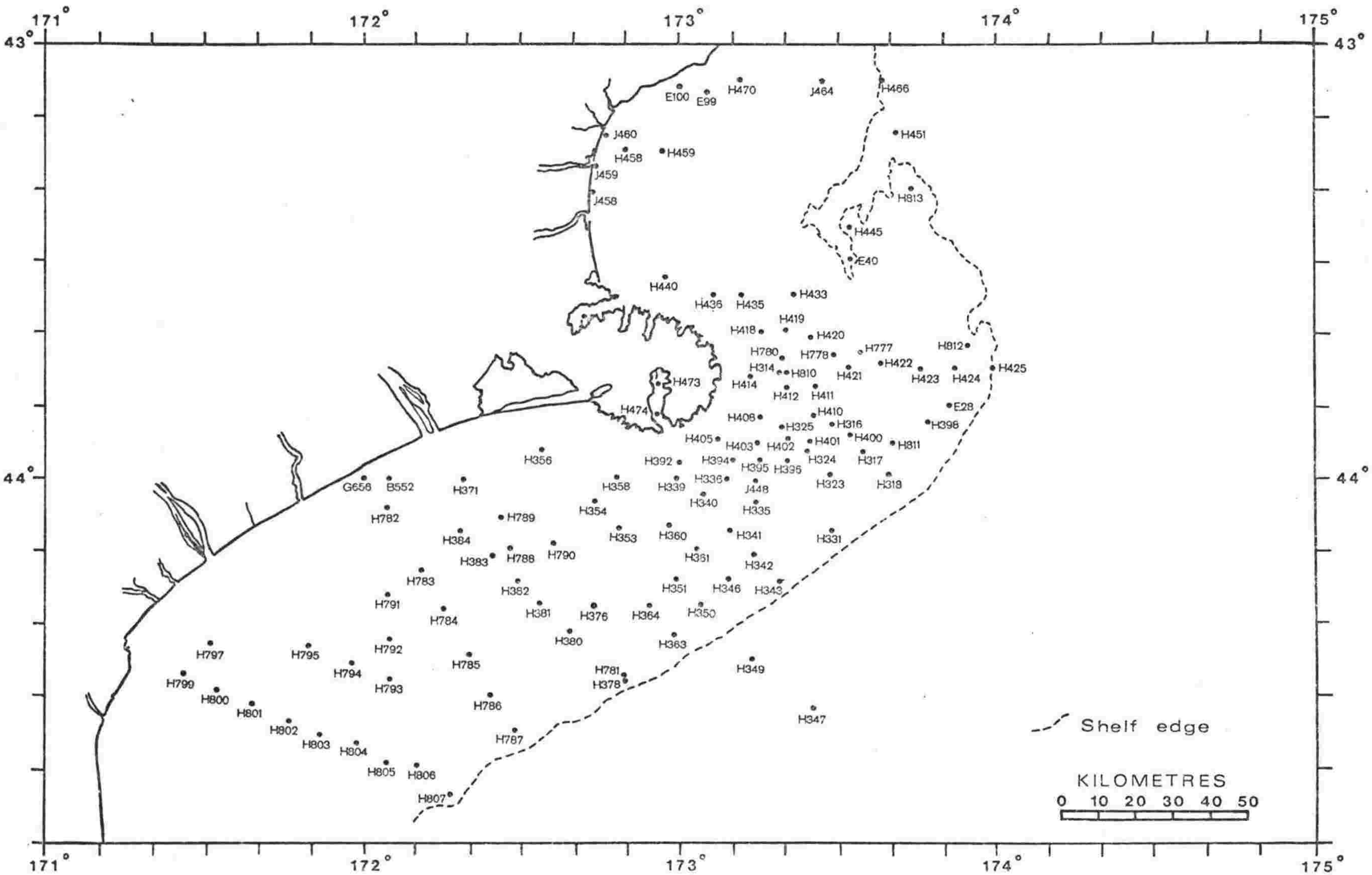


Figure B9. Locations of sample stations referred to by number in the text.

Selection of Textural Parameters

When interpreting the environment of continental shelf sediments from their textures, one has to remember that the sampling is by necessity crude relative to the complexity of the environment being studied.

During the last 18,000 years the sea has transgressed inland across the continental shelves of the world, and the whole of the shelf environment has changed. The fining-seaward sequence of contemporary clastic sediments is restricted to the inner shelf, while the sediments of the outer shelf comprise coarse detritus abandoned during the deglacial transgression, (e.g., Pilkey & Frankenberg 1964; Curray 1965; Emery 1968). It is becoming increasingly evident that the so-called "relict" sediments on the outer shelf, although not replenished by modern sediment input, have not remained static (e.g. Stewart & Jordan 1965; Belderson et al. 1971; Stubblefield et al. 1975; and numerour papers by Swift, and others). This is a "palimpsest" concept and, where energy conditions are high, we expect sediment waves, sand ribbons, linear ridges etc., to be actively forming from the atypical relict sediments and to be migrating across lag pavements. Conversely, where energy conditions are low, relict gravels may be thinly mantled with modern mud. Low or negligible rates of sedimentation on the outer shelf contribute to high concentrations of shell material which have accumulated on the surface over thousands of years. The surface of the continental shelf is therefore a surface having sediments that reflect different environments. For a particular sample the sediment texture may reflect both present conditions and past conditions, the two being very different.

A grab sample is an indiscriminate point sample. The top 10 cm or so of sea bed is collected by the sampler without regard to microstratigraphy. In an area where sediment composition may vary considerably over a space of metres, the spacing of samples will significantly affect results. Closely-spaced samples or selectively located ones (on the basis of side-scan sonar imagery or direct observation for instance), if accurately positioned, warrant detailed treatment. Widely-spaced grab samples, on the other hand, are only usefully interpreted by simple statistical measures.

The sediments on the Canterbury continental shelf exhibit the textural complexities outlined above. The grab samples were, by necessity, widely spaced. Accordingly the following simple textural parameters were used : gravel - sand - mud ratio, % lithic gravel, % shell gravel, % mud, and grain-size modes within the sand range.

The gravel - sand - mud ratio, including a provision for shell gravel content, was determined for each sample and used to construct a simple sediment distribution chart.

The remaining parameters for part of a "quick" modal analysis which was used with some support from sediment colour to map the principal sediment populations. Since grain-size modes tend to retain their integrity despite changes in transport energy or mixing with other sediment, they are an effective means of tracing discrete sediment populations with different spatial and temporal relationships through this complex zone of modern, relict and palimpsest sediments (cf. Curray 1961).

Sediment Chart

The format of the basic sediment distribution chart (Fig. B10) conforms fundamentally with that used by the N.Z. Oceanographic Institute, which is a modified form of the Folk (1968) method. However, the calcium carbonate content of the sand and mud was not differentiated since the terrigenous content is dominant in all except a very few samples on the continental slope at the extremity of the sampled area. The method of chart construction is as follows :

Two separate charts are contoured -

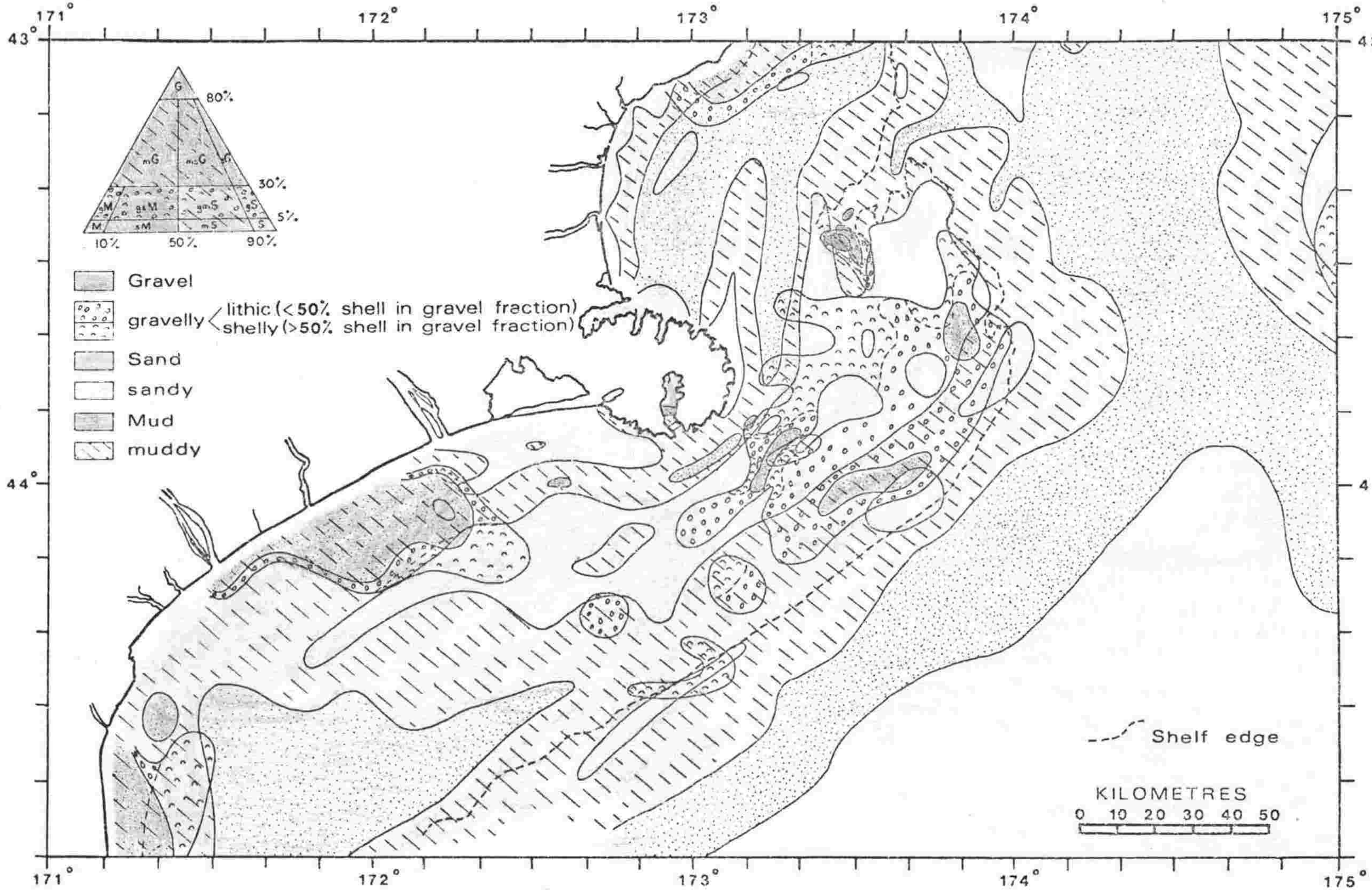


Figure B10. Surficial sediment distribution.

1. Gravel in the total sample at 80%, 30% and 5% by weight, and percentage carbonate in the gravel at 50%.
2. Sand in the fraction <2 mm at 90%, 50% and 10% by weight.

When combined on one chart the intersecting contours define areas occupied by particular grain-size classes. In areas where sample coverage is lacking (off the Ashburton River and south of Timaru) sediment boundaries were interpolated from Hydrographic chart notations and are hence subjective.

Gravel:

Gravel occurs in four areas and is, with few exceptions, dominantly lithic. It is found mixed with mud in the extreme northwest of the area along the Motunau coast up to 10 km offshore (Figs B2, B10). Gravel is also found in two locations off the south Canterbury coast. Between the Rakaia and Rangitata Rivers it occurs, with variable amounts of mud and sand as minor constituents, within 25 km of shore. South of approximate latitude 44°30'S it is found in a coastal belt 5-10 km wide that extends south of the Waitaki River. A diffuse and patchy zone of gravel and gravelly sediment exists on the outer shelf, extending from Pegasus Canyon to about 44°20'S. The highest gravel concentrations occur where the shelf is narrowest southeast of Banks Peninsula.

Gravel is absent from most of Pegasus Bay, from a narrow belt around and immediately adjacent to Banks Peninsula, from the far northern part of Canterbury Bight, and from the southern part of the Bight (except the coastal belt south of Timaru).

Sand:

Sand is almost ubiquitous on the shelf. It is present in quantity in all but the muddiest areas. Clean sand occurs along the coast of Pegasus Bay as a nearshore belt about 4 km wide; and in a 13 km wide coastal zone in northern Canterbury Bight. (This extends in a nearshore band around Banks Peninsula and then widens into a prominent lobe of sand and muddy sand that projects northwards well into Pegasus Bay.)

Clean sand also occurs in a zone on the middle shelf around Banks Peninsula along with gravels. At the northern end, clean sand extends right out to the shelf edge and into Pegasus Canyon; at the southern end, it fades gradually and unevenly into sandy mud. A belt of muddy sand occurs along the southeastern margin of this zone separating it from the shelf edge.

Isolated areas of clean sand form a chain along the shelf break from end to end of the study area.

Mud:

Mud with less than 10% sand is rare on the Canterbury continental shelf. Sandy mud is found in a large patch on the middle shelf at the southern end of the area. It grades laterally landwards, seawards and northwards into muddy sand. Its southern limit is unknown.

Most of Pegasus Bay is covered by sandy mud which extends north of Banks Peninsula in a broad band. Mud with less than 10% sand is confined to the deeper northern part of the bay and to a small patch at the southern end adjacent to Banks Peninsula. It is also found within the bays. It grades laterally landwards and seawards into muddy sand. Within the sandy mud zone in Pegasus Bay is the tongue of sand which was described above. The northern limit of the sandy mud is beyond the boundary of the study area at approximate latitude 42°52'S (Cullen & Gibb 1966). The zone extends south around Banks Peninsula as a very narrow band 6 km offshore which then trends west into Canterbury Bight. A small area of mud less than 10 cm thick, overlying muddy sand, was sampled off the Rakaia River mouth.

Beyond the edge of the continental shelf, the mud content of the sediment increases and most of the slope is covered with sandy mud and mud. The sediments become more calcareous with increasing distance from the shelf. Sandy mud and mud are common at the bottom of the submarine canyon off Pegasus Bay.

Distribution of Modes

Runs of complete -4 ϕ to 4 ϕ size analyses on a representative number of samples defined the major modal classes. These were sufficiently wide apart to be easily read from the histograms. They are :

Mode I - gravel (excluding shell gravel) -4 ϕ to -1 ϕ
Mode II - medium sand 1.1 ϕ to 1.4 ϕ
Mode III - fine sand 1.9 ϕ to 2.6 ϕ
Mode IV - very fine sand 2.9 ϕ to 3.4 ϕ

Shell gravel is present in sufficient amounts in many samples to form a gravel mode. It defines areas of low terrigenous sedimentation (relict sediments) or areas of active erosion. The parameter "weight % shell gravel" has been accordingly treated as a mode.

Lithic gravel also indicates areas of erosion or low sedimentation on the shelf, and is significant for indicating past nearshore environments. Its concentration is expressed as weight % gravel in the sediment after removal of shell gravel.

In many places, mud is the dominant sediment. Although pipette analyses were not done as a matter of routine, samples that were so analysed, contained a mode ranging from 4.5-6.5 ϕ (coarse to medium silt). For the purposes of this study the sizes within the mud range are not differentiated. Because extremely polymodal sediments are the rule rather than the exception on the continental shelf, the mud content is considered to be a more reliable indicator of the energy of the environment than the standard deviation of grain sizes. A low mud content in the sediment is taken to imply a high energy environment. The mud distribution is shown in Fig. B11.

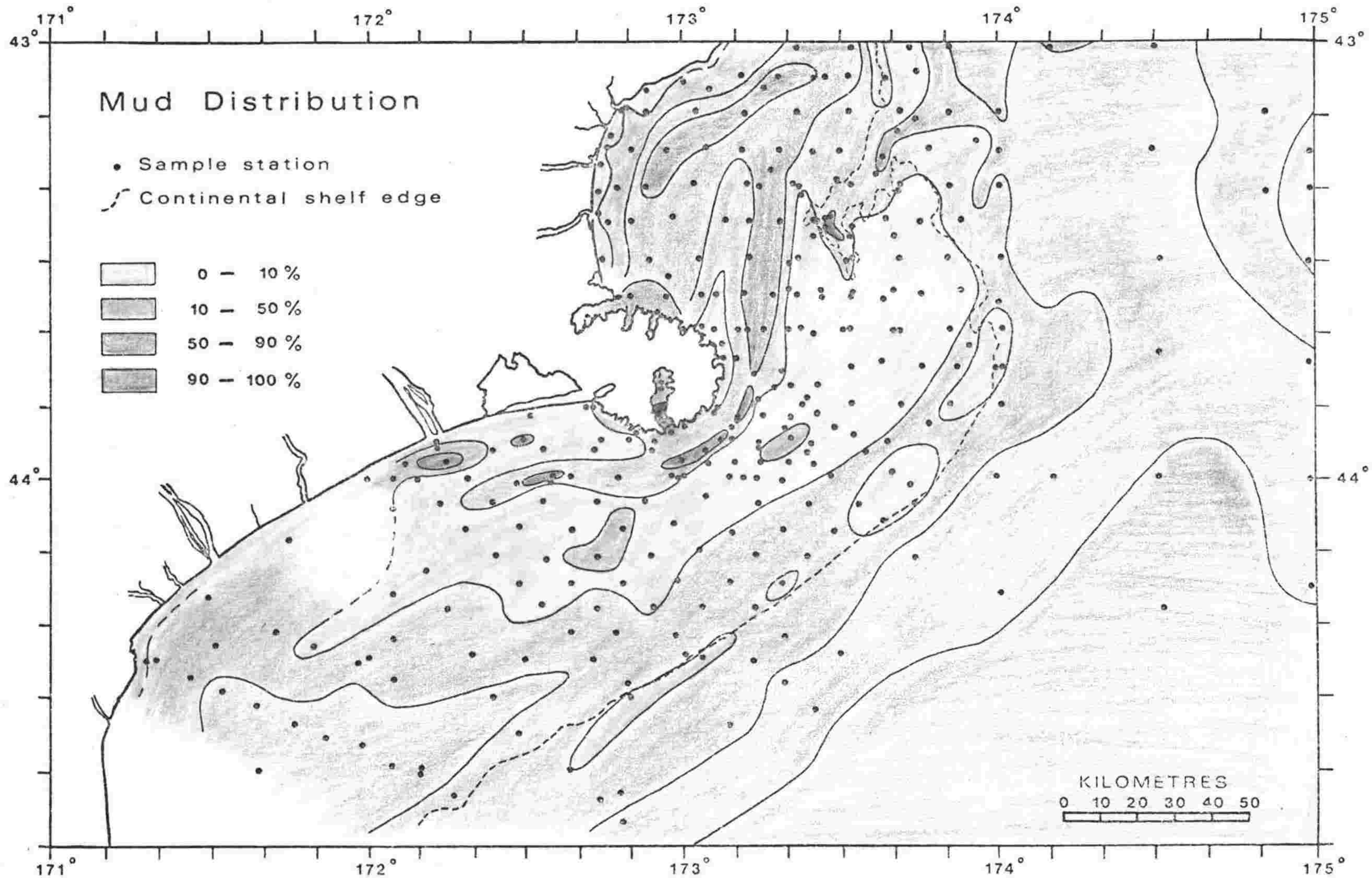


Figure B11. Mud distribution.

Lithic Gravel (Mode I) Distribution

The lithic gravel content of the sediment is calculated thus :

wt lithic gravel ÷ (wt total sediment - wt shell gravel) x 100

The results are contoured at 0.1%,2%, 5%, 10%, 20%, 40% and 80% in Fig. B12 .

It is seen that all the gravel zones of Fig. B10 (except that off the Waitaki River which is inferred from the Hydrographic chart) are greatly expanded in Fig. B12. Lithic gravel is distributed right across the muddy shelf at the northern end of the study area, and the lithic gravel zone in Canterbury Bight extends in a lobe to two-thirds of the way across the shelf. Off Banks Peninsula, the gravel belt widens to include almost the entire shelf and, within it, there are interesting trends. The largest is a relatively narrow gravel band that runs parallel to, and a few kilometres inside of, the edge of the continental shelf for most of its length (from 44°35'S in the south to Okains Canyon in the north). Two parallel shorter bands appear in the patches of gravel occupying the middle shelf off Banks Peninsula.

Shell Gravel Distribution

The shell gravel content is calculated thus :

wt shell gravel ÷ wt total sediment x 100

Results are contoured at 1%, 2%, 4%, 8% and 16% on the chart (Fig. B13).

The most obvious feature of Figs B12 and B13 is the broad correlation between shelly areas and lithic gravel areas. Even some of the minor trends within the lithic gravel are reflected in the distribution of shell gravel. The clearest matches are those of the zone fringing the inside of the continental shelf edge and the narrow band of high gravel concentration on the middle shelf off Banks Peninsula.

Some relatively high shell concentrations do occur

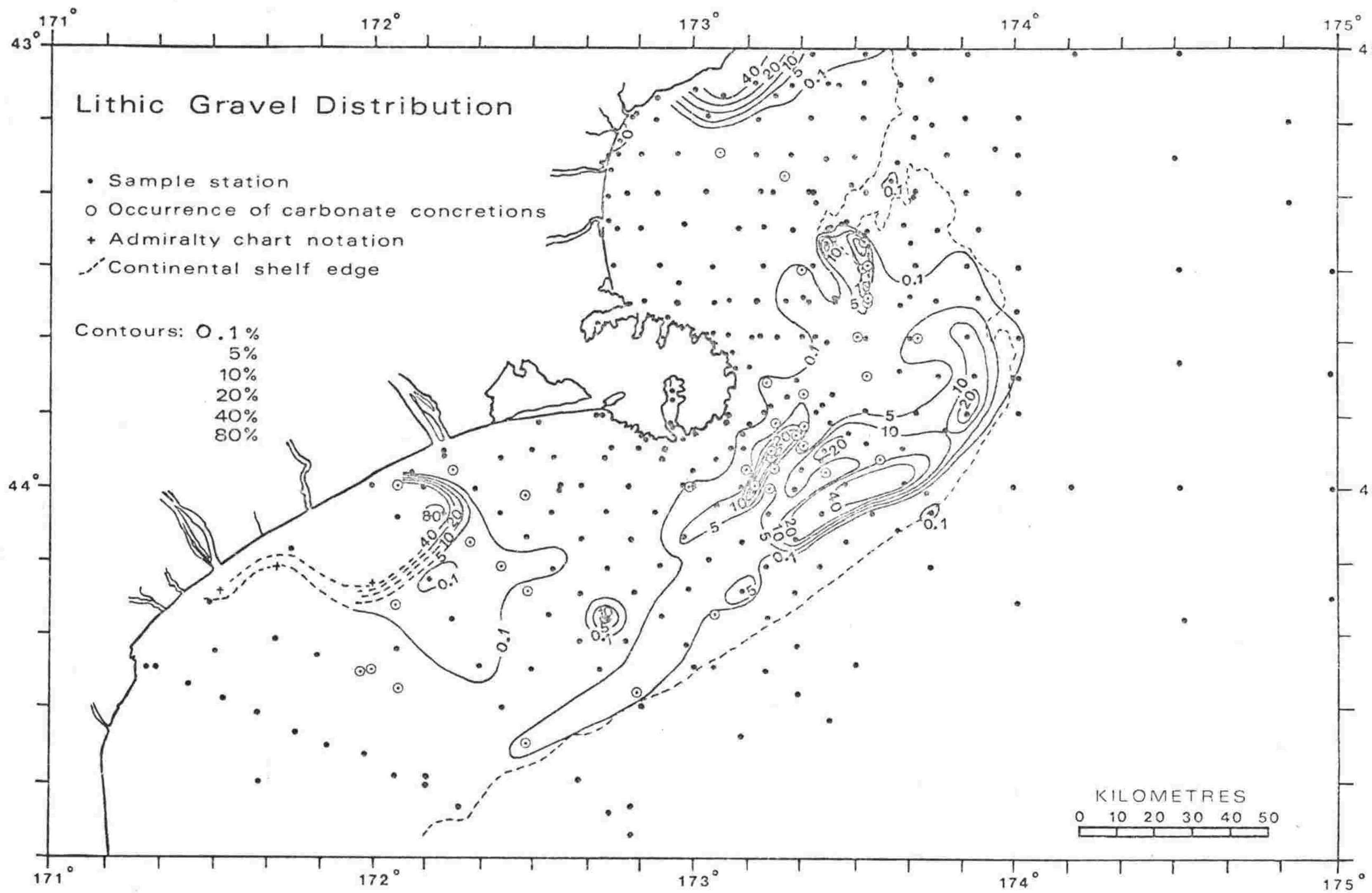


Figure B12. Lithic gravel distribution.

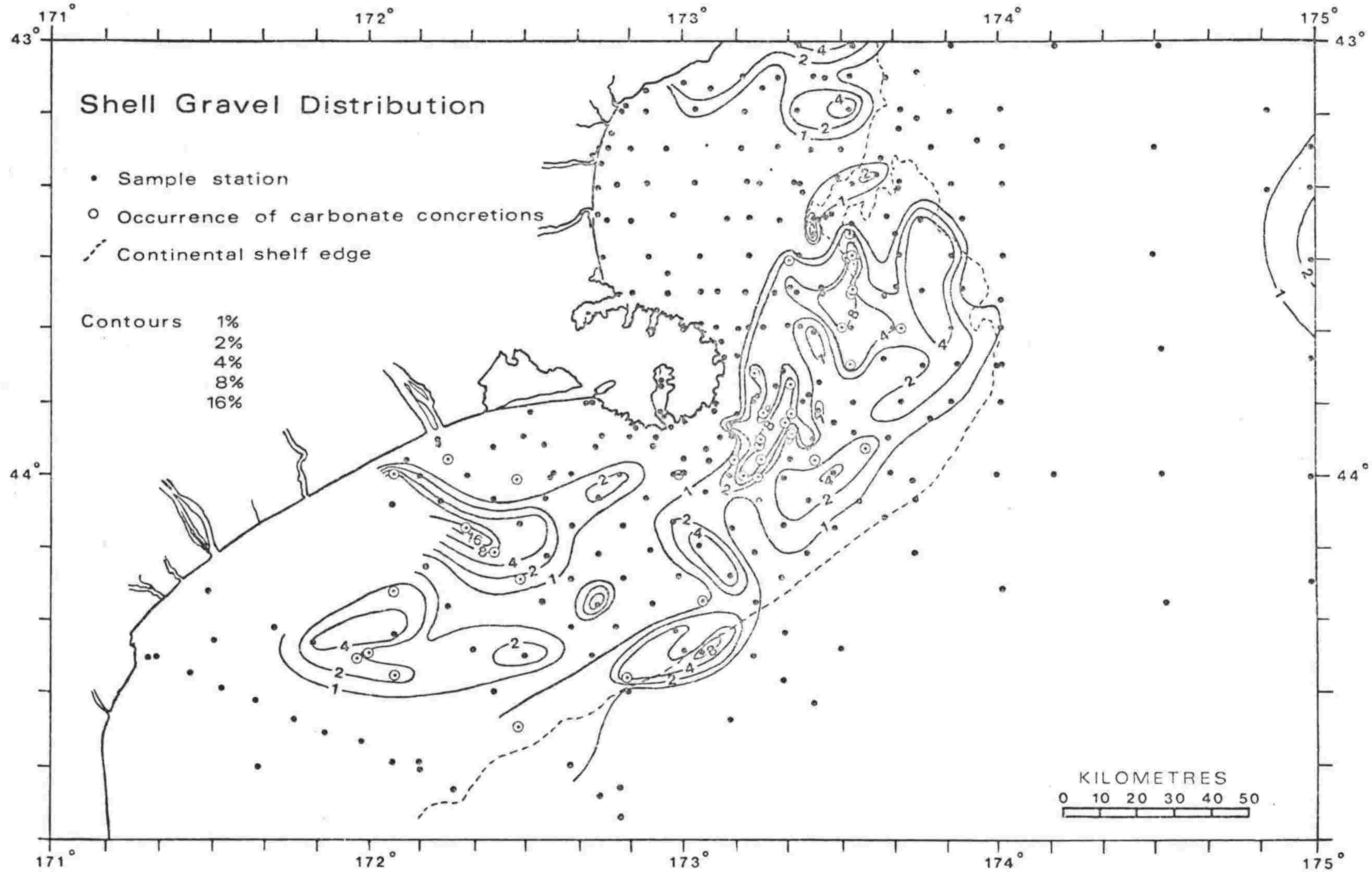


Figure B13. Shell gravel distribution.

where gravel is absent or rare. A large, isolated, 2-pronged patch of 1-4% shell gravel occurs in the southern part of Canterbury Bight in the muddy sand that separates the mud at the south end of the bight from the sand of the central part. The sand of the central bight, which contains only a trace of lithic gravel, has a shell content locally as high as 23%, though generally less than 8%. The zone of high shell concentration runs directly seaward from the lithic gravel zone south of the Rakaia River.

Concretions

Concretions occur frequently in areas of high shell concentrations (Figure B13). Even where most common, they account for less than 1% of the sediment. They consist of gravel, sand, mud and shells cemented with calcium carbonate, the sand having moulds from which shells have been partly or wholly dissolved away (Plate B1). The calcium carbonate cement is assumed to have come from the dissolved shells. Concretions were not included in the textural or petrological analyses because of their very different environmental significance.

Sand (Modes II, III and IV) Distribution

(i) Distinction of sand modes

The distribution of significant sand modes is simple and has been combined in Figure B14. The modes were picked to the nearest class midpoint from the histograms of the analysed samples (Appendix III); see Figs B8 and B9 for sample locations.

Mode II (1.1ϕ to 1.4 ϕ - medium sand) occurs infrequently, forms a very small fraction by weight of the sample, and is in a size range that is largely contaminated by shell fragments. It occurs almost exclusively in association with high concentrations of lithic gravel, but is not detectable in hand specimens. Its distribution has therefore not been separately mapped and its presence, where detected by sieve analyses, is noted on Fig. B14 by a circle.

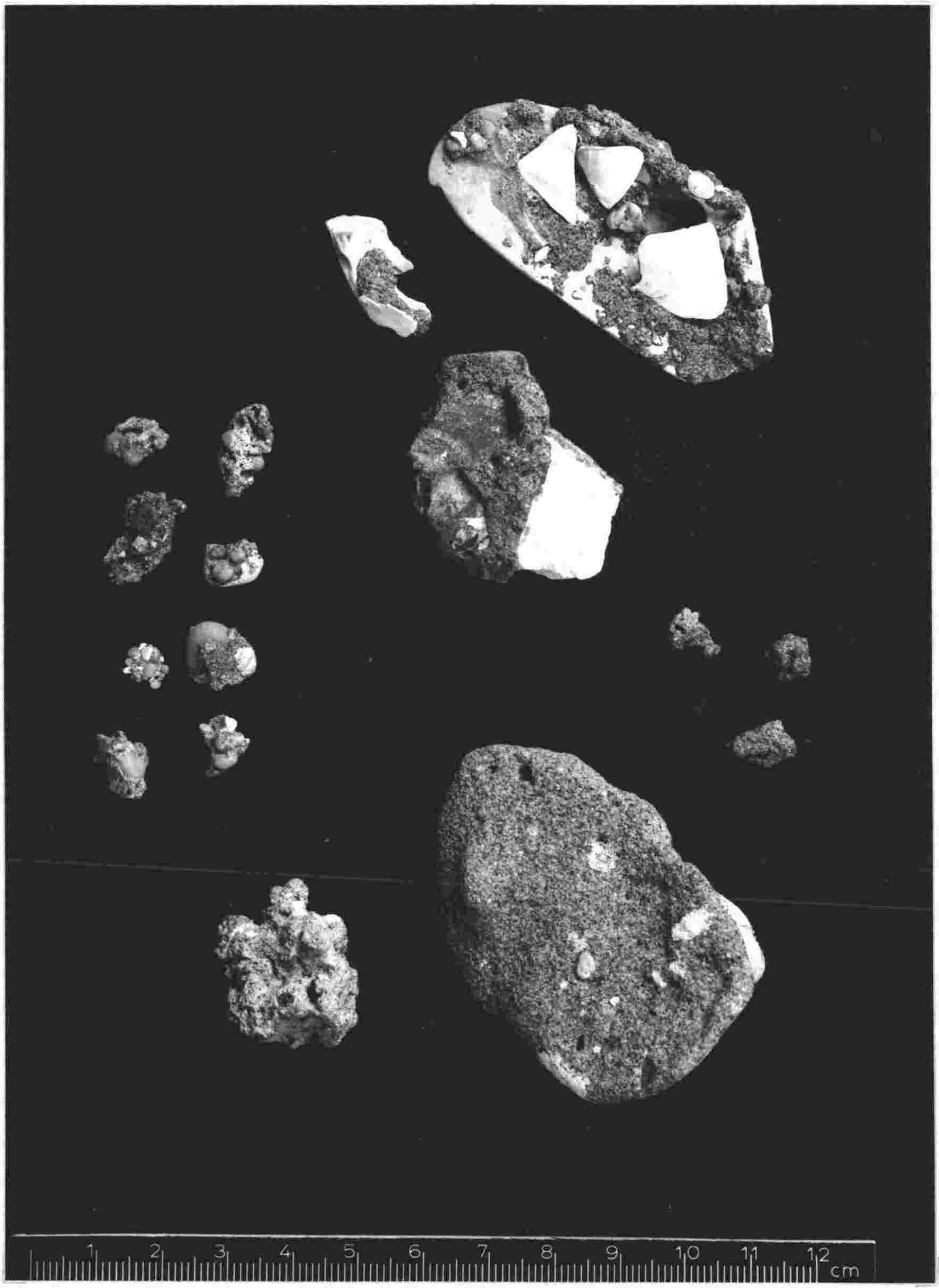


Plate Bl. Concretions from the surface of the continental shelf. Lower left from station H339; lower right from station H383; the rest from station H395.

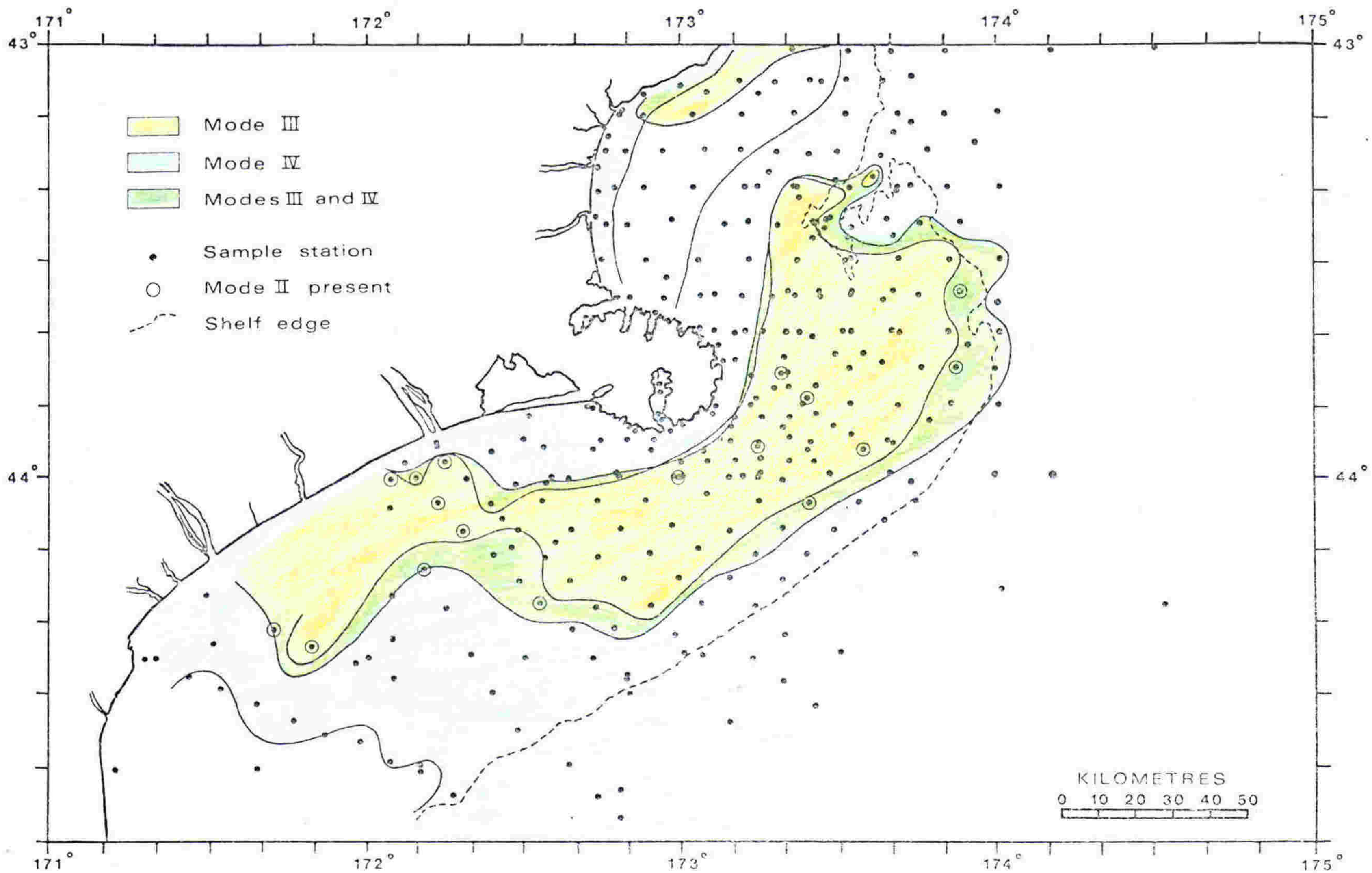


Figure B14. Distribution of sand modes.

The two most abundant modes, Mode III (1.9 ϕ to 2.6 ϕ - fine sand) and Mode IV (2.9 ϕ to 3.4 ϕ - very fine sand) can be distinguished in hand specimen by their grain-size and colour. The colours of the dry sands are olive brown (5Y 5/2-5 to 5Y 6/2-4) for Mode III and greenish grey (10Y 6/2 to 5GY 5-6/1) for Mode IV. By comparing the texture and dry colours of the unanalysed sand samples to those of the analysed samples, the presence or absence of Mode III and/or IV in the former was determined. The good correlation between dry sand colour and grain size mode is shown by Figures B14 and B15. In samples where uncertainty existed, notably in zones of mixing and around Pegasus Canyon, the sample was analysed by 1/4 ϕ sieving. In all, 139 samples were mechanically analysed and 191 were visually appraised.

(ii) Distribution of Modes III and IV

Except in very muddy areas, such as central Pegasus Bay and southern Canterbury Bight, Modes III and IV, considered together, cover the shelf. Each mode has its own region, with some marginal overlap (Fig. B14).

Mode III occurs primarily in the widespread belt of sand and gravel that occupies the middle and outer shelf around Banks Peninsula. It is also found in the northwest corner of Pegasus Bay and on the inner shelf of central Canterbury Bight. It is closely assocated with Mode I (lithic gravel) and shell gravel, but its occurrence is not restricted to high concentrations of gravel. It is common in upper Pegasus Canyon textures and on the upper continental slope opposite Mernoo Saddle.

Mode IV is found in coastal Pegasus Bay, in outer Pegasus Bay, and northernmost Canterbury Bight, in a thin band around Banks Peninsula, in southern Canterbury Bight, in a long belt just inside the shelf break, on the whole upper continental slope, and in Pegasus Canyon. Mode IV is usually associated with greater or less amounts of mud and, except in zones of mixing with Mode III, it is generally

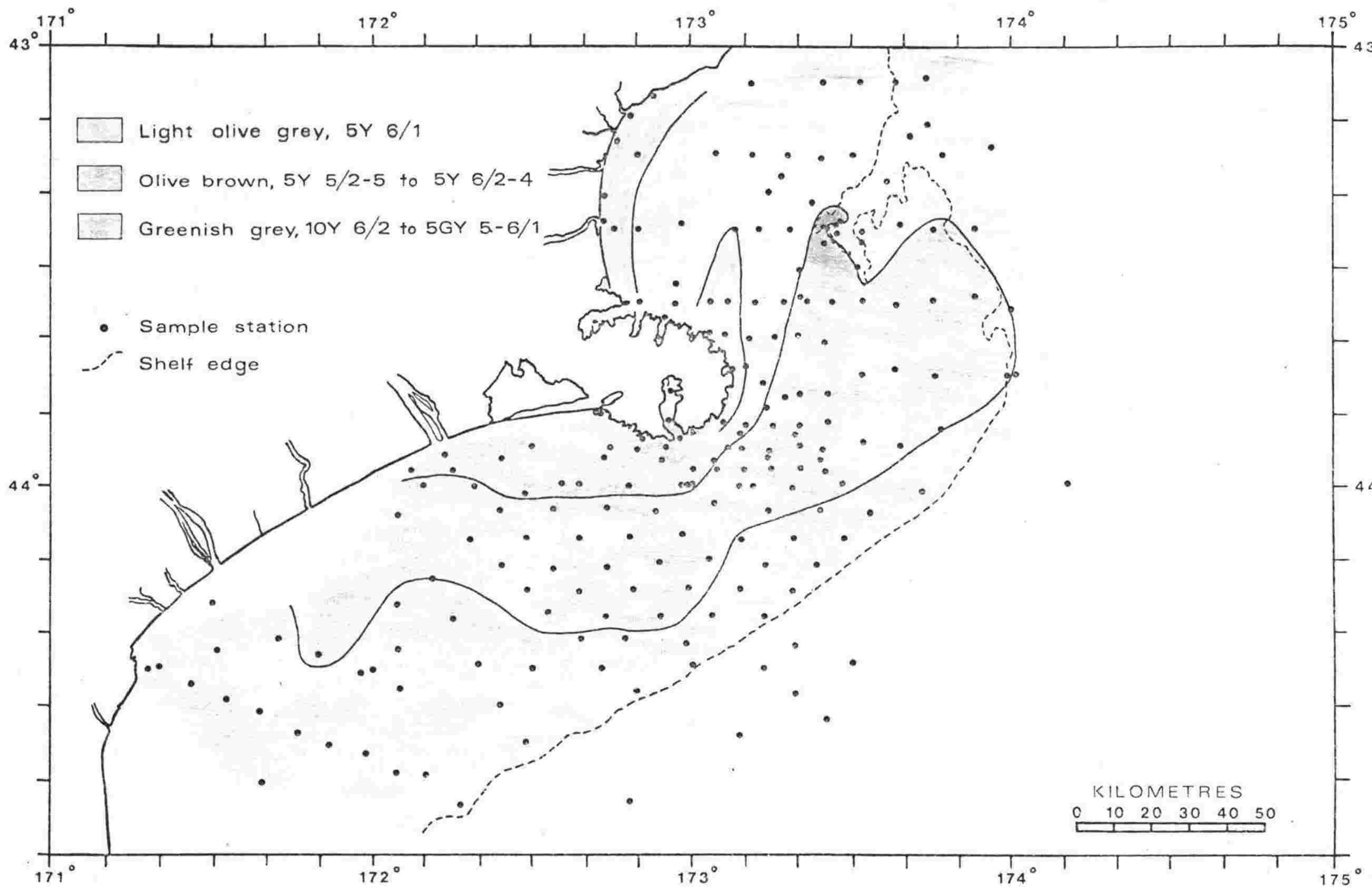


Figure B15. Distribution of sand colours. Colours are based on Rock Color Chart, Geological Society of America (1963).

free of lithic gravel. High shell concentrations occur with this mode at a few places.

Origin of the Sediments

Provenance of the Gravel

The gravel on the outer continental shelf is almost exclusively of pebble and granule size, the size commonly locally referred to as "pea gravel". Clasts larger than -4 ϕ (16 mm diameter) are uncommon and most have diameters less than -3 ϕ (8 mm). The gravel of inner Canterbury Bight tends to be large. Diameters of -3 ϕ (8 mm) to -5 ϕ (32 mm) predominate. All the gravels are rounded to well-rounded (Powers 1953, roundness scale) and tend to be dominantly spherical to rod-shaped. The rare pebbles larger than -5 ϕ (32 mm) in diameter are frequently disc-shaped but their rounding is good.

Two suites of rock contribute to over 90% of the gravel in the samples - greywacke and quartz (Tables B1, B2; see Figure B9 for sample locations). Pebbles designated as greywacke in the table include unmetamorphosed sandstones (generally of greywacke type) and argillite. The quartz pebbles are composed of massive quartzite, foliated micaceous and chloritic quartzite, vein quartz, and vein or lenticle quartz with adhering schistose wall rock. The quartz pebbles are usually iron-stained to a bright orange.

Schist occurs as a rare but persistent rock type in the gravels. It includes schist, phyllite and foliated sandstone or semischist, usually of greywacke origin, showing lenticular streaks or stretched grains. Other rocks present in the gravels are rare and occur sporadically. They include chert, felsite, intermediate and basic volcanic tuff, porphyry and scoria, orthoquartzite, jasper, agate and indeterminate rocks.

When the relative proportions of greywacke (including argillite) and quartz in the -3 ϕ to -2 ϕ (4-8 mm) fraction of each sample are plotted on a map, a clear cut pattern emerges (Figure B15). The size fraction chosen is the

TABLE B 1

LITHOLOGY OF PEBBLES IN THE -3Ø TO -2Ø SIZE RANGE*

	Quartz	Schist	Greywacke (+ Argillite)	Other Rocks	Grains Counted
B552	(6)	-	(94)	-	16
E 28	68	-	32	-	22
E 40	25	-	70	5	20
E 99	-	-	(93)	7	15
E100	-	-	(100)	-	11
H314	95	-	5	-	42
H316	65	-	33	2	46
H317	89	-	11	-	82
H318	82	-	18	-	44
H323	70	1	25	4	100
H324	83	1	15	1	100
H325	94	5	1	-	100
H335	91	1	6	2	100
H336	92	1	3	4	100
H339	23	-	68	9	22
H340	83	2	13	2	100
H341	100	-	-	-	54
H346	70	1	24	5	100
H351	93	1	3	4	119
H360	95	-	1	4	100
H361	81	2	16	1	168
H364	80	-	20	-	69
H376	80	-	17	3	100
H378	81	-	14	5	57
H380	63	-	37	-	46
H382	16	-	79	5	19
H383	22	1	72	5	100

TABLE B1 (cont'd)

	Quartz	Schist	Greywacke (+ Argillite)	Other Rocks	Grains Counted
H384	13	2	78	7	100
H394	89	-	3	8	35
H395	93	-	5	2	105
H396	94	-	6	-	100
H398	88	-	11	1	100
H400	69	1	21	9	104
H401	66	1	32	1	100
H402	92	-	5	3	100
H403	89	1	3	7	100
H408	91	-	8	1	100
H410	78	1	19	2	115
H412	90	2	4	4	100
H418	78	-	18	4	27
H421	80	1	15	4	100
H423	78	-	19	3	100
H424	74	-	21	4	99
H425	80	2	14	5	63
H470	3	-	91	6	100
H782	2	-	95	3	100
H785	75	-	22	3	32
H787	(78)	-	(22)	-	9
J448	93	-	4	3	71
J458	-	-	(100)	-	8
J459	-	-	(100)	-	5
J460	2	1	83	14	79

* The underlined sample numbers in Table B1 appear in the analysis of coarser gravel in Table B2.

largest one that provides a sufficient number of pebbles to make a valid plot of the distribution.

It can be seen from Fig. B16 that, close to shore both in Canterbury Bight and in Pegasus Bay, the gravel is almost entirely greywacke, while on the middle and outer shelf the gravel is a mixture of greywacke and quartz. At midshelf, off Banks Peninsula, there is an elongate zone of gravel that is particularly rich in quartz.

Only 15 samples contained enough gravel larger than $-3\ \phi$ (8 mm) to be useful (Table B5). The ratio of greywacke to quartz in them is generally higher than in the smaller sizes but the distribution pattern is otherwise unaffected.

The rare pebbles composed of rocks other than greywacke and quartz consist of rock types that outcrop on the eastern side of the South Island but do not provide any useful data on source areas.

However, different source areas can be determined for the greywacke and quartz.

The gravel will have come from the eastern side of the South Island opposite the study area, and because of the northward drift, from some distance to the south, that is from about latitude 43°S to the southern end of the South Island.

The bed-rock geology of the South Island is shown by Fig. B3. In Canterbury, south to latitude 45°S, it is almost entirely greywacke; and in Otago, from latitude 45°S to latitude 46°S, it is almost entirely schist. The boundary is gradational and it is generally accepted that the schist is metamorphosed greywacke. There are rare quartz veins in most of the greywacke and abundant quartz in the schist, but no other evident bedrock source for the quartz. There is no lack of quartz gravels that have been derived from the schist (Gage 1957; Speden 1971; Andrews 1973, and others). They occur as Upper Cretaceous to mid-Cenozoic strata resting on the schist, as Quaternary gravels in river

TABLE B2

LITHOLOGY OF PEBBLES LARGER THAN -3∅

	Quartz	Schist	Greywacke (+ Argillite)	Other Rocks	Grains Counted
B552	-	-	(100)	-	5
E 99	-	-	(100)	-	3
G656	2	-	95	3	20
H323	26	-	66	8	144
H324	(50)	-	(50)	-	16
H340	69	2	23	6	51
H346	41	9	47	3	34
H376	63	1	33	3	202
H384	2	-	96	1	78
H395	64	2	29.5	4.5	44
H396	(67)	-	(33)	-	18
H398	56	2.5	39	2.5	36
H401	65	-	32	3	60
H424	51	3	46	-	61
H470	3	-	94	3	30
H782	-	-	98	2	100
J459	-	-	(100)	-	15

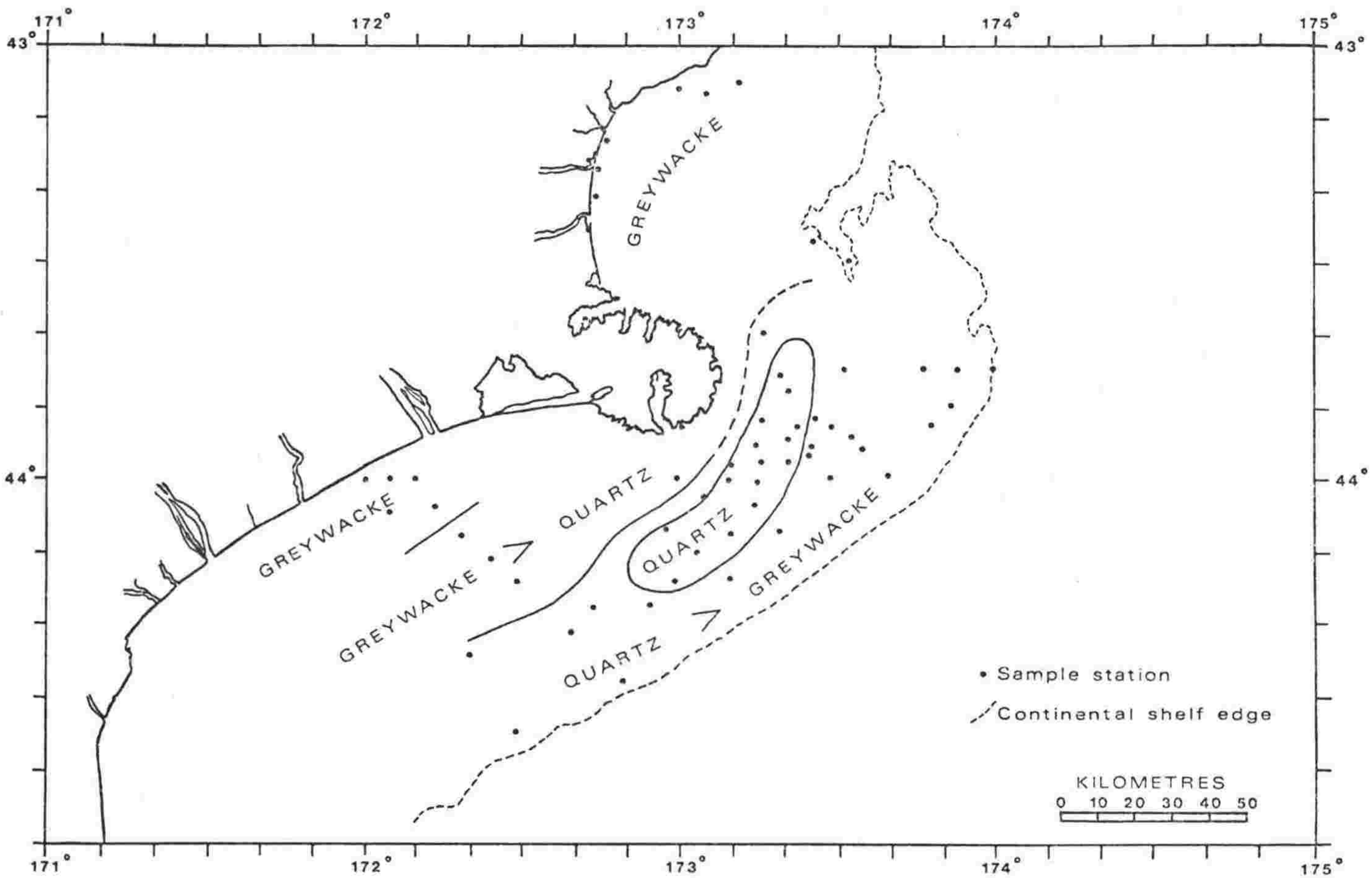


Figure B16. Distribution of the dominant rock types in the -2ϕ to -3ϕ gravel fraction. The greywacke field contains more than 90% greywacke (+ argillite). The quartz field contains more than 90% quartz. The mixed areas are subdivided according to the relative proportions of the two rock types.

valleys draining the schist, as Holocene and present-day beach gravels along the Otago coast, and as relict gravels on the continental shelf of Otago from the Clutha River (46°20'S) to the Otago Peninsula (45°45'S). There are no corresponding quartz gravels from the greywacke.

Two different sources are thus suggested for the greywacke and quartz on the Canterbury shelf.

The greywacke is presumed to have come directly from the rivers draining the greywacke region to the west. Features of the quartz gravels indicate a schist provenance for the quartz : schist is present in small amounts in most of the quartz gravels but is absent in the greywacke gravels and much of the quartz is itself clearly schistose.

The relative lack of greywacke pebbles on the outer shelf is explained by the Pleistocene profile of the Canterbury rivers (Fig. B17). The profile shows that the gradient decreased very quickly about 10 km seaward of the present shore. The onshore section of the profile is drawn along the crest of the Rakaia fan; the offshore section is drawn from a 3.5 kHz seismic record and represents the closest approximation to the surface of the coastal plain during the Last Glacial maximum, free of any later sediment blanket . Such an abrupt change in river gradient has been explained by Yatsu (1955) and others by a very rapid reduction of bed load grain size, and this is assumed to have occurred in the Pleistocene rivers of Canterbury. It is thus assumed that greywacke gravel from the Canterbury Plains was not transported across the exposed shelf in very large quantities during the Last Glacial.

The absence of quartz pebbles on the inner shelf is probably due to two factors operating towards the end of the deglacial transgression :

1. the establishment of the rugged coastline of Otago with its embayments and headlands which would have halted the northward flow of quartz gravel;
2. the greatly increased supply of greywacke from cliff

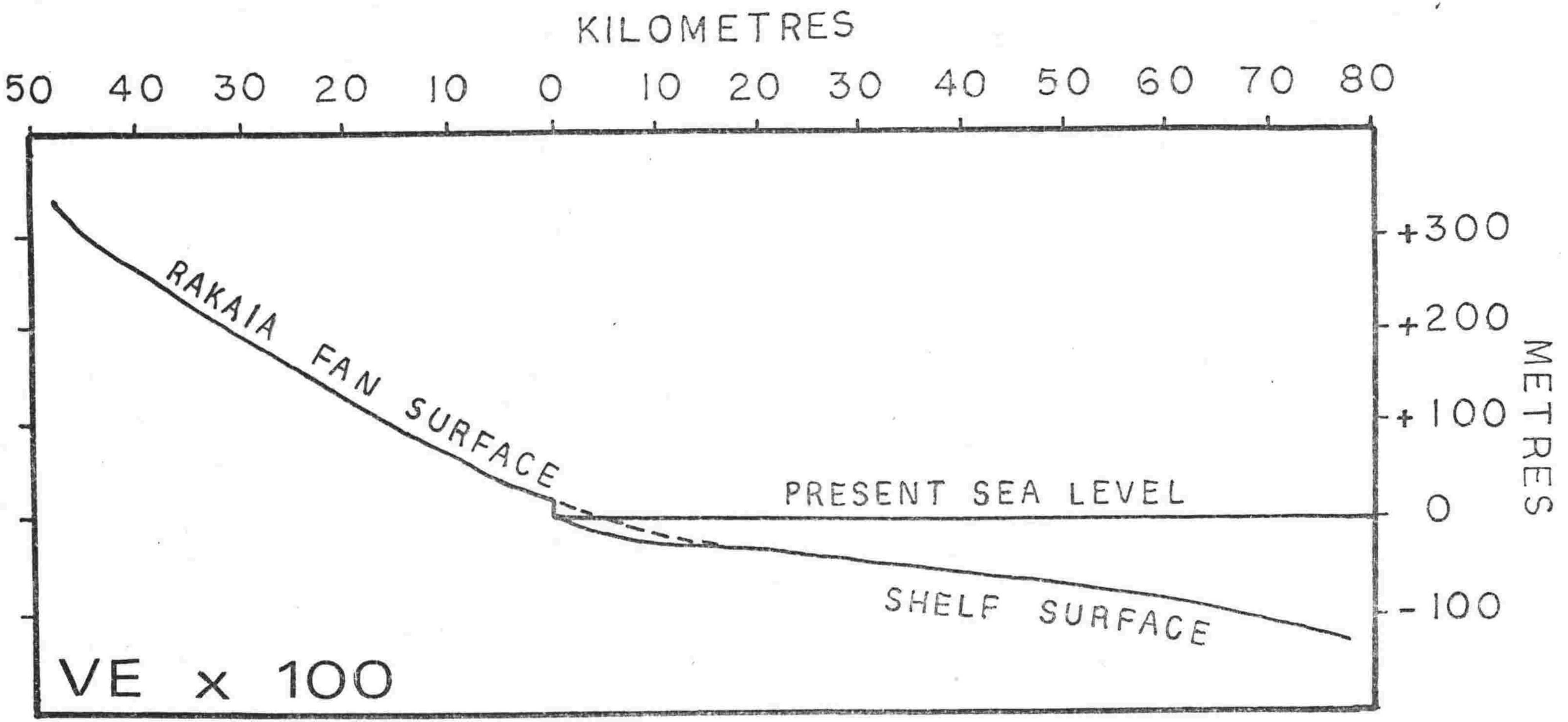


Figure B17. Gradient profile of the crest of the Rakaia fan surface (Canterbury Plains) and the adjacent continental shelf stripped of modern sediment. See Figure B2 for location of profile.

erosion of the Canterbury fans (see Fig. B17) and the Waitaki fan, and from downcutting of the riverbeds as the local ice retreated.

Provenance of the Sands

The sand grains on the continental shelf range from very angular to well-rounded (scale of Powers 1953). They are in general better rounded than those in the modern river beds and in the sea cliffs of Pleistocene river alluvium. The degree of rounding tends to increase with grain size. Hence, Modes III and II sands are better rounded than the finer Mode IV sands. Modes II and III contain a large proportion of iron-stained sand grains which Mode IV does not. Both these facts could suggest a separate provenance for each mode. However, Emery (1965) and Judd et al. (1969) have stated that a yellow surface rind may be acquired during Pleistocene subaerial weathering, and Swift & Boehmer (1972) have suggested that yellow colour can be simply a function of grain size in marine shelf sands. That larger sand grains are often better rounded than the smaller ones is well known.

The composition of grain size fractions representing the different modes from various places on the shelf was determined petrographically. As a rule, 200 grains were identified in each thin section but in several slides of poor quality, only about 100 grains could be identified. Potassium feldspar was distinguished by staining with sodium cobaltinitrite (Bailey & Stevens 1960).

The results are presented in Table B3 (see Fig. B9 for sample locations). There are no consistent differences between the sand composition of one mode and another; nor are there obvious differences in the sand composition from one place to another. The great majority of the sand grains are from sedimentary rock and the remainder from low grade metamorphic rock. This is consistent with the two sources mentioned above - greywacke and schist. The glauconite in samples from northwestern Pegasus Bay (H458) was traced to

TABLE B 3

PETROGRAPHIC ANALYSES OF THE SANDS

Explanation of Terms:

Quartz - includes single crystal, finely and coarsely polycrystalline, strained and unstrained grains; grains with sericite and chlorite inclusions; and some grains with secondary overgrowths

K-feldspar - includes altered and unaltered orthoclase, microcline and some perthite

Plagioclase - altered and unaltered

Chlorite

Biotite

Muscovite

Glauconite

Other minerals - including zoisite, hornblende, sillimanite, serpentine, rutile

Indeterminate minerals

Sedimentary rock fragments - mainly sandstone, argillite, some chert

Metamorphic rock fragments - mainly greenschist facies, pelitic and psammitic (greywacke) derivatives

Igneous rock fragments - includes volcanic and leucocratic plutonic rocks

Indeterminate rock fragments

TABLE B3 - COMPOSITION OF TERRIGENOUS FRACTION OF REPRESENTATIVE SAND MODES EXPRESSED AS %

Grains Counted	Indeterminate Rock Fragments	Igneous Rock Fragments	Metamorphic Rock Fragments	Sedimentary Rock Fragments	Indeterminate Minerals	Other Minerals	Glauconite	Muscovite	Biotite	Chlorite	Plagioclase	K-feldspar	Quartz	Mode	Sample No.
195	4.1	0	13.8	13.3	0	0	0	0	0	0.5	3.6	7.6	57.5	IV	H331
194	4.6	0.5	5.2	16.0	1.0	0.5	1.0	0.5	0	0.5	7.2	8.5	55.5	IV	H343
192	1.6	0.5	12.0	15.1	1.1	0	0	0	0	0	5.2	6.5	59.2	III	H351
199	8.5	0.5	7.5	23.1	1	0	0	0.5	0.5	0	1.5	10.4	47.4	IV	H356
196	4.6	0.5	12.2	41.8	0	0	0	1	0	0.5	0.5	9.6	30.2	III	H371
99	5.1	1	6.1	33.3	1	0	1	0	0	0	0	2.7	39.7	III	H395
99	9.1	0	4	26.3	1	0	0	0	0	0	0	8.2	61.4	III	H423
199	6.5	0	12.1	16.6	1	0.5	0	0.5	0	0.5	1.5	9.8	52.0	IV	H436
197	2.5	0.5	4.6	13.2	2	0.5	0	0	0.5	0	3	6.9	65.7	IV	H445
197	2	0.5	3	17.8	0	0	4.1	0	0.5	0	3	6.8	62.2	IV	H458
192	0	1	7.3	20.4	0.5	0.5	0	0.5	0	0.5	3.6	8.5	57.7	IV	H466
163	2.5	2.5	6.1	32.5	0	0	0.6	0	0	0	2.5	12.8	40.6	III	H470
152	5.3	2.6	9.2	46.7	0	0.7	0	0	0	0	2.0	8.7	24.9	III	H782
118	3.4	0	8.4	12.7	0.8	1.7	0.8	0.8	0	0.8	0	3.8	66.6	IV	H784
196	2.6	0.5	11.2	20.9	0.5	0.5	0	1.5	0.5	1.0	1.5	7.6	51.6	IV	H793

the Waipara River where it is being eroded from Tertiary strata.

The modes of the offshore sands are about the same as the input grain size modes from the south and from the west. The spectrum of sand grain size modes reported by Andrews (1973) on the Otago continental shelf, is very similar to that on the Canterbury shelf. His modal class II 1.3 - 2.4 ϕ like the combined modes II and III of this paper, shows a relatively high degree of rounding, is generally iron-stained and is associated with the gravel mode. His modal classes III (2.5 - 2.95 ϕ) and IV (3.05 - 3.4ϕ) together are like Mode IV of this paper in distribution (close inshore and outermost shelf) and in physical appearance (not iron-stained and more angular overall). Andrews concluded that all his modes, although of different ages, were derived mainly from the Otago rivers draining schist.

The sands of the major Canterbury rivers and the sands of the Pleistocene river gravels in the coastal cliffs of Canterbury Bight (Appendix III) have the same modal sizes as the three sand modes offshore.

gravel facies, Maoricolpus roseus, Tawera spissa and Pulastra largillierti are common.

The muddier facies of the nearshore and inner shelf, including the bays of Banks Peninsula, commonly contain dead Atrina zelandica shells (supporting barnacles and worm tubes), thickets of branching bryozoa and chitinous polychaete tubes, and wood fragments.

The assemblage of shells on the middle and outer shelf is considered to actually comprise two faunas; one relict and dating from when the sea was lower and depths shallower, and one younger and consistent with present-day water depths. The two faunas are distinguished from each other by state of preservation of individual shells, by abundance (the younger being more abundant than the older), and by the accepted depth range of the shells. The total fauna, and the accepted depths of the important species are set out in Table B4 (see Fig. B9 for sample locations). The depths are those of Powell (1961), Morton & Miller (1968), and of Rodley (1961) who summarised and evaluated depths given by Suter (1913), Powell (1947, 1958, 1961), Fleming (1950), Dell (1956), Marwick (1957) and Hulme (1958).

The following is a list of the important shells that are thought to belong to the younger, deep-water fauna. They are the most pervasive species, and in contrast with the relict fauna, are well preserved.

Chlamys (Mimachlamys) subsp.; Diplodonta globus; Nemocardium pulchellum; Notocallista multistriata; Pleuromeris zelandicus; Saccella bellula; Scalpomactra scalpellum; Tellinella charlottae; Zeacolpus (Stiracolpus) symmetricus; the small Myadoras : M. antipoda, M. huttoni and M. novaezelandiae, and the Nuculidae : Enucula strangei and Nucula strangeiformis.

The following is a list of the important shells that are thought to belong to the older (relict) shallow-water fauna. The shells are frequently abraded, corroded, and bored.

Species	Approximate Depth range (m)
BIVALVIA	
Anomia sp	
Atrina zelandica (Gray, 1835)	0 – 30
Aulacomya maoriana (Iredale, 1915)	0
Barbatia novaezealandiae Smith, 1915	
Cardita aoteana (Finlay, 1927)	
Caryocorbula (Anisocorbula) zelandica (Quoy and Gaimard, 1835)	0+
Chione (Austrovenus) stutchburyi (Gray, 1828)	0 – 4
Chlamys (Mimachlamys) incl. {C. gemmulata gemmulata (Reeve, 1853); C. zelandiae (Gray, 1843)}	10+
Chlamys (Zygochlamys) delicatula (Hutton, 1873)	0 – 40
Cuspidaria sp incl {C. fairchildi Suter, 1903; C. traill (Hutton, 1873); C. willetti Fleming, 1948}	
Diplodonta (Zemysina) globus (Finlay, 1927)	0 – 80
Divaricella (Divalucina) huttoniana Vanatta, 1901	
Dosinia (Austrodosinia) anus (Philippi, 1848)	0 – 20
D. (Dosinia) lambata (Gould, 1850)	
D. (Kereia) greyi (Zittel, 1864)	20 – 40
Dosinula zelandica (Gray, 1835)	
Escalima regularis Powell, 1955	
Gari sp. incl {G. lineolata (Gray, 1835); G. stangeri (Gray, 1843)}	0 – 20
Glycymeris (Glycymerula) modesta (Angas, 1879)	0 – 80
Lima colorata colorata Hutton 1873	
Limatula maoria Finlay 1927	0 – 220
Mesopeplum convexum (Quoy and Gaimard, 1835)	10 – 200
Modiolarca impacta (Hermann, 1782)	
Modiolus areolatus (Gould, 1850)	
Myadora biconvexa Powell 1927	
M. novaezelandiae Smith 1880	
M. striata (Quoy and Gaimard, 1835)	0 – 20
Myadora sp incl {M. antipoda Smith, 1880; M. boltoni Smith, 1880; M. subrostrata Smith, 1880}	8+
Mytilus edulis aoteanus Powell, 1958	
Neilo sp incl {N. australis australis (Quoy and Gaimard, 1835); N. rugata Dell, 1956}	10 – 275
Nemocardium (Pratulum) pulchellum (Gray, 1843)	10 – 200
Notocallista (Striacallista) multistriata (Sowerby, 1851)	20 – 75
Nuculidae incl {Ennucula strangei (A Adams, 1856); Nucula strangeiformis Dell, 1956}	0+
Ostrea sp	0 – 30
Paphies (Mesodesma) subtriangulatum (Wood, 1828)	0 – 10
P. (Paphies) australe australe (Gmelin, 1791)	0 – 10
P. (Tavia) ventricosum (Gray, 1843)	
Pecten novaezelandiae novaezelandiae (Reeve, 1852)	
Pleuromeris zelandica (Deshayes, 1854)	0 – 200
Proleda lanceolata (Hutton, 1885)	
Pullastra largillierti (Philippi, 1847)	0 – 20
Saccella bellula (A Adams, 1856)	8 – 300
Scalpomactra scalpellum (Reeve, 1854)	0 – 90
Spisula aequilateralis (Deshayes, 1854)	0 – 20
Tawera spissa (Deshayes, 1835)	
Tellinella charlottae (Smith 1885)	
T. huttoni huttoni (Smith, 1885)	
Thracia vegrandis (Marshall and Meredith, 1918)	
T. vitrea (Hutton, 1873)	
Thracia sp	
Venericardia purpurata (Deshayes, 1854)	0 – 30
Zenatia (Zenatia) acinaces (Quoy and Gaimard, 1835)	0 – 110
Bivalvia indet	
GASTROPODA	
Amalda (Gracilispira) novaezelandiae novaezelandiae (Sowerby, 1859)	0 – 200
Antisolarium egenum (Gould, 1849)	4 – 70
Argalista fluctuata (Hutton, 1883)	
A. nana Finlay 1930	
Austrofusus (Austrofusus) chathamensis Finlay 1928	
A. (A.) glans (Roeding, 1798)	
Austrofusus sp	
Buccinulidae Cominellidae	
Cylichna thetidis Hedley, 1903	
Emarginula striatula (Quoy and Gaimard, 1834)	0+
Epitonium sp incl. E. philippinarum (Sowerby, 1844)	
Glaphyrina sp	
Leporemax fusus fusus (Quoy and Gaimard, 1843)	
Maoricolpus roseus roseus (Quoy and Gaimard, 1843)	0 – 70
Maoricrypta (Zeacrypta) monoxyla (Lesson, 1830)	0+
Maoritomella albula (Hutton, 1873)	
Marginellidae incl {Marginella (Volvarinella) subfusula Powell, 1932; M. (Sinuginella) pygmaea (Sowerby, 1846)}	
Maurea sp incl M. foveauxana (Dell, 1950)	
Micantapex angustatus Powell, 1940	
Microlenchus huttoni (Smith, 1876)	
Naticidae incl {Proxiuber australe (Hutton, 1878); Tanea zelandica (Quoy and Gaimard, 1832); Uberella vitrea (Hutton, 1873)}	
Patellids indet	
Pervicacia tristis (Deshayes, 1859)	0 – 40
Phenatoma novaezelandiae (Reeve, 1843)	0 – 60
Poirieria kapua Dell, 1956	20 – 200
Pyramidellidae incl. Agatha georgiana (Hutton, 1885)	
Splendrillia aoteana Finlay, 1930	
Trochidae incl {Coelotrochus tiaratus (Quoy and Gaimard, 1834); Thoristella viridis (Gmelin, 1791)}	4 – 110
Xymene ambiguus (Philippi, 1844)	
Xymene sp	0 – 20
Zeacolpus (Stiracolpus) symmetricus (Hutton, 1873)	4 – 130
Zeatrophon sp	
Zegalerus tenuis (Gray, 1867)	0+
Zethalia zelandica (A Adams, 1854)	0 – 20
Gastropoda indet.	
SCAPHOPODA	
Dentalium (Fissidentalium) zelandicum (Sowerby, 1860)	
D. (Antalus) nanum Hutton, 1873	30 – 200
BRACHIOPODA	
Neothyris lenticularis (Deshayes, 1839)	
Terebratella sanguinea (Leach, 1814)	
OTHER GROUPS	
Arthropoda	
Cirripede fragments	
Crustacean fragments	
Bryozoa bun-shaped, branching, encrusting	
Echinoid fragments	
Polychaete tubes	
Flabellum rubrum (Quoy and Gaimard, 1833)	
Ophiuroidea	

Station No.: H323, H324, H325, H339, H340, H341, H342, H343, H350, H351, H353, H354, H358, H363, H376, H378, H380, H381, H382, H383, H384, H385, H398, H411, H412, H414, H418, H419, H420, H421, H422, H423, H424, H425, H782, H783, H784, H785, H786, H787, H791, H792, H793, H794, H795, H797, H799, H800, H801, H802, H803, H804, H805, H806, H807, J464

* Abundant + Common – Rare

TABLE B4 BENTHIC MACROFAUNAL ASSEMBLAGES IN SELECTED SURFACE SAMPLES

Paphies australe; Paphies subtriangulatum; Chione stutchburyi; Pullastra largillierti; Venericardia purpurata; Myadora striata; Gari stangeri; Gari lineolata; Ostrea sp.; Micrelenchus huttoni; Zethalia zelandica; and the mussels - Mytilus edulis aoteanus; Aulacomya maoriana; Modiolarca impacta and Modiolus sp..

In many samples the shallow water species are far more abundant than the deep water ones. For this reason they are thought to have lived where they are now found, and not to be shells that have been transported across the shelf from shallow water by bottom currents or by being attached to flotsam.

Several cores taken on the middle and outer shelf in areas of shallow water shell occurrences penetrated shell layers from 0.5-2 m below the sea bed (H403, H405, H777, H790, H810, H812 - Fig. B9 and Appendix IV). The buried shell layers contain the same fauna as that at the surface but the shallow water species are much more abundant while the deep water species are distinctly rarer (Table B5). Three additional shallow-water species were found in the cores : the beach dweller Dosinia subrosea; the coastal mussel Perna canaliculus, and Glycymeris laticostata which inhabits the inner shelf. The sediment of the middle and outer shelf, with its shallow water shells, was evidently originally deposited during glacially lowered sea level and the upper part has been progressively mixed with younger and deeper water shells.

REMOTE SENSING OBSERVATIONS

Instrumentation and Coverage

A study was included in the planned research programme of each of the geomorphic-textural provinces on the shelf by side-scan sonar and by underwater camera. A few short tracks with the side-scan sonar were successfuly run immediately east and south of Banks Peninsula (Fig. B6).

Species	Approximate depth range (m)	H350 90-110	H353 8-32	H403 24-38	H403 38-42	H403 42-49	H405 206-230	H433 30-39	H777 80-122	H777 122-167	H781 80-165	H788 86-98	H788 170-183	H788 213-227	H788 263-316	H789 215-240	H789 258-290	H789 290-308	H790 170-207	H810 60-86	H810 95-142	H812 72-82	H812 166-208	H813 54-71
BIVALVIA																								
Anomia sp				-				-															-	+
Aulacomya maoriana	0			-		-			+	+	+								-					
Bathyarca cybaea Hedley, 1906		-																						
Cardita aoteana																						-	-	+
Caryocorbula zelandica	0+					-					-		-			-						-	-	-
Chione stutchburyi	0-4						*		-	-					-				+	+	+		-	
Chlamys (Mimachlamys) incl {C. gemmulata, C. zelandiae}	10+	+	-	-				-	-	-	-	-	-		-	-	-	+	-	-	-	+	+	*
Chlamys (Zygochlamys) delicatula	0-40		-								-					-						+	-	-
Diplodonta globus	0-80		-								-	-	-	+	+	-		-	-					-
Divaricella huttoniana		+	-				-							-		-	-	-	+					+
Dosinia grayi	20-40		+								-													-
D. lambata		-					-									+	+	-						
D. (Phacosoma) subrosea (Gray, 1835)	0-20						-		-	-									-	+	+			-
Dosinia sp															-									
Escalima regularis											-											-		
Gari sp incl. {G. lineolata, G. stangeri}	0-20						-		-	-		*	+	+	+	+	+	+	-	+	+		-	-
Glycymeris modesta	0-80			-	-	-	-		+	+	-	+	+	+	+	+	+	+	+	+	+	-	-	
G. (Grandaxinea) laticostata (Quoy & Gaimard, 1835)	0-40																					+	+	
Lima colorata																						-		
Limatula maoria	0-220																						-	
Mesopeplum convexum	10-200																			-	-	-	-	
Modiolarca impacta							-																-	
Myadora biconvexa							-					-	+	+	+	-	-	-					-	
M. novaezelandiae																								-
M. striata	0-20		*				-		-	-			-	-		-	-	-	+	-	-			
Myadora sp incl. {M. antipoda, M. boltoni, M. subrostrata}	8+	-						-			-	-	+	+	+	-	-	-	-	-				-
Mytilidae							-									-								
Mytilus edulis aoteanus							-																	
Neilo sp incl {N. australis, N. rugata}	10-275																		-					
Nemocardium pulchellum	10-200	+	-	-			-				-	-		-	-	-	-	-		-	-	-	-	+
Notocallista multistriata	20-75	+	-	-	-			-			+	-				-	-	-	-	-	-			*
Nuculidae incl {Ennucula strangei, Nucula strangeiformis}	0+	+	-	-		-	-	-	-	-	-	-	-	+	+	-	-	-	+	-	-			-
Ostrea sinuata Lamarck 1819	0-30								-	-								+						
Ostrea sp	0-30						-										-							
Panopea zelandica (Quoy & Gaimard, 1835)	0-20										*													
Paphies australe	0-10			+	-	+	*		+	+	-									-	*	+	+	
P. subtriangulatum	0-10		-	+			*		*	*			-	-					-	*	*			
Paphies sp					-	-																		
Pecten novaezelandiae							-						-										-	
Perna canaliculus (Gmelin, 1791)									+	+										-	-			
Pleuromeris zelandica	0-200	+	+	-		-		-			+	-				+	-	-	-	-	-	+	+	-
Proleda lanceolata		-																						
Pullastra largillierti							-				-													
Saccella bellula	8-300	*	+			-		*			*	-	-		-	+	+	-	-	-	-			+
Scalpomactra scalpellum	0-80		-	*	*	+	-	-	-	-		*	*	*	*	+	+	+	+	-	-		-	-
Spisula aequilateralis	0-20																		+					
Tawera spissa			-	+	*	+	*	-	*	*	*	*	*	*	*	*	*	*	-	*	*	-	+	-
Tellinella charlottae		-	-																+					-
T. huttoni		-														-		-						
Thracia vegrandis							+					-	+	+	+	-	-	+		-	-			
T. vitrea																	-	-	-					
Venericardia purpurata	0-30			-		-					-									-	-	-	-	
Zenatia acinaces	0-110		+																					
Bivalvia indet			+	+				-				-											+	-
GASTROPODA																								
Amalda novaezelandiae	0-200													-	-			-						
Antisolarium egenum	4-70	-	-				-	-	-	-	-	+	+	+	+	-	+	-	+	-	-		-	
Argalista nana																								-
Austrofusus glans		+	-				-																	-
Austrofusus sp											-			-	+	+	+	+	-	-	-			
Buccinulum sp ?																			-					-
Cominella sp ?										-														
Daphnella cancellata																								-
Emarginula striatula	0+		-																	-	-	-	-	
Epitonium sp		-																						-
Lucominia sp?											+													
Fusitriton sp?													-	-		+	-	-						
Glaphyrina sp.								-												-	-			-
Maoricolpus roseus	0-70		-				-				+												-	-
Maoricrypta monoxyla	0+		-					-									-	-						
Maoritonella albula																	-	-	-					-
Marginellidae																								-
Maurea sp											-	-				-		-						
Micrelenchus huttoni						-	-		-	-	-	-	-	-	-		-	-	*			+	+	
Naticidae incl Tanea zelandica		-					-		-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-
Patellids indet																			-					
Pervicacia tristis	0-40				-														+	-	-			
Phenatoma novaezelandiae	0-60																-	-	-					
Pyramidellidae			-																					
Splendrillia aoteana																								-
Trochidae	4-110								-	-	-			-				-						
Xymene sp.?	0-20								-	-	-	-	-	-	-	-	-	-	+					
Zeacolpus (Stiracolpus) symmetricus	4-130	+	+	-	+	-	-		-	-	-	+	+	+	+	-	-	-	*	-	-	-	-	*
Zeacolpus (Zeacolpus) vittatus (Hutton, 1873)		-																						
Zegalerus tenuis	0+	-	-								-	-	-	-	-	-	-	-					+	-
Zethalia zelandica	0-20		+	-		-	+	-	+	+		-	-	-	-	-	-	-	*	+	+		-	
Gastropoda indet								-	-	-	-	-	-	-	-	-	-	-				-		-
SCAPHOPODA																								
Dentalium zelandicum		+	-								-													+
D. nanum	30-200	+	-				-	-								-		-						+
BRACHIOPODA																								
Neothyris lenticularis		-				+																		
Terebratella sanguinea						-																		
OTHER GROUPS																								
Arthropoda																								
Cirripedea			-			-	-	-	+	+	+	+	-	-	-	+	+	+	+	-	-	-	+	-
Crustacea														-					-					
Bryozoa		+	-			-		-			+	+	-	-	-	-	-	-	-	+	+	+	+	+
Echinoidea		-	-		+	-	-	-	-	-		+	+	+	+	-	+	-	+	-	-		-	-
Polychaeta tubes		-									-								-	-	-	-		+

Core No and depth in core (cm)
* Abundant + Common — Rare

TABLE B5 BENTHIC MACROFAUNAL ASSEMBLAGES IN CORES

The underwater camera was used at widely spaced stations. Chronic problems in the side-scan system resulted in rather poor records; and an untraceable break in the towing/ conductor cable after 104 km of running ended the side-scan programme altogether. The camera was also unsatisfactory and only a few useful photographs were taken.

Results

It was found that the steeply sloping band of Zone A, Mode IV silty sand that hugs the coast of Banks Peninsula is featureless on the sonographs, having no bedforms high enough to cast a sonic shadow. Plate B2a shows rock out-cropping through the featureless sand off Steep Head, Banks Peninsula. In this zone the water is mostly too turbid for photography.

Successful bottom photographs taken of the muddy trough at the base of Zone A (Stn H392; see Fig. B9 for sample locations) show a rather flat, fine-textured, very lightly rippled surface with an epifauna of echinoids and crustaceans (Plate B3).

In the zone of second-order ridges off Banks Peninsula, (Zone D, Mode III sand, gravel and shell) sand ribbons are conspicuous and abundant (Plate B2b) (cf. Kenyon 1970; Belderson et al. 1972). Indistinct sand waves with an amplitude of 0.3-0.4 m were locally observed, especially on the peripheries of sand ribbons. In addition there are some gradual textural changes shown on the sonographs by a gradual lightening or darkening of the background and some sharp interfingering contacts, the fingers being parallel to the trend of the sand ribbons (Plate B2c). The textural distinctions on the side-scan sonographs probably represent fine sand (Mode III) moving across shelly sandy gravel. Bottom photographs at Stns H396 and H423 show strongly rippled, shelly sand (Plates B4 and B5).

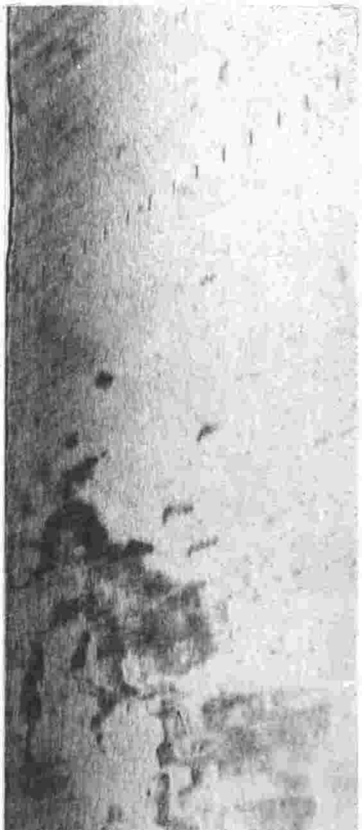
Although the programme was less successful than hoped, it was possible to determine the orientation of the sand

Plate B2.

(a) Outcrop of volcanic rock surrounded by very fine, silty (Mode IV) sand off Steep Head, Banks Peninsula.

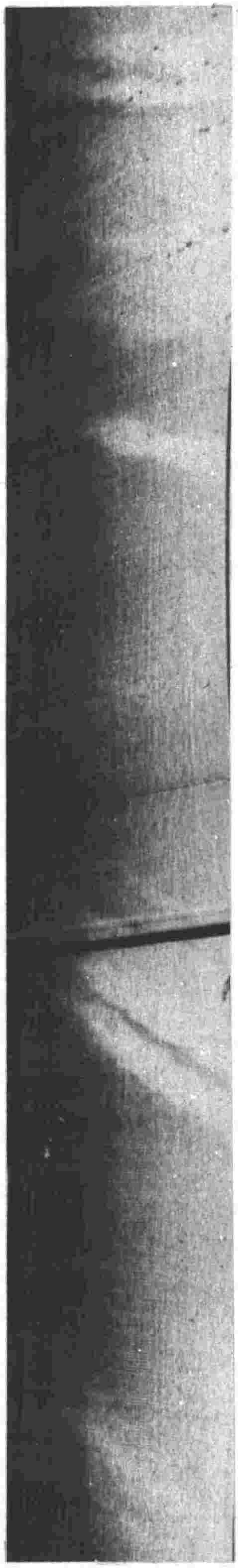
(b) Sand ribbons in relict (Mode III/II) sand and gravel. The dark areas are sandy, shelly gravel and the light areas are fine sand.

(c) Sand ribbon-like interfingering contacts between fine (Mode III/II) sand (light) and sandy, shelly gravel (dark). Sand waves trending obliquely to the ribbon trend are faintly visible.



(a)

Plate B2



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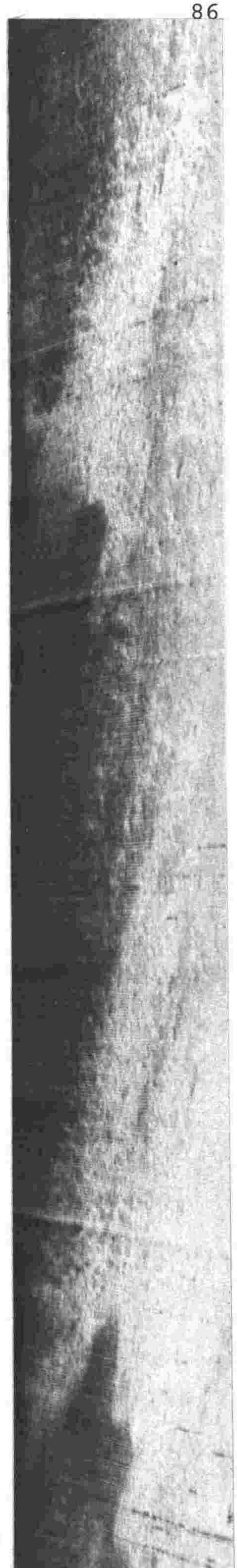


(c)

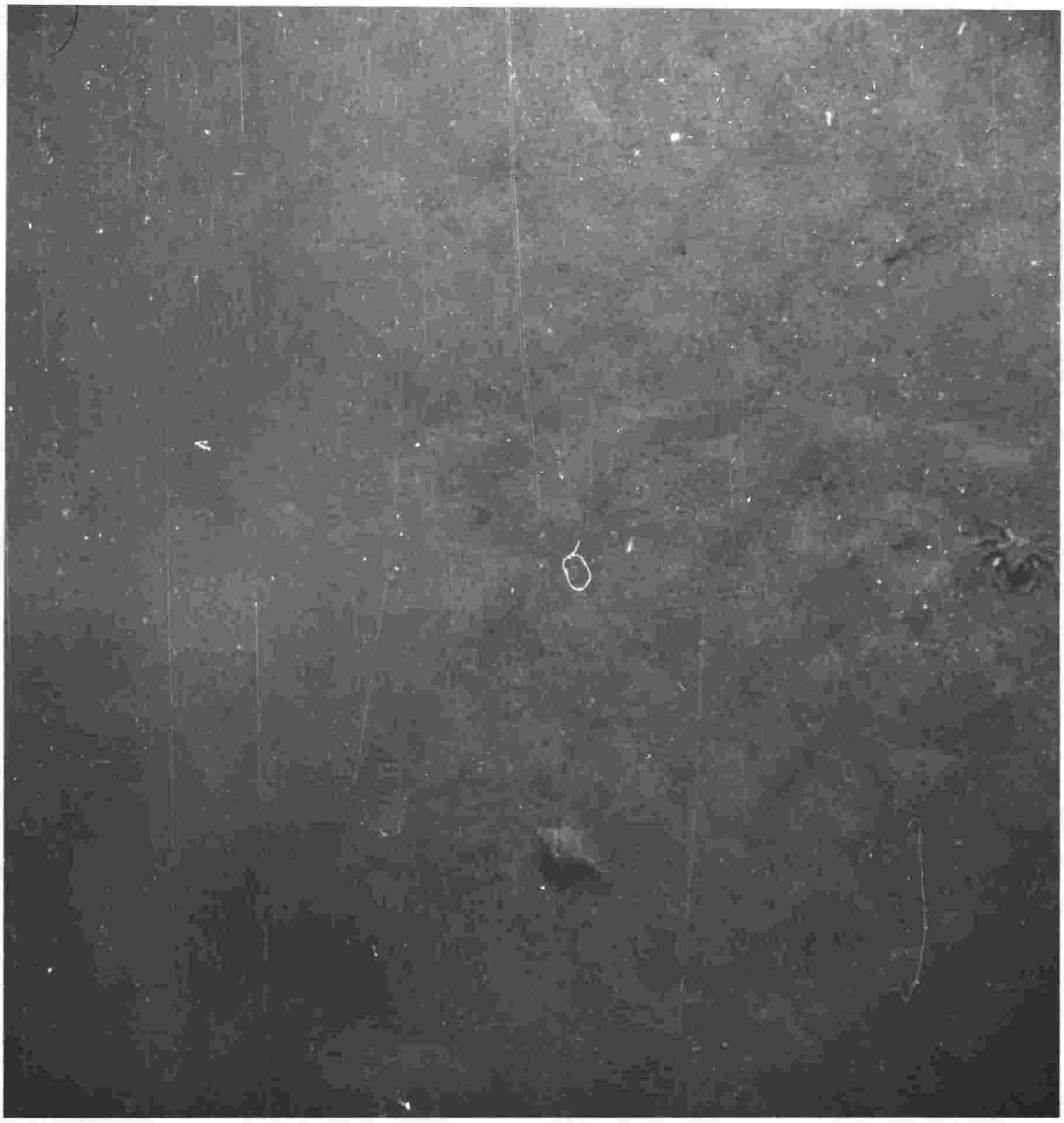


Plate B3. Gently rippled silty substrate in a trough off Banks Peninsula (station H392 - latitude 43° 58' S, longitude 173° 00' E). Depth 70 metres. Photograph dimensions approximately 80 cm. x 80 cm.

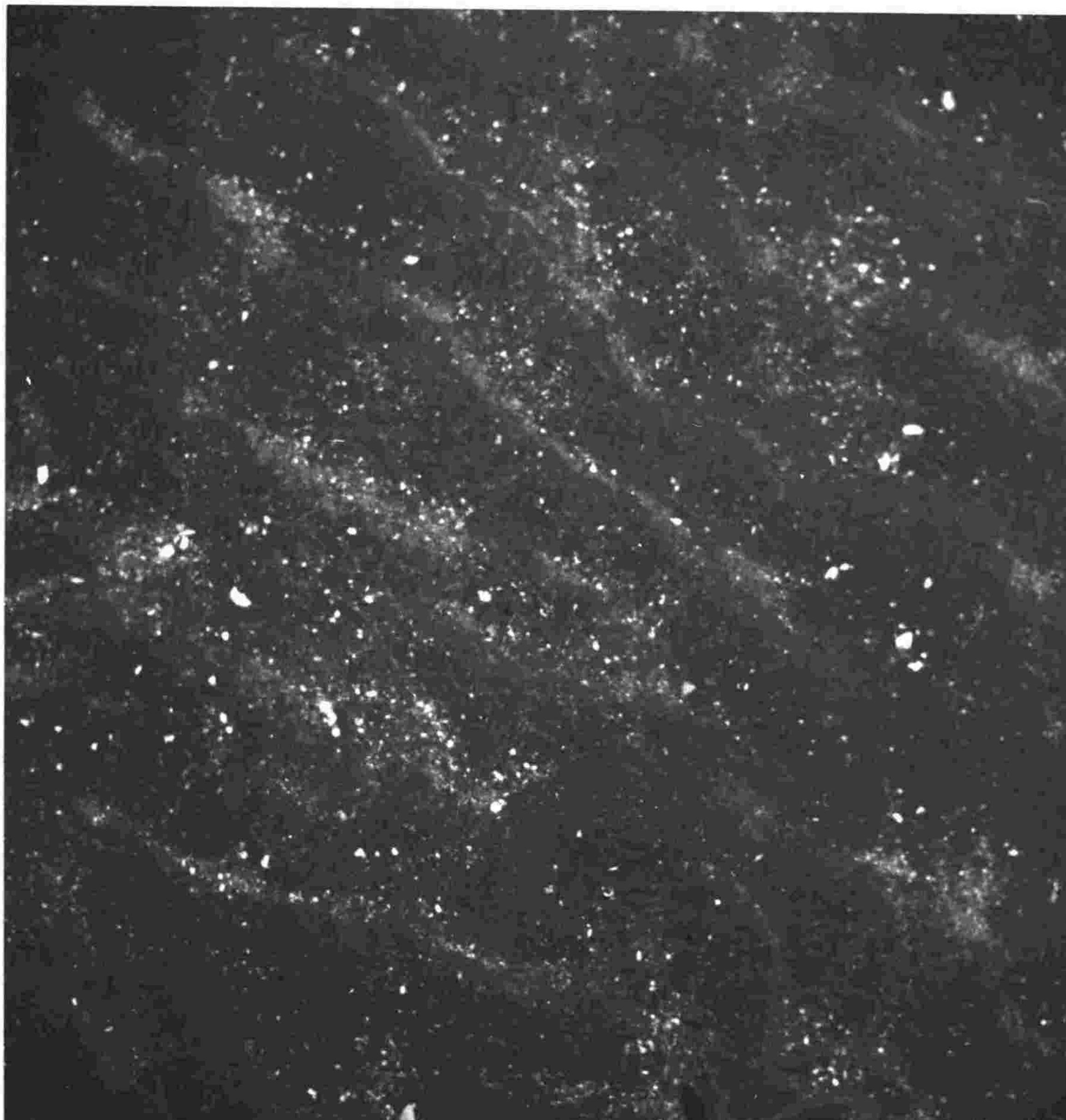


Plate B4. Ripple-marked fine sand on the continental shelf east of Banks Peninsula (station H396, latitude 43° 57.5' S, longitude 173° 19' E). Depth 70 metres. Photograph dimensions approximately 80 cm. x 80 cm.

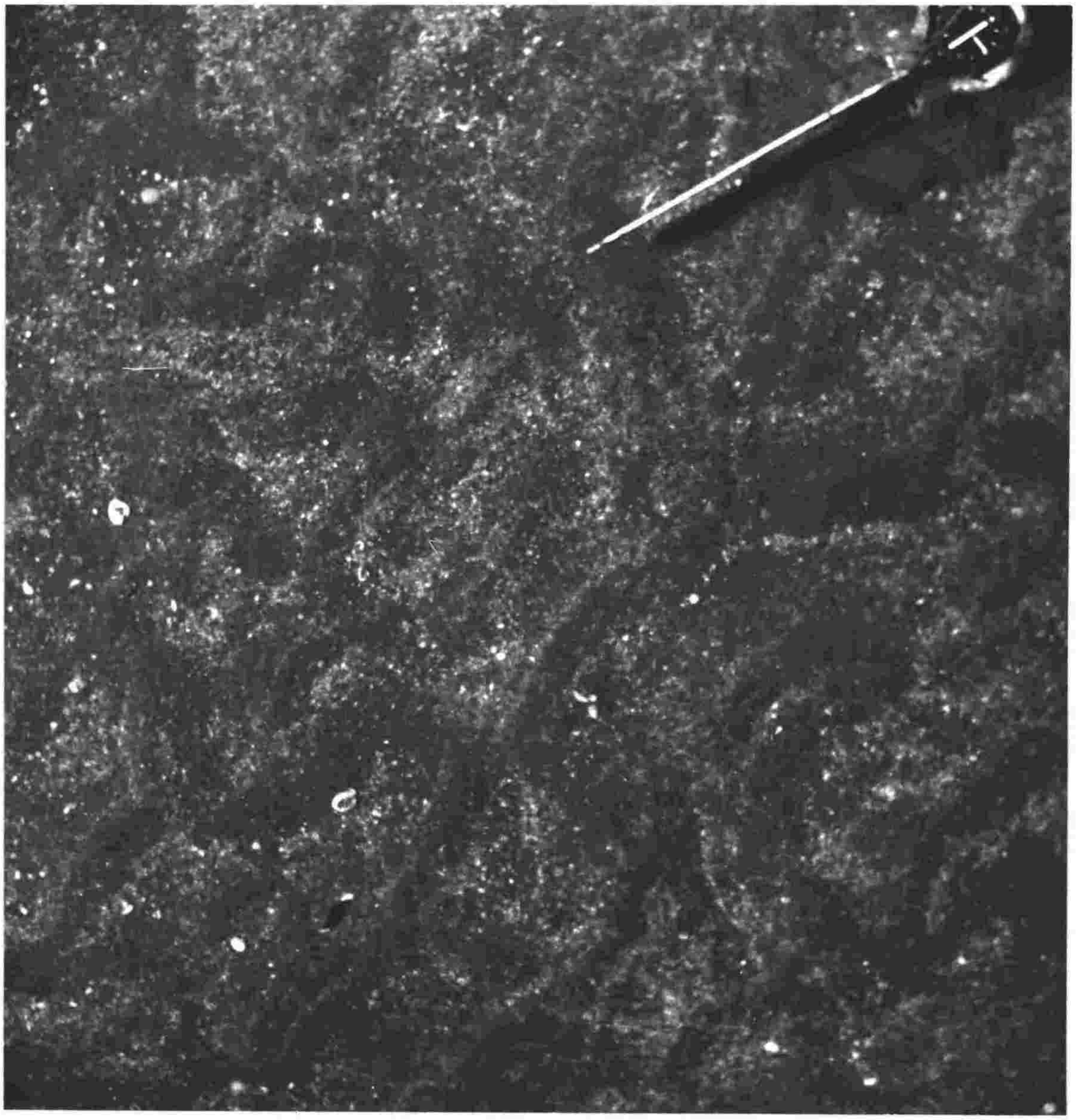


Plate B5. East-west trending ripples in shelly fine sand on the continental shelf east of Banks Peninsula (station H423, latitude 43° 45' S, longitude 173° 45' E). Depth 95 metres. Photograph dimensions approximately 80 cm. x 80 cm.

bodies. The sand ribbons, which are current-parallel structures, trend roughly parallel to the strike of the second-order ridges, i.e., northeast to north-northeast. The axes of the sand waves, which are current-normal structures trend at high angles to the long axes of the ribbons and ridges. The ripples in the photographs at Stn H423 have east-west long axes and undetermined symmetry. With the data to hand, no preferred location of the ribbons or sand-waves with respect to the ridges (on crests, on flanks or in troughs) was found.

STRATIGRAPHY

Instrumentation and Coverage

Using an EDO 3.5 kHz profiler, a basic array of lines was run more or less at right angles to the coast with many intersecting tie lines (Fig. B4). The transducer is hull-mounted and it was possible to run the profiler during other operations and while steaming between stations. This added greatly to the coverage of the area. In addition to the main survey, a series of short lines were run in the vicinity of the submarine canyons. The profiles of 10 selected long lines at right angles to the coast are reproduced here (Fig. B18). All the original records are stored in the N.Z. Oceanographic Institute.

Because of its relatively high frequency of 3.5 kHz, the profiler has a high resolution but a fairly limited penetration. A strong echo is returned from sand and gravel, and penetration is virtually nil where these are at the surface. Mud is more acoustically transparent; reflectors are thin and clear. Penetration of 60 m or more is possible through mud. Gas, generated from peat, kelp and organic-rich mud, produces a strong reflection and limits deeper penetration (Schubel & Schiemer 1973; Keen & Piper 1976; Hicks & Kibblewhite 1976). Reflections from gas occur at places in the muddy sediments of Pegasus Bay (Profile B,

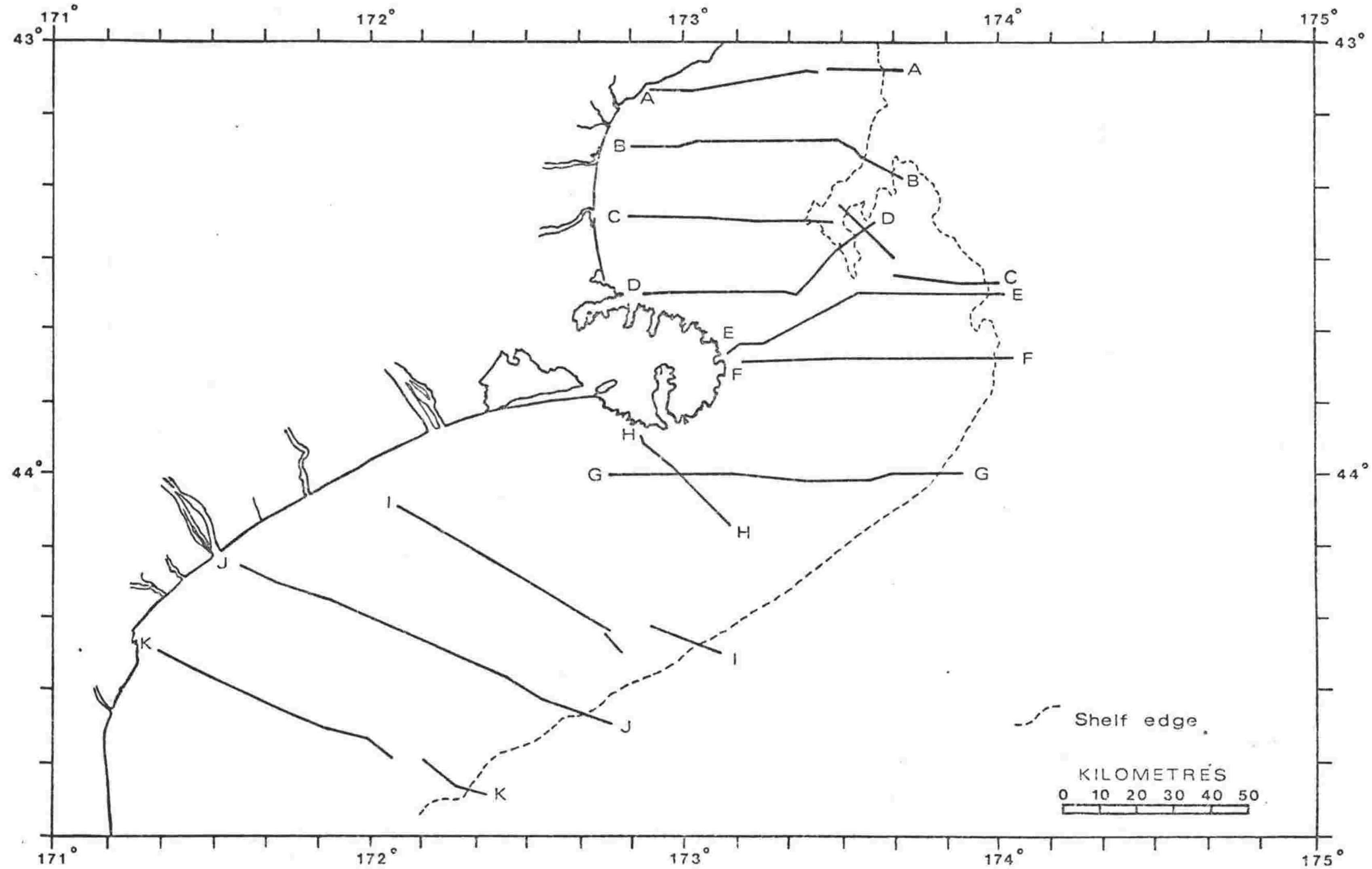


Figure B18. Locations of the 3.5 kHz seismic profiles illustrated in the text.

Fig. B19). Thus, certain characteristics of the sediment may reduce the penetration of the 3.5 kHz system, but this very fact makes it possible to infer sediment types from the profile.

Stratigraphic Nomenclature

Figures B19 to B23 are line drawings of 10 selected profiles set out in order from north to south. Three major units are apparent, and are coloured differently.

The top unit (P) is a discontinuous blanket of variable thickness and is best developed on the inner continental shelf, particularly in Pegasus Bay (Profiles B, C, D), and skirting Banks Peninsula (Profiles E, F, H). It thinly covers the sea bed of southern Canterbury Bight (Profiles J, K).

The middle unit (CB) extends over the entire continental shelf. It is best shown in the southern part of Canterbury Bight (Profiles J, K) where the top unit is thin and muddy. It is relatively thin nearshore and thickens seaward with well defined foreset beds that continue down the continental slope. It is bounded above and below by zones of apparent erosion, infilling and reworking which show fairly clearly in the profiles.

The lower unit (X) shows up clearly at a few places only (Profiles I, J, K) and is not discussed in detail.

The middle and upper units are considered to be formations and are named and described accordingly. The vertical limits of the formations do not conform precisely to those generally used in terrestrial stratigraphy, since the basal transgressive sequence is included in the underlying formation rather than in the overlying one. It is felt that the mappability of the formations would be severely restricted if normal convention had to be followed, since the basal sequence, including transgressive and palimpsest sediment, is derived from the underlying formation and is texturally and compositionally distinct from the overlying progradational sequence.

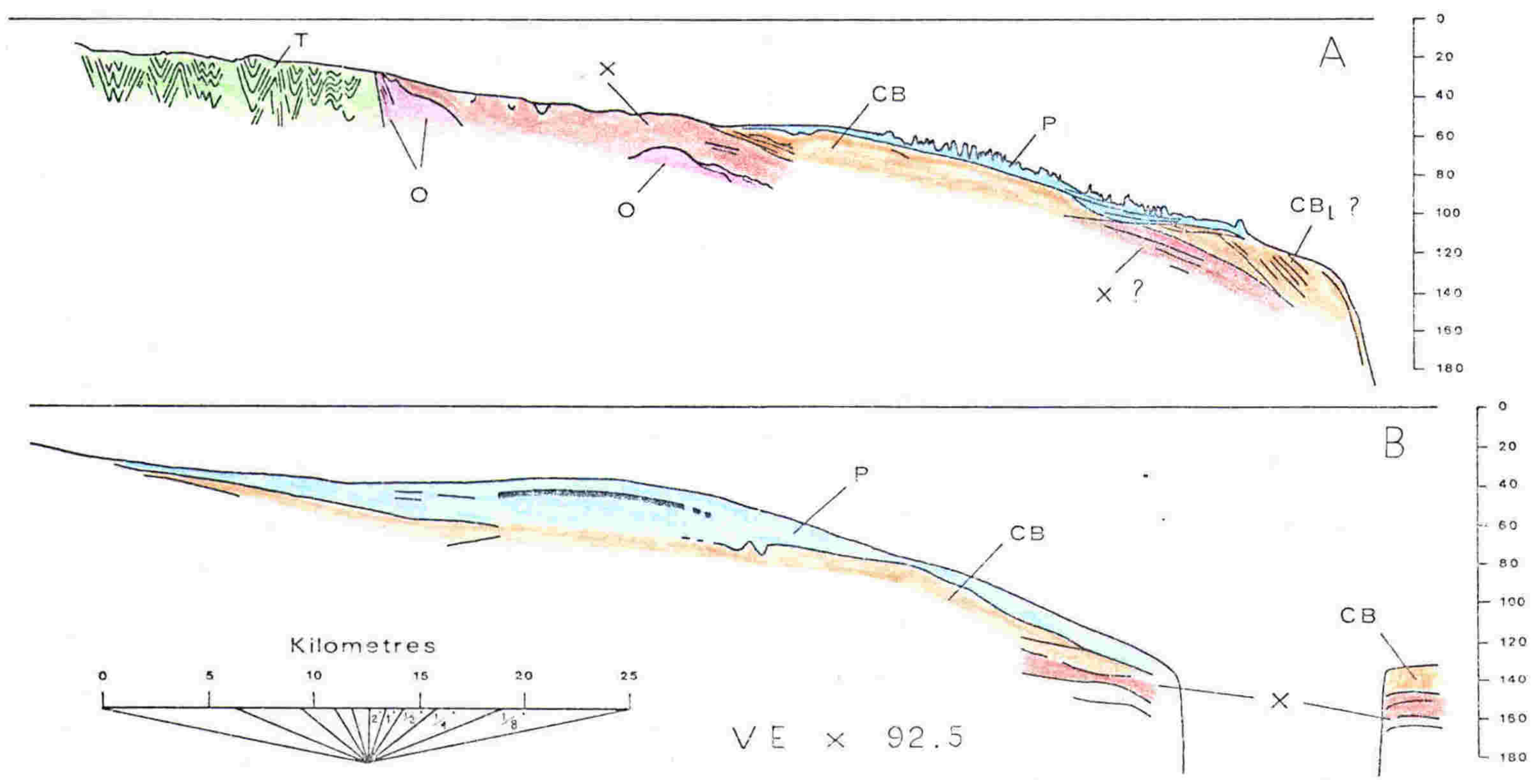


Figure B19. 3.5 kHz seismic profiles A and B of the Canterbury continental shelf. P - Pegasus Formation; CB - Canterbury Bight Formation; CB_L - Canterbury Bight Formation (lower member); X - Penultimate Glacial unit; O - Older Pleistocene units; T - Probable Tertiary rock. Vertical scale in metres.

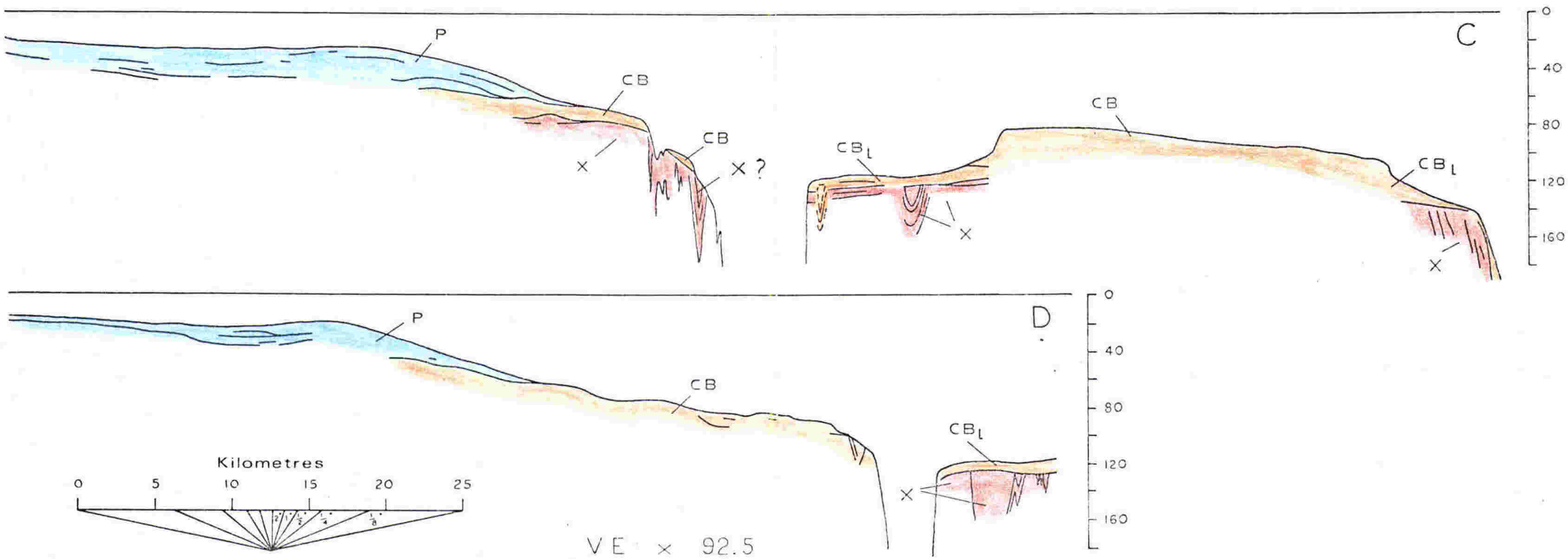


Figure B20. 3.5 kHz seismic profiles C and D of the Canterbury continental shelf.
P - Pegasus Formation; CB - Canterbury Bight Formation; CB_U - Canterbury Bight Formation (upper member); CB_L - Canterbury Bight Formation (lower member); X - Penultimate Glacial unit. Vertical scale in metres.

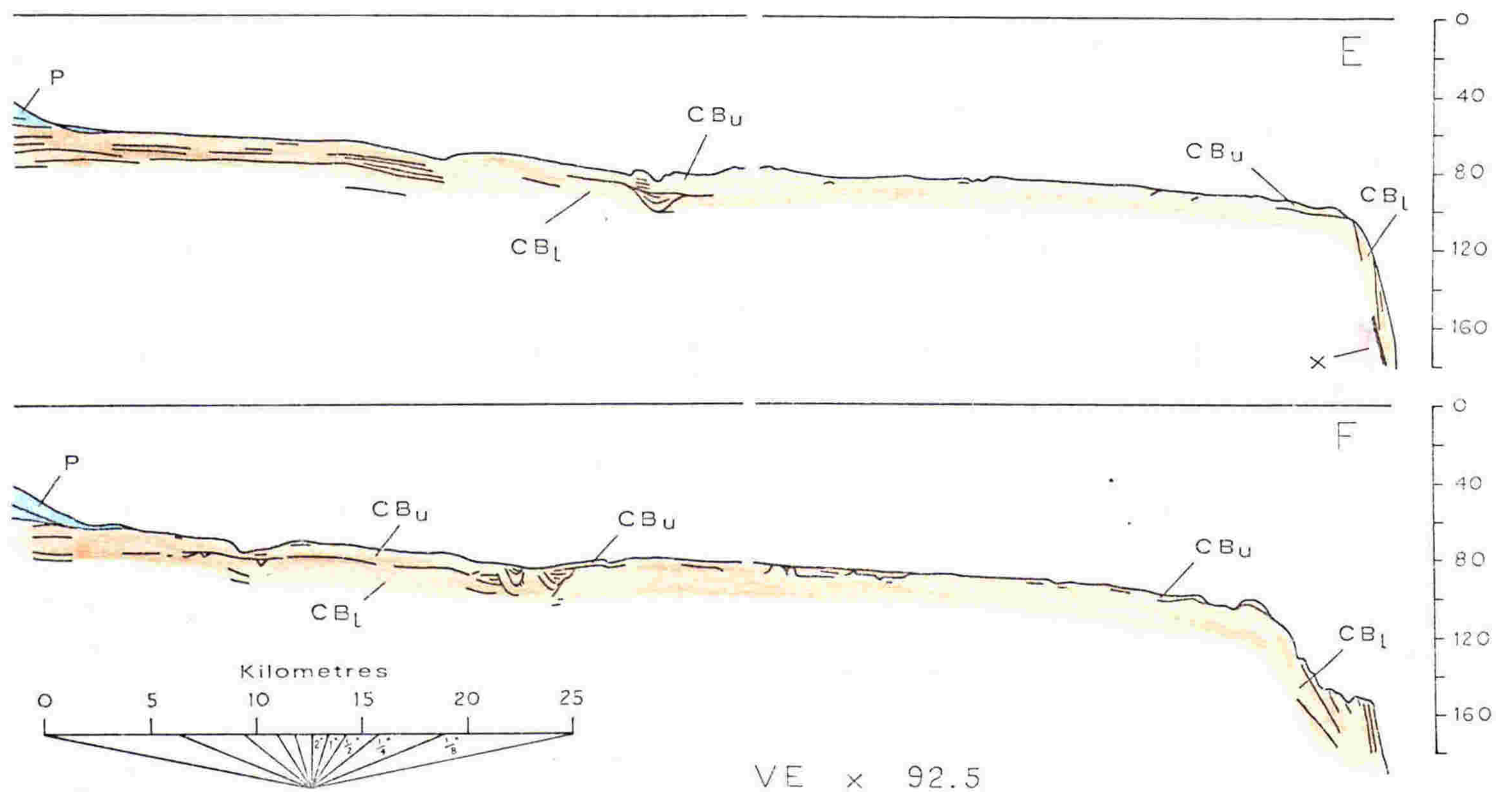


Figure B21. 3.5 kHz seismic profiles E and F of the Canterbury continental shelf. P - Pegasus Formation; CP_U - Canterbury Bight Formation (upper member); CB_L - Canterbury Bight Formation (lower member). Vertical scale in metres.

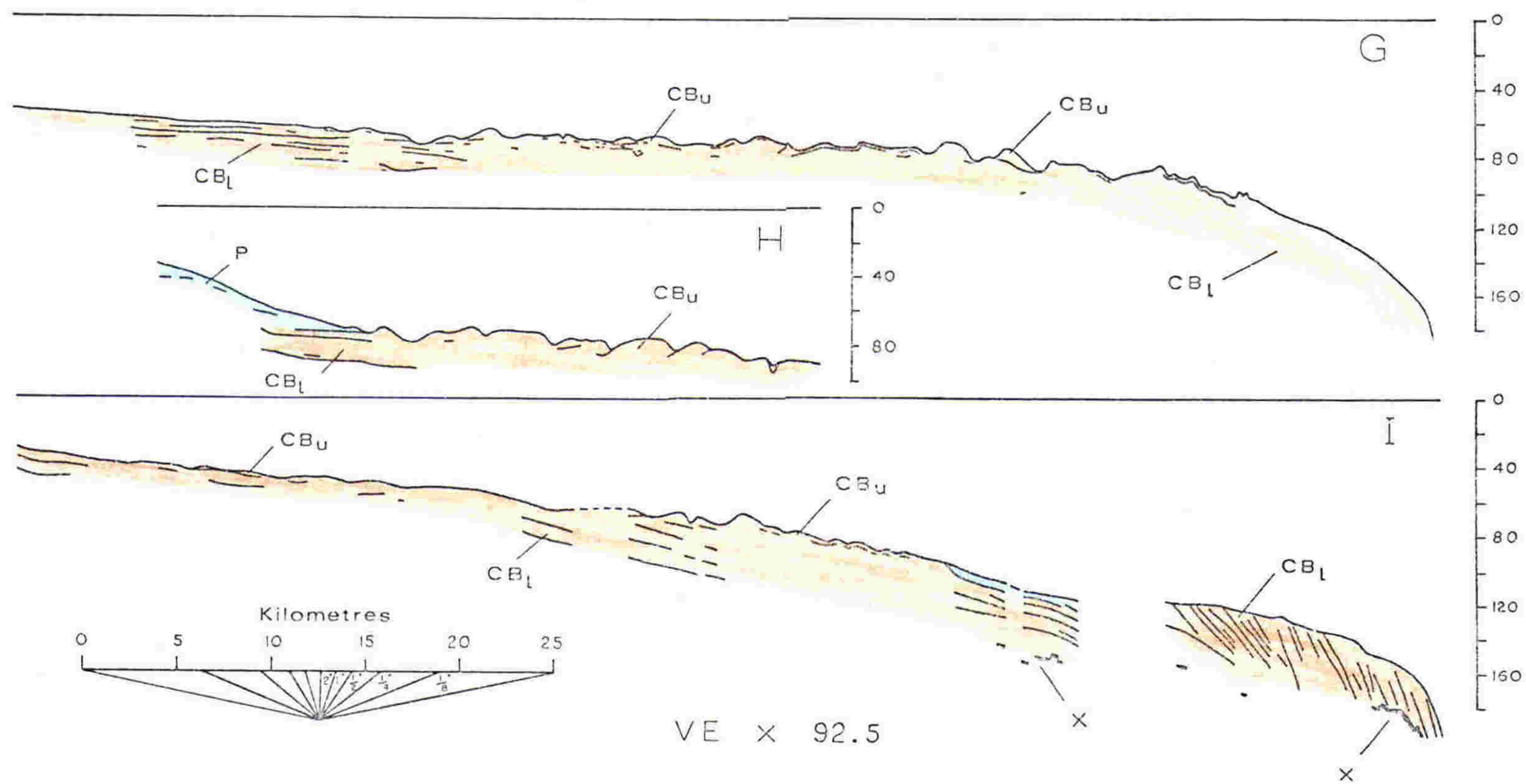


Figure B22. 3.5 kHz seismic profiles G, H and I of the Canterbury continental shelf. P - Pegasus Formation; CB_U - Canterbury Bight Formation (upper member); CB_L - Canterbury Bight Formation (lower member); X - Penultimate Glacial unit. Vertical scale in metres.

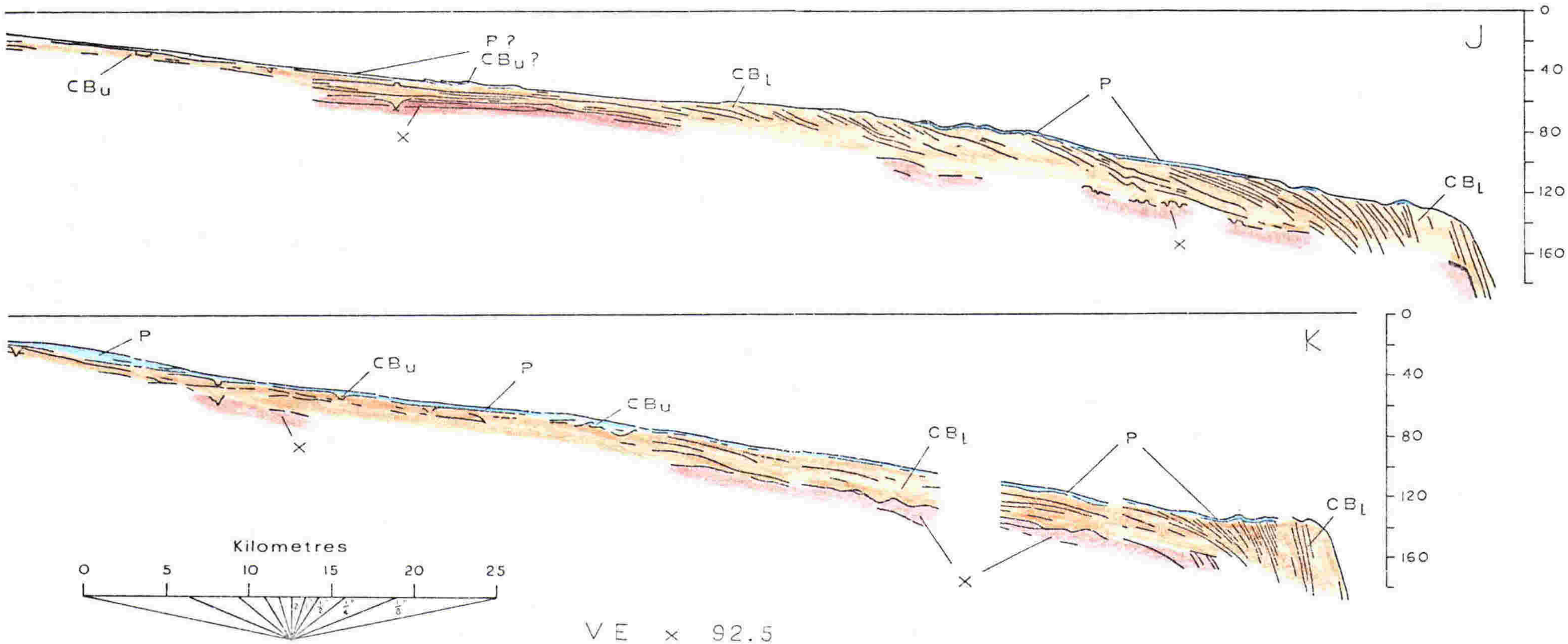


Figure B23. 3.5 kHz seismic profiles J and K of the Canterbury continental shelf. P - Pegasus Formation; CB_U - Canterbury Bight Formation (upper member); CB_L - Canterbury Bight Formation (lower member); X - Penultimate Glacial unit. Vertical scale in metres.

Pegasus Formation

(a) Type and reference profiles

Profile C (Fig. B20) (N.Z.O.I. No. 1002-18) (in Pegasus Bay) is designated as the type profile and Profile K (Fig. B23) (N.Z.O.I. No. 1034-22) (in southern Canterbury Bight) is designated as a reference profile. Together they show most of the diagnostic features of the formation as required by the American Commission on Stratigraphic Nomenclature (1961).

(b) Upper and lower boundaries

The upper surface is that of the sea floor (smooth zones A and E already described; Fig. B7). The base of the formation is uneven, being the eroded and reqorked top of the underlying Canterbury Bight Formation. The formation is thickest on the inner shelf and thins landward and seaward. It is from 2-7 m thick in southern Canterbury Bight, and much thicker in northern Canterbury Bight and Pegasus Bay. Where thick, its base is ill-defined on the profiles. It is thickest - more than 28 m - in south-central Pegasus Bay.

(c) Lithology and structure

Mud and/or very fine Mode IV sand, free of gravel, form the top of the formation (cf. Figs. B11, B12, B14).

Three cores (H435, H440, H459) in Pegasus Bay (Zone A) and one (H350) in outer Canterbury Bight (Zone E), extend into the top 3 m of the formation (see Fig. B9 and Appendix IV). The inner-bay sediments (H440) are mainly heavily bioturbated sandy (Mode IV) mud and silty clay beds, 10-150 m thick, which alternate with thin beds 4-10 cm thick, of finely laminated coarse silt with few burrows (Plate B6). The outer Canterbury Bight sediments (H350) are muddy fine (Mode IV) sand and sandy mud that are so strongly bioturbated that bedding is entirely destroyed. The sandy part of the Pegasus Formation is composed of clean or coarsely silty, very fine, hard-packed (Mode IV) sand that cannot be penetrated with a piston corer. The only core (H435) obtained

Plate B6. Core H440 from muddy facies of inner Pegasus Bay (Pegasus Formation).

was from a slightly muddier facies on the edge of the formation in outer Pegasus Bay. The sediment is bioturbated, muddy very fine (Mode IV) sand. Shells are rare in all the cores from the formation.

The muddy parts of the formation indicate low energy conditions in which an active infauna is generally able to effectively rework fairly rapidly accumulating sediment. occasional pulses of rapid sediment input are indicated by the laminated silt beds in cores H440 and H459 of inner Pegasus Bay. They do not extend out to outer shelf core H350. The sandy parts (core H435) indicate a similar sedimentation rate and higher energy conditions.

Except along the seaward margin of the thickest deposits, where it dips gently seawards, the bedding on the seismic profiles is horizontal.

(d) Anomalies

In southern Canterbury Bight, as the Pegasus Formation thins northwards, the ridge-and-swale topography of the top of the underlying Canterbury Bight Formation gradually emerges, the Pegasus Formation being too thin (Profile J, Fig. B23) to smooth the profile. The southernmost part of the ridge-and-swale Zone D (Fig. B7) therefore actually becomes Pegasus Formation on the map (Fig. B25). In this area the northern limit of the formation is defined by the change in surface sediment type, particularly by the sand modes (Fig. B14).

On the inner shelf in northernmost Pegasus Bay, the Pegasus Formation thins to a veneer where seismic profiles show folded rocks directly below an eroded sea bed (Profile A, Fig. B19).

The curious pinnacled terrain in the Pegasus Formation shown at the outer end of Profile A may be due to low angle submarine sliding. Large, shallow earthquakes have occurred in this area during historic time (Evison 1971) and earthquakes may have caused the inferred sliding.

(e) Age of the Pegasus Formation

The distal, deep water part of the formation probably began to accumulate shortly after the beginning of the deglacial transgression some 18,000 years ago. However, because its greatest thickness is on the inner shelf, most of the formation was probably deposited much later, when the sea surface had risen to its present level about 6,000 years ago. The Pegasus Formation is considered to be entirely marine.

Canterbury Bight Formation

(a) Type and reference profiles

Profile J (Fig. B23) (N.Z.O.I. No. 1012-13) is designated as the type profile of the Canterbury Bight Formation and Profiles G (Fig. B22) (N.Z.O.I. No. 1012-05, 06) and F (Fig. B21) (N.Z.O.I. No. 1012-19) are designated as reference profiles.

(b) Upper and lower boundaries

The Canterbury Bight Formation underlies the entire continental shelf in the study area. Its base is the top of the eroded and reworked upper part of the unnamed lower formation (X) which includes buried river channels, secon-order ridges and truncated foresets (Fig. B23). On the continental slope, the boundary between the Canterbury Bight Formation and the underlying formation is evidently a paraconformity or a low amplitude disconformity that can only be identified with certainty by tracing the reflector to its distinctive equivalent on the continental shelf.

The top of the Canterbury Bight Formation shows in profiles as a diachronous sequence of truncated foresets, buried river channels and ridge-and-swale topography. About half of it is exposed on the present sea bed where it is represented by Zones C, D and F, and about half is unconformably overlain by the Pegasus Formation.

The Canterbury Bight Formation is about 35 m thick on the outer continental shelf and thins to less than 10 m near the shore. It thins seaward to 7 m within 50 km of the shelf edge. The formation consists of a lower and upper member.

(c) Lower member

The lower member, which makes up the bulk of the formation, is progradational and youngs seaward. On the inner shelf it is horizontally bedded but, as it thickens seaward, seaward dipping foreset beds appear. A low rate of sedimentation during a high sea level was thus followed by rapid sedimentation during a falling sea level.

Two 4 m cores (H347 and H349; Appendix IV) were taken from the progradational part of the lower member where it is exposed on the upper continental slope. They consist of structureless mud with occasional silt bands and colonies of calcareous worm tubes. Rapid deposition in quiet water is inferred from the very fine grain size and from the dearth of micro- and macro-fauna. The top 20-40 cm is sandy (Mode IV) and rich in foraminifera.

On the continental shelf most of the lower member is buried beneath the upper member. The lower member is, however, exposed on the edge of the continental shelf off northern Canterbury Bight and on the margin of Pegasus Canyon where the shelf edge terrace (Zone F; Fig. B7) has cut deeply into it. Two places where the 3.5 kHz profiler indicated no apparent overlying sediment were cored (H781 and H813; Fig. B9). The cores consist of compacted, very fine (Mode IV) muddy sand and sandy mud with a high shell content (Plate B7; Appendix IV; Table B5).

Very fine (Mode IV) sand and mud are the typical sediments of the shelf edge terrace and upper continental slope and are regarded as the typical sediments of the lower progradational member.

(d) Upper member

The upper member is thin but well defined by bathymetry and sediment type. Zones C and D (Fig. B7) are

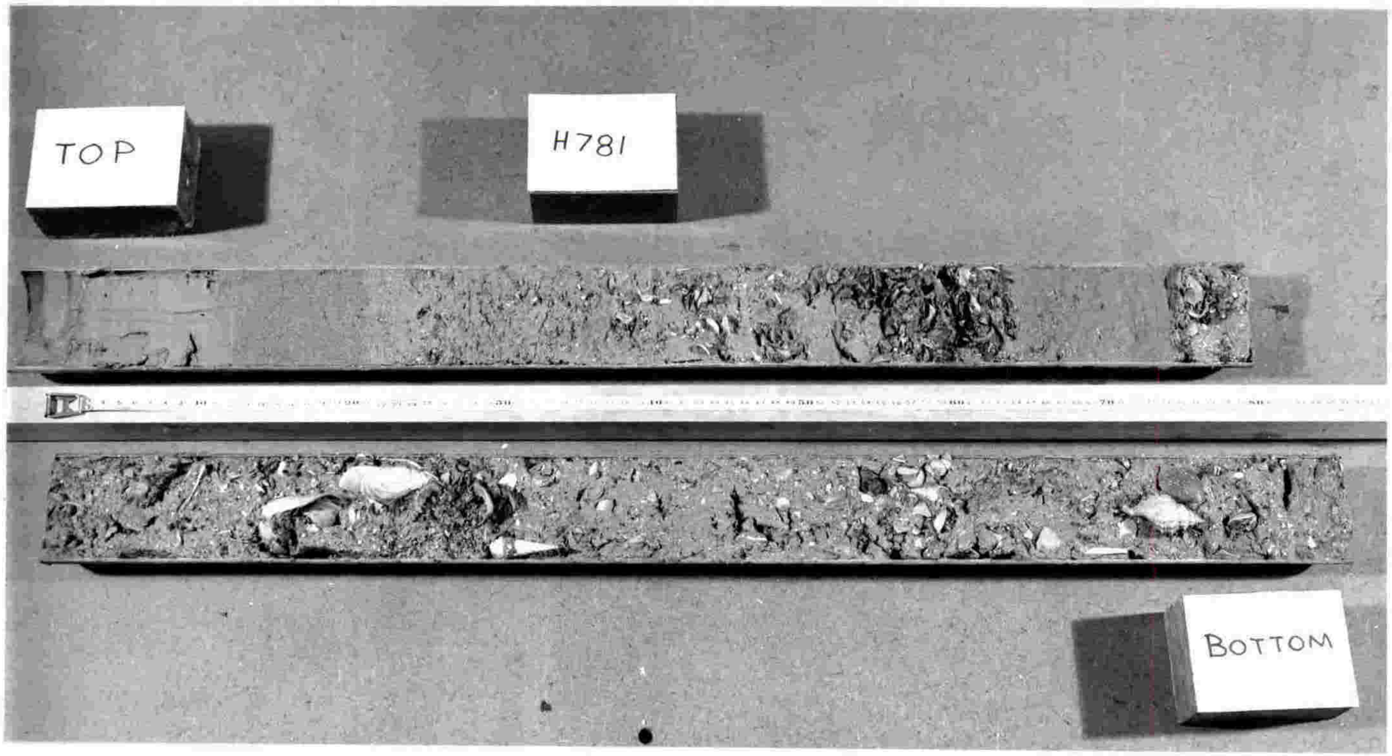


Plate B7. Core H781 from the shelf edge terrace (lower member of the Canterbury Bight Formation).

its surface expression, and Mode II and III sand (Fig. B14) and Mode I gravel (Fig. B12) are exclusively its sediments.

The upper member records the formation of a coastal plain and the subsequent reworking of the surface of the plain by the sea, and consists of two facies - a fluvial facies and a marine facies.

(i) Fluvial facies

The fluvial facies is defined by small, steep-sided, cut-and-fill features on the seismic profiles, assumed to represent buried river channels (Fig. B22). At most places it is covered by the Pegasus Formation and is too deeply buried to be sampled. However, it virtually reaches the sea floor in the shallow water of inner Canterbury Bight. Where the arcuate shape of the 25 m and 50 m bathymetric contours are assumed to represent the eroded seaward extension of the Canterbury fan surfaces (Fig. B2). The sea bed is covered by coarse, rounded, greywacke-argillite gravels that are assumed to have been eroded from the alluvial fans.

(ii) Marine facies

The marine facies of the upper member appears in the seismic profiles and in the bathymetry as widespread second-order ridges and as the first-order ridges and troughs that are prominent east of Banks Peninsula.

Three different sediment facies within the marine facies were cored to a depth of 3 m :

(a) First and second-order ridges
(b) The long troughs adjacent to first-order ridges
(c) The inner edge of the shelf edge terrace.

Sand modes in the cores were estimated visually as described earlier. It is assumed that the minor mode (II) occurs sometimes with Mode III as it does on the surface. The sand, classed visually as Mode III, is therefore called Mode III/II here.

(a) First and second-order ridges

The cores taken in this facies are H353, H403, H777, H788, H789, H790, H810 and H811 (see Plates B8 and B9 ; Fig. B9 and Appendix IV).

In most cases, the top 150-200 cm is composed of apparently graded, structureless, fine to medium sand (Mode III/II) with small amounts of finely fragmented shell material. In some (H353 and H403) shells and/or pebbles are found at the top. In cores H777 (Plate B8), H789 and H810 the structureless sand horizon is underlain by dense, cross-bedded, shell beds.

The top layers of sandy cores tend to be disturbed during the horizontal extraction of the liner from the barrel aboard ship, and the grading of the top unit may be an artifact. The top sandy unit otherwise resembles the "traction zone" of Powers & Kinsman (1953) and it probably represents sections through modern sand bodies that are moving across the shell beds of an "accumulation zone".

In core H788 (Plate B9) there are four cyclic graded beds, each 45-75 cm thick. Each bed comprises a sub-horizontally bedded sand with fine shell fragments, grading downwards to a cross-bedded sedimentary breccia of oblong clasts of soft sticky clay, bivalve shells (with their concave sides upwards) and sand. The cyclic beds may be sections through sand waves, formed during phenomenal storms. The soft clay of the breccia clasts was probably derived from a thin clay deposit formed off a river mouth (such as one found 10 km off the present Rakaia River), which was ripped up by the storm currents and incorporated into an activated sand substrate.

The commonest shells in the core are Scalpomactra scalpellum and Tawera spissa, both of which have a wide depth range (subtidal to middle shelf). The radiocarbon ages of the shell layers are shown in Table B6. The ages of the shells in the upper three beds increase downwards and are separated by 700-1300 years. However, the date for the lowest layer is younger than that for the next overlying one, implying that older and younger shell layers have occasionally

TABLE B 6 - RADIOCARBON AGES OF SHELL LAYERS

N.Z.O.I. Station No.	Depth of Shells below sea level	Depth of Core	Dated Species	Depth Range of Species	^{14}C Age+ (Years B.P.)	^{14}C Age* (Years B.P.)	R Number
H777	87 m	1.22-1.67 m	Paphies australe P. subtriangulatum	0-10 m	27900±1550	28800±1600	4999/1
H781	139 m	0.8-1.05 m	Panopea zelandica	0-20 m	11850±250	12200±300	4999/2
H788	59 m	0.86-0.98 m	Tawera spissa	0-120? m	7340±150	7550±150	4999/3
H788	60 m	1.7-1.83 m	Scalpomactra scalpellum	0-90 m	8070±170	8310±170	4999/4
H788	60 m	2.13-2.27 m	Scalpomactra scalpellum	0-90 m	9370±260	9650±270	4999/5
H788	61 m	2.63-3.16 m	Scalpomactra scalpellum	0-90 m	8560±220	8810±220	4999/6
H789	56 m	2.52-2.9 m	Tawera spissa	0-120? m	6370±110	6560±110	4999/7
H790	53 m	1.7-2.07 m	Zethalia zelandica	0-20 m	11750±250	12100±300	4999/8
H810	76 m	0.95-1.42 m	Paphies australe P. subtriangulatum	0-10 m	15100±200	15550±200	4999/9
H812	112 m	1.66-2.08 m	Glycymeris laticostata Tawera spissa	0-40 m 0-120? m	11250±250	11600±250	4999/10

\+ Age calculated with respect to old T½ of 5568 yr (Libby 1955).

* Age calculated with respect to new T½ of 5730 yr (see Godwin 1962).

Plate B8. Core H777 from the ridge facies of the upper member of the Canterbury Bight Formation, showing the sandy "traction zone", interpreted as parts of a palimpsest sand body, overlying the shelly "accumulation zone".

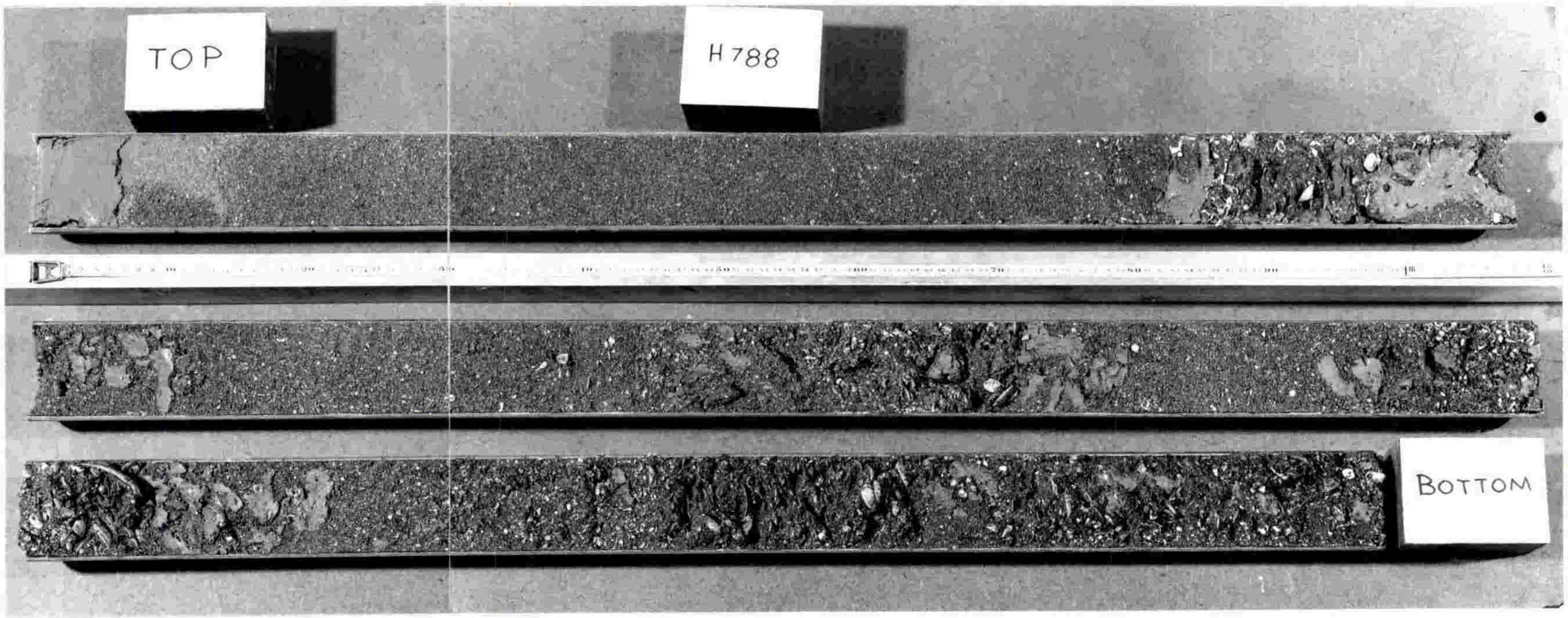


Plate B9. Core H788 from the ridge facies of the upper member of the Canterbury Bight Formation, showing cyclic, graded beds that are interpreted as storm deposits.

been mixed during reworking, and that the cyclicity of the events may have been as frequent as 500 years. By comparing the ages of the shells and their present depth below sea level to the Pleistocene sea level curve (Fig. B24), it is inferred that they were living on the inner shelf in a water depth of approximately 40 m when the presumed storm reworking occurred.

(b) Troughs of first-order ridges

The troughs east of Banks Peninsula (Fig. B5 and Profiles E, F; Fig. B21) contain a generally muddy facies (cores H405, H778 and H780, Plate B10; Fig. B9 and Appendix IV).

As in the other cores the top 20-80 cm is a structureless mud and graded Mode III/II sand unit. The top unit is thought either to have been produced during handling or to represent the modern "traction zone".

Below the top unit, two of the cores contain alternating muddy and sandy layers and one is entirely muddy to the bottom. The mud is moderately bioturbated, burrows being either sand or mud filled. Horizontal lamination is frequently preserved. The sand, with few exceptions, is Mode III/II throughout.

The muddiness of the cores indicates a low energy environment which may simply reflect modern infilling of the troughs. The alternating sand layers however reflect occasional input from an adjacent higher energy facies. The shell bed in H405 is dominated by black, sulphide-stained Paphies australe, P. subtriangulatum and Chione stutchburyi, in a matrix of coarse sand and gravel suggesting that the mud-sand alternations may be part of a lagoonal facies The origin of the troughs is discussed later.

(c) Inner edge of shelf edge terrace

The inner edge of the shelf edge terrace is the zone of change between the upper and lower members on the surface of the outer shelf. The upper member has a relatively high concentration of gravel (Fig. B12) in Mode III/II sand.

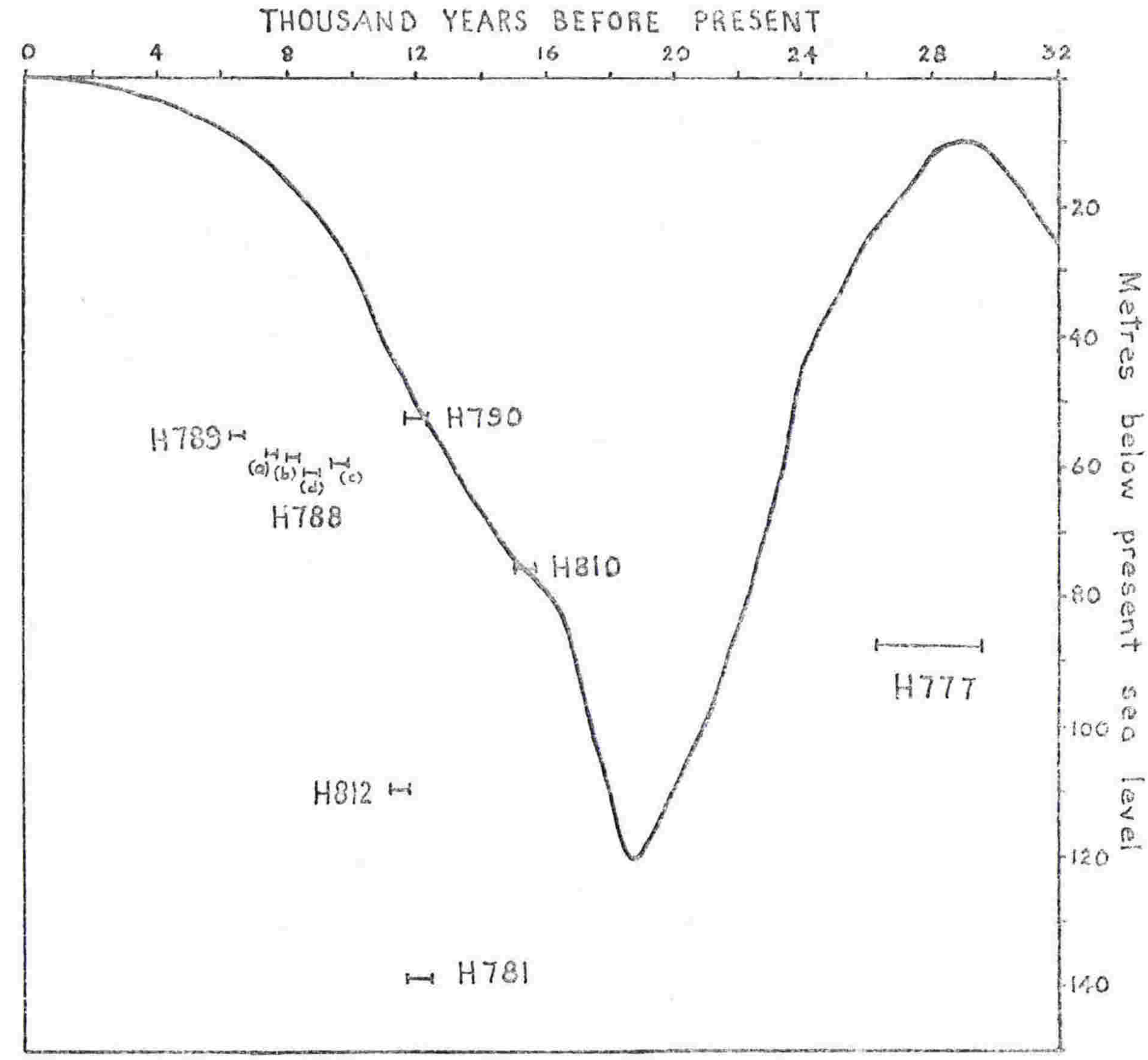


Figure B24. Radiocarbon ages and depths below present sea level of shells obtained from cores on the Canterbury continental shelf. The sea level curve is that of Curray (1965). See Table B6 for identities and depth ranged of species.

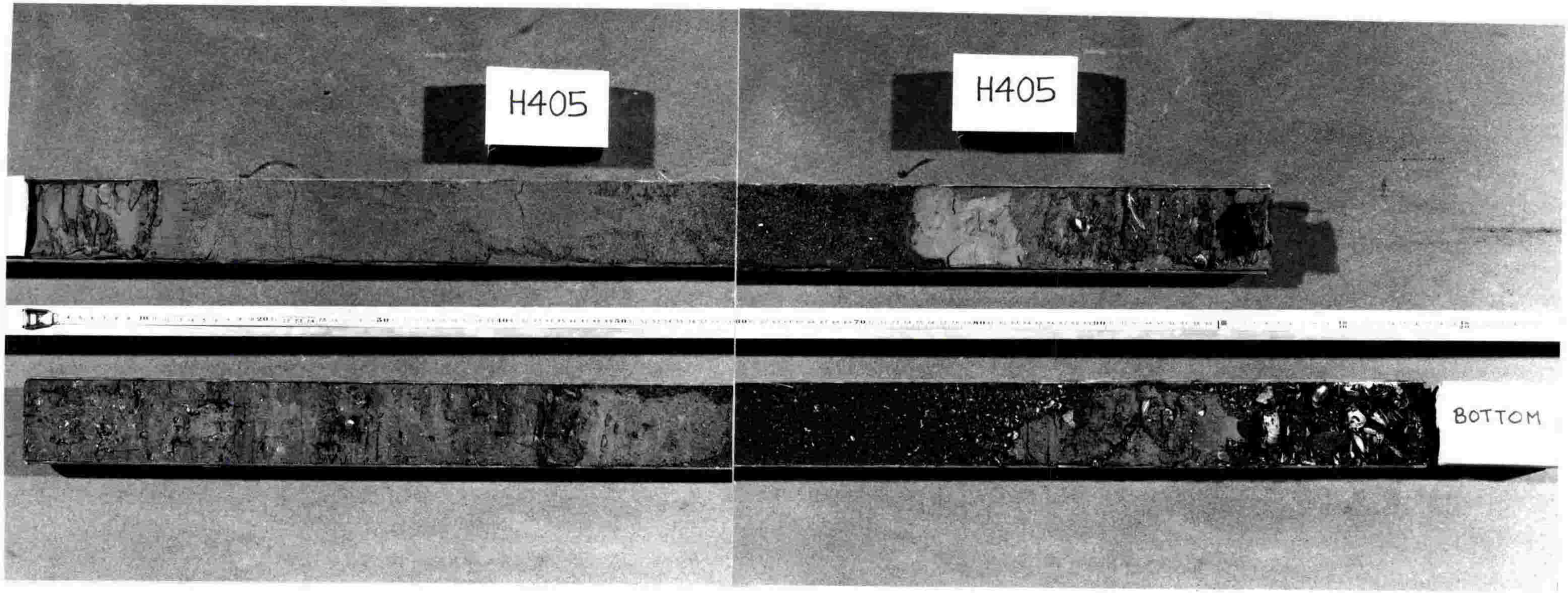


Plate B10. Core H405 from the trough facies of the upper member of the Canterbury Bight Formation, showing alternating layers of mud and coarse to medium sand, gravel and intertidal shells.

The lower, as mentioned above, is quite deeply eroded and is mostly muddy Mode IV sand.

The single core taken in the terrace edge facies (H812, Plate B11; Fig. B9 and Appendix IV) penetrated 2 m into the upper member. Its top 26 cm is composed of the graded mud to sand sequence that is found in other cores. The remainder is dominated by pea-gravel in a sandy (Mode III/II) or muddy matrix, the mud being confined to the upper 86 cm. The gravel contains numerous intertidal and shallow water species (Table B5). It is thus thought to include reworked shore deposits. The mud at the top of the core accumulated after the sea rose. The thorough mixing of the mud, sand and gravel is thought to have been caused by bioturbation.

(e) Age of the Canterbury Bight Formation

The bulk of the lower member of the Canterbury Bight Formation is assumed to have accumulated during the Last Glacial lowering of sea level.

The upper member has been well dated by radiocarbon. Exclusively shallow water shells, selected from cores H777, H790 and H810, are of Last Glacial age (11,750 - 27,900 yr), while deeper water shells, selected from cores H788 and H789, are of Holocene age (6,400 - 9,400 yr). The upper member is thus considered to have been deposited during the Last Glacial sea level regression and to have been reworked by the sea during the deglacial transgression. At places, the reworking may still be continuing.

DISCUSSION

Geologic Map of the Canterbury Shelf

Figure B25 is a geological map of the outcrop pattern of the formations discussed above.

Although the 3.5 kHz seismic profiles provide the basis for establishing the formations, the lateral formation

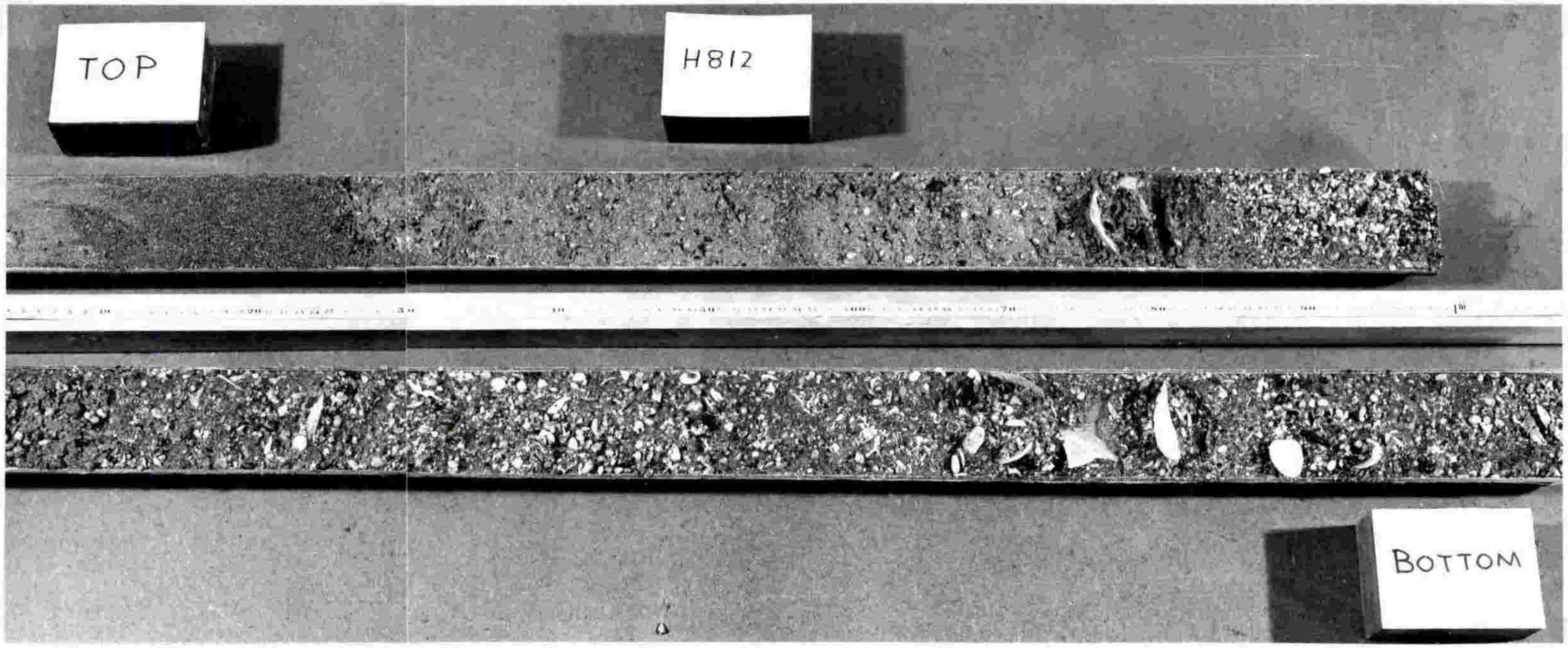


Plate B11. Core H812 from the inner edge of the shelf edge terrace (upper member of the Canterbury Bight Formation), containing a dense deposit of pebble gravel.

QUATERNARY	PLEISTOCENE	Holocene	PEGASUS FORMATION	Greyish olive, very fine marine sand and mud.
QUATERNARY	PLEISTOCENE	Last Interglacial - Last Glacial	CANTERBURY BIGHT FORMATION (Upper member)	Palimpsest, olive brown, medium to fine shelf sand and fine, shelly gravel; fluviatile and littoral greywacke gravel in central Canterbury Bight; littoral transgressive quartz-greywacke gravel and some dark greenish grey lagoonal mud off Banks Peninsula.
QUATERNARY	PLEISTOCENE	Last Interglacial - Last Glacial	CANTERBURY BIGHT FORMATION (Lower member)	Greyish olive, very fine marine sand and mud.
QUATERNARY	PLEISTOCENE		OLDER PLEISTOCENE SEDIMENTS	Undifferentiated.
TERTIARY			TERTIARY SEDIMENTARY ROCKS	Undifferentiated.

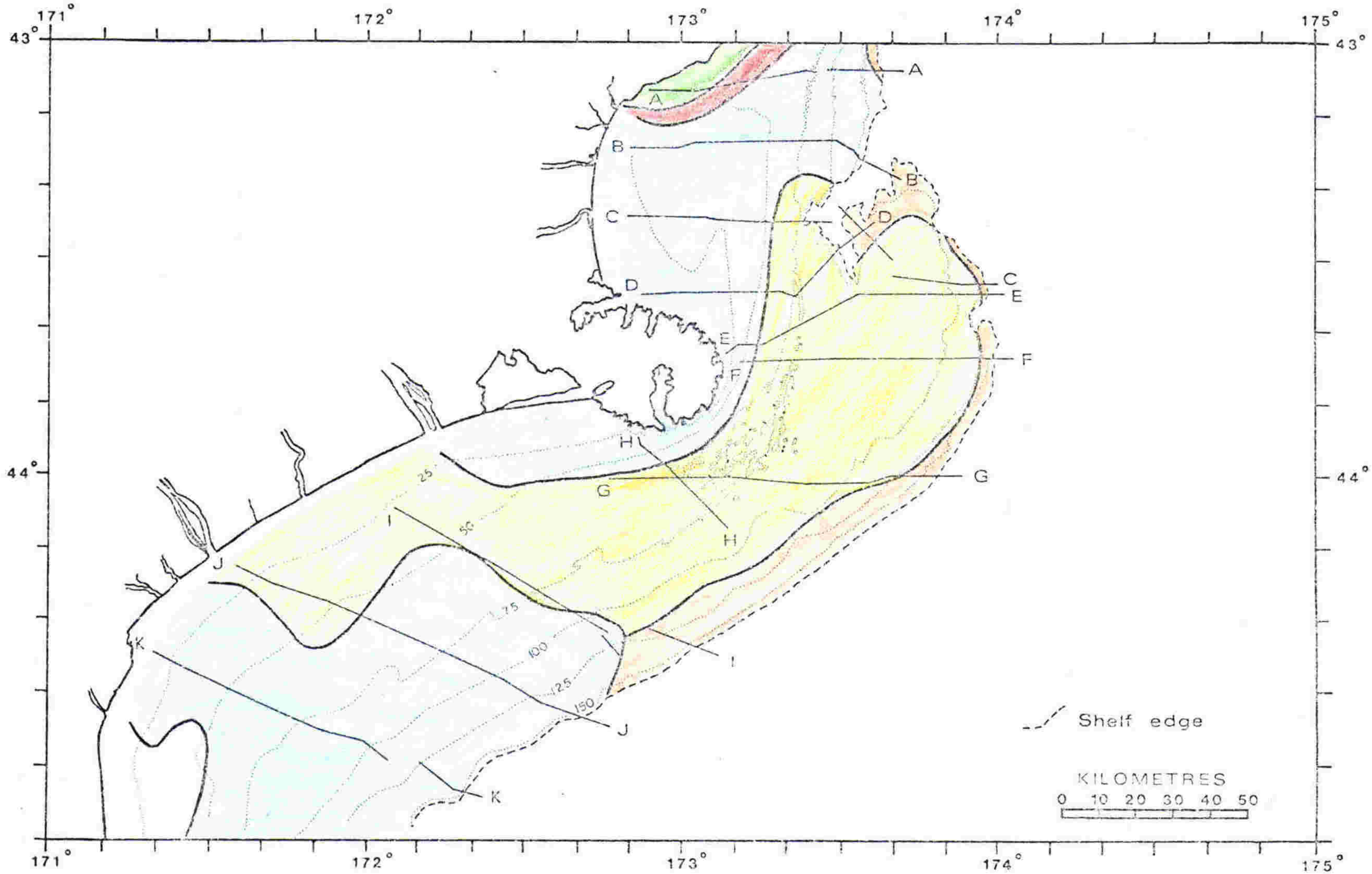


Figure B25. Geological map of the Canterbury continental shelf. Contours in metres.

boundaries are defined primarily by the boundaries between the different size modes. The echogram morphology, contoured microbathymetry and 3.5 kHz profiles were then used to supplement the lithologic data and to refine the boundaries.

Segregation of Size Modes

The most obvious feature of the sediment distribution pattern on the Canterbury continental shelf is the virtually complete areal segregation of unimodal Mode IV sand from the polymodal assemblage of coarser sands and lithic gravel (Modes I-III, Figs B14, B12). It is generally agreed that the coarse relict sediment on a continental shelf was transported to its apparently anomalous location during glacially lowered sea levels and left there when the deglacial shoreline moved landward. The coastal retreat model has been proposed by Bruun (1962) and Schwartz (1965). During a rise of sea level on a low unconsolidated coast, erosion of the shore-face will tend to be balanced by an equal-volume accumulation on the adjacent sea floor. The shore-normal transfer that this process requires creates the thin transgressive sheet of relict materials now mantling the shelf. Input and output by longshore drift is assumed to be steady state, and river input is not taken into account. A modification of this model put forward by Dillon (1970) and Swift et al. (1971) explains coastal retreat and sediment redistribution on a barrier island coastline. The barrier superstructure moves landward by a cyclic process involving storm washover of the coarse sediments, their burial, and their re-emergence at the retreating shoreface.

In both the models, fine as well as coarse sediment is carried offshore during deglacial coastal retreat. Neither model embodies a satisfactory explanation for the total absence of the finer sand (Mode IV) from the relict sand/gravel sheet on the Canterbury shelf. Since all the sand modes (II through IV) that occur in the present coastal plain sediments apparently occurred in the Pleistocene coastal plain sediments as well, the separation of Mode IV from the others must have taken place by marine processes.

It is possible that winnowing of the very fine (Mode IV) sand from the fine (Mode III) sand, which dominates the transgressive sand/gravel sheets on the shelf, has been taking place for the last 6,000 years since the return to present high sea level. However, a number of obstacles present themselves :

(a) This would require stronger currents on the middle shelf sea-bed than on the inner shelf sea-bed. This is not impossible but remains to be proved.

(b) In several places (in northern Pegasus Bay and off Banks Peninsula) relict Mode III sand is mixed with modern mud deposits but Mode IV sand is absent, indicating that Mode IV sand was removed before the present current system was established.

(c) Mode IV sand is absent throughout the cores in the transgressive sand/gravel sheet, which includes buried shell beds dominated by littoral species that are presumed to have been deposited and reworked, in very shallow water and to be undergoing no reworking now.

This again suggests that Mode IV was removed (probably in shallow water) before the present current system was established.

It is possible that the very fine Mode IV sand was removed from the transgressive sand/gravel sheet as it was being laid down. This argument has some basis.

The present coastline of Canterbury is, at different places, eroding, prograding or stable. All three sand modes (and gravel) are at present being supplied to the coast by rivers. Off prograding or stable portions of the coast (the coast of Pegasus Bay and Kaitorete Spit) the sea bed is made up of very fine Mode IV sand (Fig. B14; see also Campbell 1974) and mud, that is accumulating as a thick modern deposit (the Pegasus Formation) on the inner shelf. The bathymetric profile of the deposit is in equilibrium with the present coastal hydraulic regime. The beaches consist of medium and fine (Modes II and III) sand and gravel (Mode I) (cf. Blake 1964; Campbell 1974). Such seaward fining of sediment is a normal feature. The sorting takes place within and just seaward of the surf zone, gravel and coarser sand being thrown landward up on to a beach while mud and finer sands are carried seaward (Keulegan 1948; Scott 1954; Ippen & Eagleson 1955; Ingle 1966; Johnson & Eagleson 1966; Cook 1969; Swift 1969, and others).

Off the eroding coast - the coast of central Canterbury Bight (Kirk 1967) - the sea bed is made up of gravel and Modes II and III sand (Figs B10, B14). Very fine (Mode IV) sand is absent, although it may be present very close to shore. In the beginning of this chapter it was mentioned that the surface of the inner continental shelf off central and southern Canterbury Bight is steeper than to seaward and has the form of two very broad fans. The fans are thought to be the submerged extensions of the Rakaia and Rangitata gravel outwash fans shown in Fig. B2. The drowned fans are well defined between the 50 m and 25 m contours, indicating that the drowning was initially rapid and that, little erosion took place. The later stage of coastal retreat involved a large amount of cliffing. It is assumed from the vestigial fluvial geomorphology and the absence of a modern fine sediment cover that the inner shelf in this area has not reached a profile of equilibrium with the hydraulic regime, that high energy conditions prevail, and that the seabed is thus continually swept clean of fine sediment. The transport path of bedload sediment on the inner shelf in this area is northwards and shorewards (Chapter A). Very fine Mode IV sand introduced by the local rivers is therefore transported away towards the northeast in a nearshore belt.

During the rapid sea level transgression of the last deglaciation the profile of the sea bed off the whole coast would have been continually out of equilibrium. Conditions would have been unfavourable for deposition of Mode IV sand. The sand would thus have been removed from the transgressive sand-gravel sheet as it was laid down and transported northwards out of the area.

Ages of the First and Second-order Ridges

Because of the complexity of the geomorphology and sediment distribution on the exposed top surface of the Canterbury Bight Formation, it is thought that some features are modern and some are old.

Theories of Origin of Ridge-and-Swale Topography

The origin of the ridge-and-swale topography on the Canterbury continental shelf is not fully understood, but much can be inferred from better known examples in other parts of the world. The best studied examples of ridge-and-swale topography are on the Atlantic continental shelf of the U.S. and in the North Sea - English Channel - Celtic Sea area of Europe. The former are on a long, linear continental shelf that directly faces the deep ocean, whereas the latter are in two semi-enclosed bodies of water and the channel joining them.

Different parts of the ridge-and-swale topography on the Atlantic shelf of the U.S. have been explained as :

i) barrier beaches overstepped by the transgressing sea (Veatch & Smith 1939; Emery 1966; Garrison & McMaster 1966; Uchupi 1970)

ii) beach ridges formed during ealier Pleistocene sea level stands (Sanders 1962; Dietz 1963; Hyne & Goodell 1967; Kraft 1971)

iii) a drowned fluvial surface (Garrison & McMaster 1966; McKinney & Friedman 1970; McMaster & Ashraf 1973)

iv) nearshore shoals, abandoned during deglacial coastal retreat, and subsequently modified by the inner shelf hydraulic regime (Moody 1964; Swift _et al_. 1972a and b, 1973), and

v) modern submarine ridges formed after the deglacial transgression (Duane et al. 1972; Schlee & Pratt 1972).

Recent studies indicate that the sediments on the ridges and swales of the inner shelf are active (Duane et al. 1972; McKinney et al. 1974; Stubblefield et al. 1975). Wind and wave-generated currents caused by intense winter storms often disturb the entire inner shelf water column. The currents progress parallel to the ridge axes with a helical flow pattern that scours out the troughs and carries sand obliquely up the flanks of the ridges thus building them up. During weaker storms, sand is swept back from the crest towards the flanks. Rotary tidal currents are an alternative cause for the present activity of ridges (Stewart & Jordan 1965; Smith 1969).

The North Sea-English Channel-Celtic Sea region is tide dominated, although meteorologic effects are still important (e.g., Carruthers 1963; Stride 1963, 1973; Robinson 1966; Allen 1968b; Houbolt 1968; Kenyon & Stride 1970; Belderson et al. 1971; Bouysse et al. 1976). The proferred mechanism for ridge construction in this case is also one of helical flow parallel to the long axes of the ridges with scouring of the troughs and sediment transport towards the ridge crests (e.g., Houbolt 1968; Caston & Stride 1970; Caston 1972). Surface current velocities reaching 3 knots (154 cm/sec) seem to be required (Stride 1973). The constructional current is mainly tidal; degradational currents are supplied by waves which winnow the sediments from the ridge crests. Ridges in shallow water (30-40 m) are apparently active today. Ridges in deeper water (140-170 m) of the Celtic Sea are considered to have been most active during lower sea levels (Bouysse et al. 1976).

Second-order Ridges on the Canterbury Shelf

The second-order ridge-and-swale topography on the Canterbury Shelf is assumed to have been formed by helical currents of the type described above. From their present distribution and from their appearance in seismic profiles, inferences can be made about their origins and about their present state of activity.

(i) Ridges on the constricted shelf off Banks Peninsula

The second-order ridges on the constricted shelf off Banks Peninsula are numerous and high. Ridge-parallel sand ribbons (and oblique-trending sand waves) occur with the ridges and, like the ridges, they are thought to be related to a 3-dimensional, longitudinal flow pattern, where pairs of counter rotating, helical vortices maintain swept strips and parallel strips of sand accumulation (Allen 1968a, 1968b; Houbolt 1968). Ridges are thought to form where the currents flow at 3 knots (154 cm/sec) (Stride 1973), and sand ribbons where currents have maximum near-surface velocities of 2 knots (103 cm/sec) (Kenyon 1970). Unidirectional surface currents higher than 2 knots and possibly as high as 3 knots have been detected in the region of constricted flow off Banks Peninsula (Chapter A). The microbathymetry (Fig. B6) shows that the long axes of the ridges trend north to northeast, parallel to the direction of present current flow. The internal structure of the ridges suggests that they have migrated seawards (Profile H, Fig. B22), which in turn suggests that they are moved by the present northward-going bottom current which has a frequent wind-driven offshore component (Chapter A). It is thus probable that the high second-order ridges southeast of Banks Peninsula are maintained today by the accelerated currents in the constriction caused by the peninsula.

Belderson (1964) and Stride (1973) have shown that where tidal currents flow at less than 1 knot (51 cm/sec) the depositional area for sand is flat, or in very low mounds at bedload convergences. The change from second-order ridges off Banks Peninsula to essentially smooth sea bed north of Banks Peninsula probably reflects the slackening of currents beyond the constriction.

Although the ridges on the constricted shelf southeast of Banks Peninsula are thought to be active today, they probably originated in shallower water during the deglacial sea level rise.

(ii) Ridges on the open shelf of Canterbury Bight

In Canterbury Bight the outer belt of second-order ridges in Zone D and the low, second-order ridges on the shelf edge terrace (Zone F) occur far to the southwest of Banks Peninsula and the zone of constricted circumpeninsular flow. Southwards the ridges become buried under a modern sandy mud deposit, indicating that these ridge-swale systems, which probably once extended south of the study area, are now inactive. It is likely that the ridges were formed as nearshore shoals during lower sea levels by the storm-current process described by Moody (1964) and Swift et al. (1972a and b, 1973).

The inner band of second-order ridges in Canterbury Bight dies out about 74 km southwest of the peninsula (Fig. B7) with no evidence from seismic profiles of any buried extension. The available data is insufficient to determine if these ridges are modern or relict.

Ridges are restricted to depths between 50 m and 150 m in Zones D and F and do not occur on the inner shelf. Nearshore storm-current, ridge generation is not taking place at present.

First-order ridges on the Canterbury shelf

The clearest exposure of first-order ridges is in the area northeast of Banks Peninsula where the second-order ridges are absent. The two very long, low, broad, coast-parallel ridges, each backed by a trough on the landward side (Fig. B5) do not resemble any common submarine bedforms. The crest of each first-order ridge was cored and dense shell beds were penetrated (cores H777 and H810). As mentioned already, the fauna consists exclusively of species that are found in shallow water and is dominated by species restricted to beaches and lagoons.

Shells of the intertidal bivalve Paphies australe and the beach dwelling P. subtriangulatum, obtained from 1-1.5 m below the surface of each first-order ridge crest, have the following radiocarbon ages : the shells on the outer ridge (H777) are 27,900 ± 1,550 years old, and those on the inner ridge (H810) are 15,100 ± 200 years old. The first-order ridges with their associated troughs are interpreted as being a pair of barrier-lagoon complexes that have been transgressed and reworked by the sea. Minor features, such as beach ridges, dunes etc. would have been destroyed during the transgression, only the general high of the barrier and the general low of the lagoon being features large enough to withstand the reworking.

Ages of the Shallow-Depth-Range Shells

It will be seen from Fig. B24 on which the ages and depths of the radiocarbon dated samples are plotted against the widely accepted Pleistocene sea level curve of Curray (1965), that samples H790 and H810 (which have restricted, shallow depth ranges, Table B6) lie on the curve, while samples H781 and H777 (with similarly restricted depth ranges) are anomalous and lie well below the curve.

The ages of samples H790 and H810 are accepted as being correct. Sample H781 was taken from the shelf edge terrace (Figs B7,B9) which is presumed to have formed during the Last Glacial minimum sea level about 18,000 years ago. The dated species Panopea zelandica is restricted to shallow water (0-20 m; Table B6). Its depth below the lowest point of the curve lies within the depth range of its habitat but its age is anomalously young. The shells are assumed therefore to have contained younger contaminants and the age is rejected.

H777, on the other hand, cannot be similarly rejected. Its anomalous position relative to the curve can be explained by:

1. substantial downwarp at Stn H777
2. an unexplained error in the radiocarbon date, or
3. an error in the sea level curve at 27,900 years.

1. If downwarp is assumed, the computed rate of downwarp, based on the Curray (1965) sea level curve, for a line passing, through Stns H790 and H810, which lie on the curve, is 0 m/kYr; that for H777, 15 km to the east, is 2.5 m/kYr. Except for superficial reworking, the present shelf surface is essentially the 18,000 yr B.P. surface. It slopes extremely gently and evenly seaward. If the surface were tilted back to its supposed 18,000 yr B.P. level at the computed rates, its slope would be reversed - a highly improbable situation. Other published curves are no more satisfactory for the resolution of the problem. There is no evidence for this degree of tectonism in this region. Unpublished oil company data (P.J. Hill and P. Dean, B P Shell Todd (Canterbury) Services Ltd, pers. comm.) indicates that there has been only 50 m of relative downwarp between H810 and H777 since the beginning of the Miocene (a rate of 2 mm/kYr) and that downwarp in this area has actually been towards the west rather than towards the east.

2. Sample H777 (27,900 yrs old) is assumed to be from a very large and well developed lagoon complex, i.e., a shoreline feature. The period 25,000-35,000 yr is a well established interstadial, and an interstadial is a time when well developed shoreline features are likely to have formed. On this basis, the radiocarbon date seems valid.

If the 27,900 yr date is correct, the outer first-order ridge marks the probable shore of the last interstadial which preceded the main Last Glacial advance. The lower formation (X) would then of necessity be of Penultimate Glacial Age, and disconformities related to minor regressions and transgressions of the interstadials during the Last Glacial would be hidden in the Canterbury Bight Formation. The sea level of the last interstadial would be at least 60 m lower than that shown on the curves of Curray (1965) and Milliman & Emery (1968).

If a high interstadial sea level, as suggested by the eustatic curves of Curray (1965) and Milliman & Emery (1968), is accepted, and the radiocarbon date rejected, the outer first-order ridge would simply mark a sea level stillstand during the main regression of the Last Glacial. Formation X underlying the Canterbury Bight Formation, would then be of earlier Last Glacial age and the shelf-wide unconformity separating the two would be that of the last interstadial.

Resolution of this problem must await further work. It is assumed here that the 27,900 yr age of sample H777 is correct until the age can be checked by a further sample.

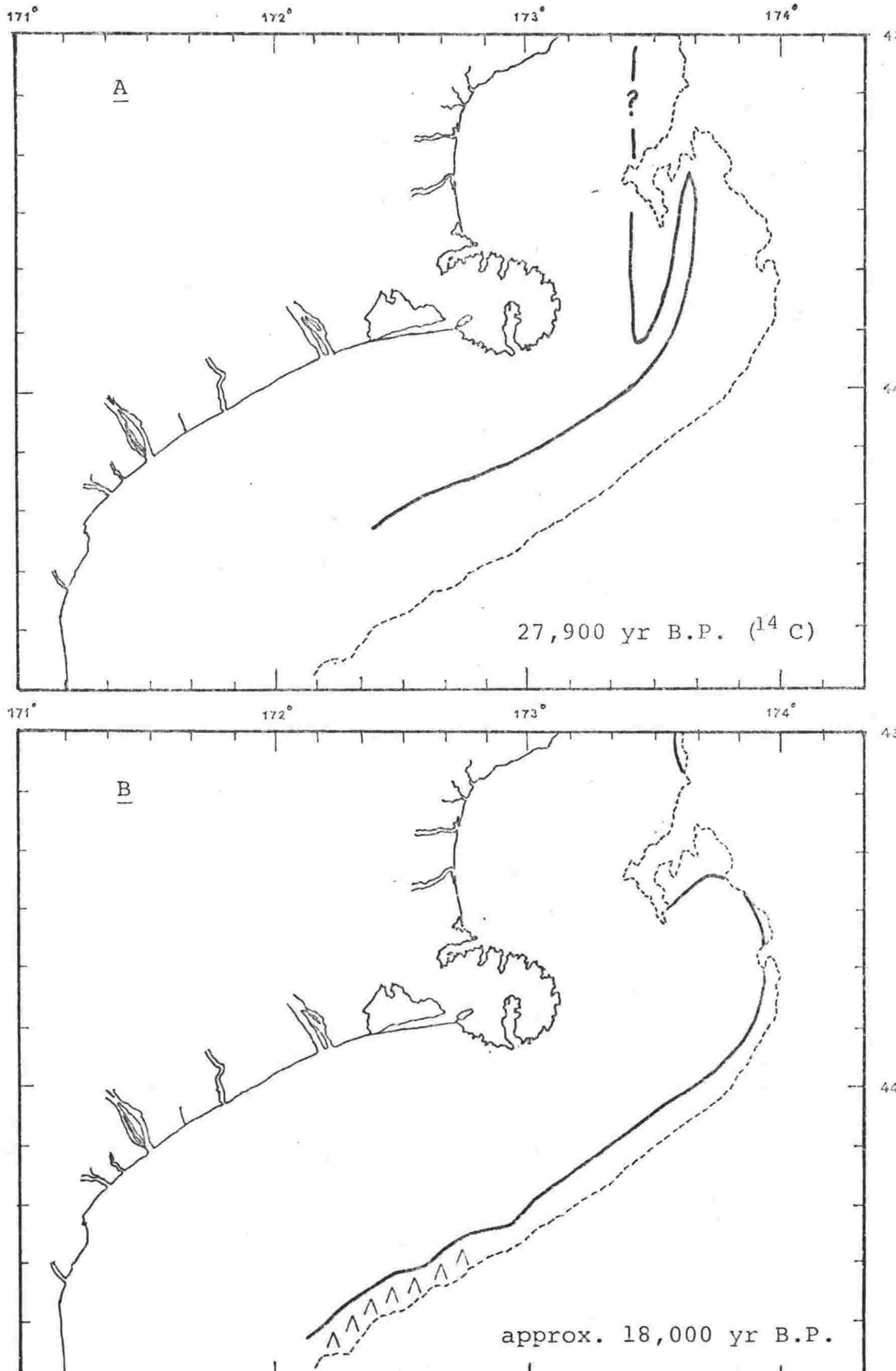
History of the Regressive - Transgressive Surface

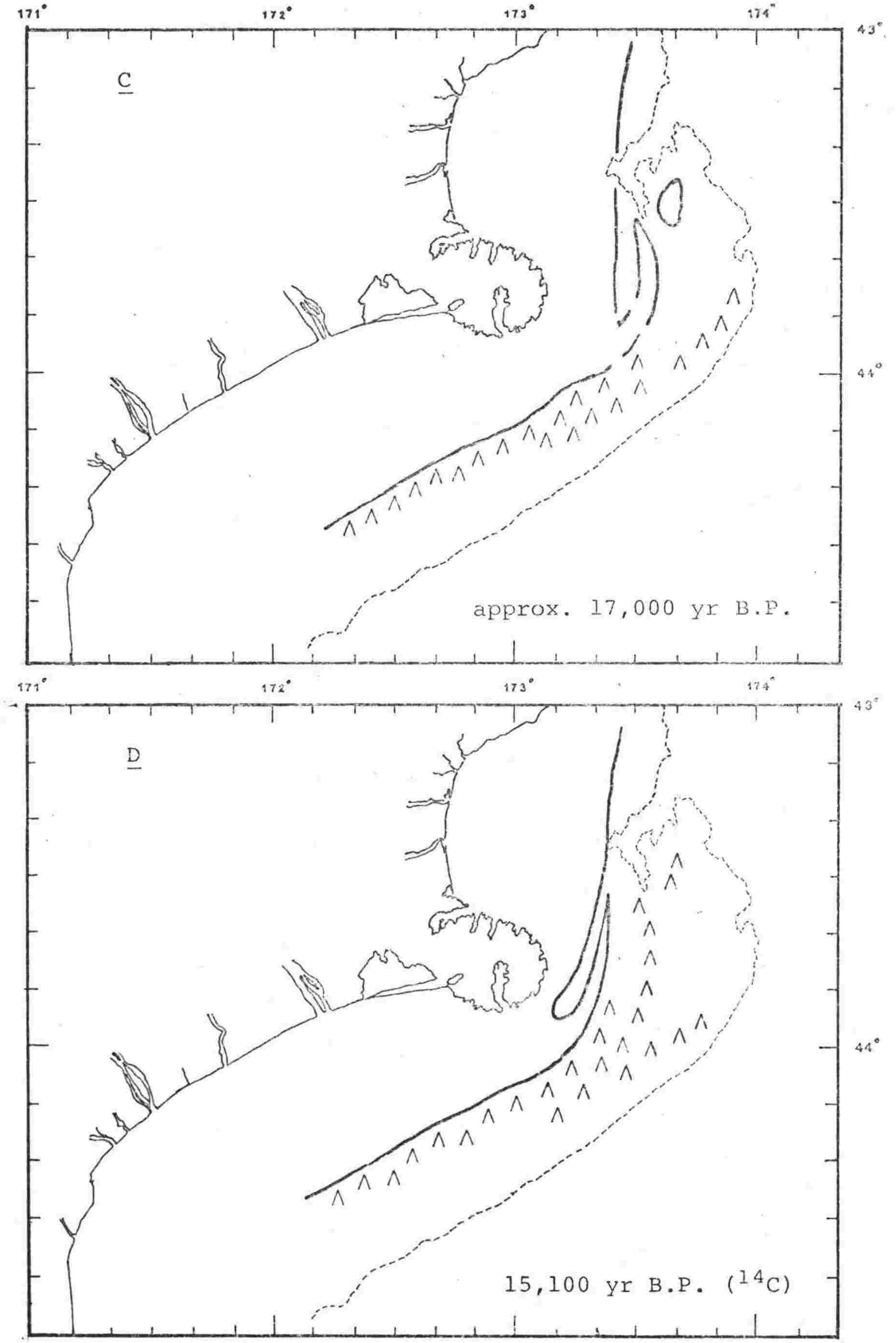
With the ancient and modern ridges distinguished, and the valid radiocarbon dates established, a chronological sequence of late Pleistocene - Holocene events on the shelf can be worked out. The two radiocarbon-dated first-order ridges and the Last Glacial shelf-edge terrace provide the necessary framework. The shelf edge terrace is assumed from the sea level curve (Curray 1965) to have formed 18,000-20,000 yr ago.

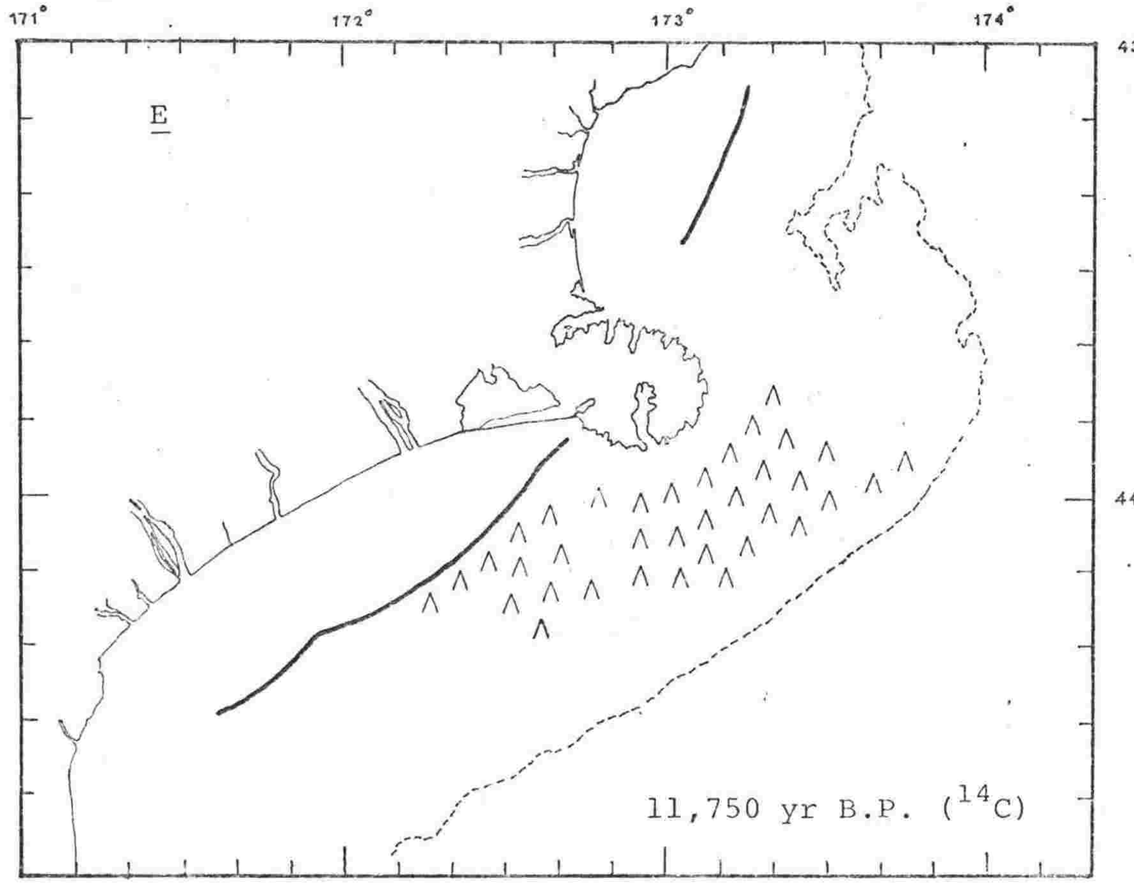
In Fig. B5 it is seen that, in the region of Pegasus Canyon, the terrace truncates the end of the broad, low, eastern branch of the outer first-order ridge that passes east of the canyon head (cf. Fig. B7, B26a). The ridge has been interpreted above as the remains of an old shore zone. It is inferred therefore that during the 27,900 yr B.P. interstadial, the shoreline stood just east of the head of Pegasus Canyon (Fig. B26a). A large barrier or spit/lagoon complex formed - the lagoon opening northwards into the canyon. The interstadial lagoon has subsequently been largely infilled and locally buried. This is shown by deep cut-and-fill structures midway across the shelf in Profiles E and F (Fig. B21). Off Canterbury Bight the interstadial shore is marked by a first-order ridge

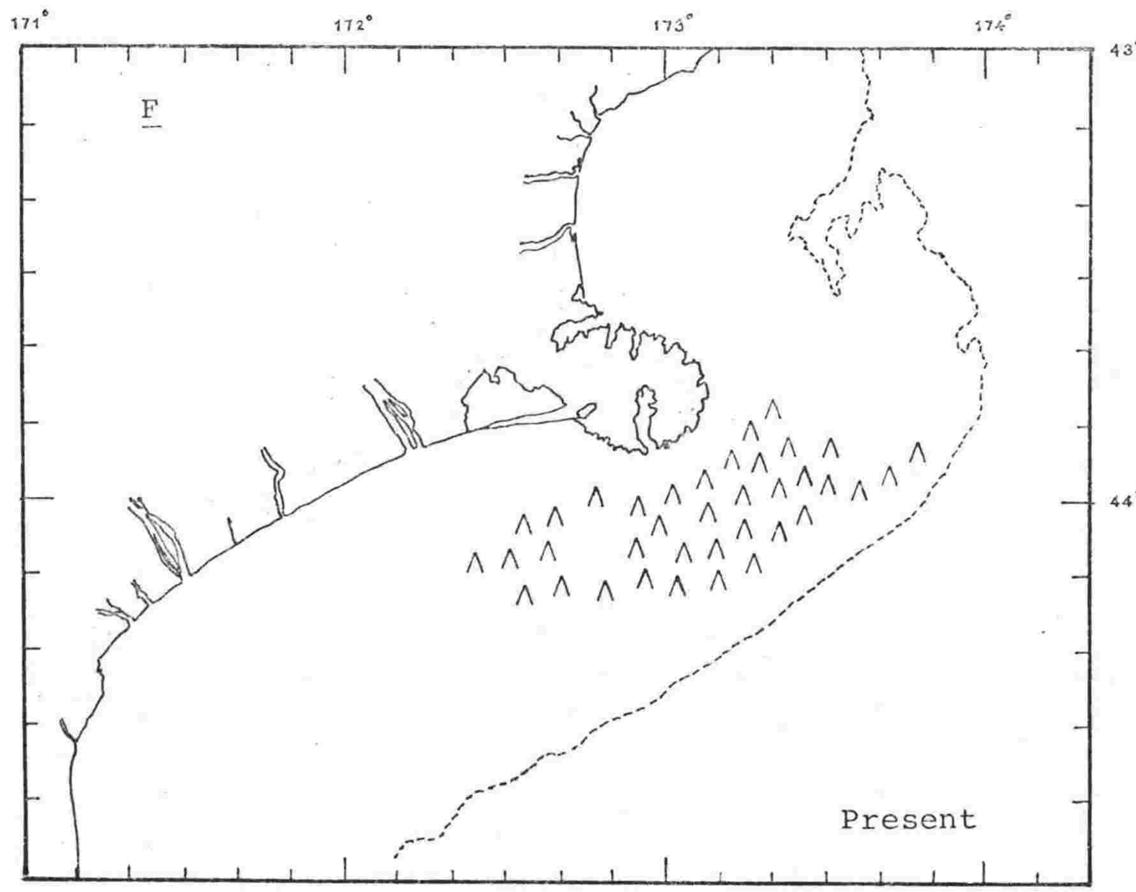
Figure B26 (a,b,c,d,e,f).

Positions of successive Late Quaternary shorelines. Shoreline ages that are based on radio-carbon-dated shells are indicated by: (^{14}C). Other shoreline ages are inferred from the sea level curve of Curray (1965).
ΛΛΛΛ - Inferred active offshore shoals or submarine ridges.


171°
172°
173°
174°
43°
44°
A
?
27,900 yr B.P. (^{14}C)
B
approx. 18,000 yr B.P.


171°
172°
173°
174°
43°
44°
C
approx. 17,000 yr B.P.
171°
172°
173°
174°
43°
44°
D
15,100 yr B.P. (14C)


171°
172°
173°
174°
43°
44°
E
11,750 yr B.P. (^{14}C)


171°
172°
173°
174°
43°
44°
F
Present

(Fig. B7) but there is no evidence in the profiles (Fig. B23) for a barrier/lagoon system. Instead, with a relatively stable sea level, a thick, prograding wedge of sediment, analagous to the present day one in northern Canterbury Bight, developed and the shore migrated very slowly seawards (Profiles I, J, K; Figs B22, B23).

Straightforward progradation took place in Canterbury Bight because this region was at the advancing foot of the Canterbury Plains with its copious direct input of glacio-fluvial sediment. A spit/lagoon system formed east of present day Banks Peninsula because this latter region was then, from a fluvial aspect, in the depositional shadow of the mountains which now form the peninsula. Sediment input east of the mountains would have been almost exclusively by northward longshore and shelf transport, and any long continued period of sea level stability would have led to the development of a spit or barrier. The spit extended well north of the depositional shadow of the mountains because Pegasus Canyon would have prevented the eastward progradation of the northern part of the plains.

As shown above, coastal stability or progradation leads to the accumulation offshore of very fine (Mode IV) sand and mud and the accumulation onshore of the coarser mode (II and III) sands and gravel. The progradational portion of the Canterbury Bight Formation at this time would thus have been forming from Mode IV sand and mud while the surface of the shoreline and spit would have been forming from gravel and modes II and III sand. Gravel and sand, carried northwards by littoral drift and currents on the inner shelf, would have poured into Pegasus Canyon through the small tributaries that enter it partway along its length.

After the inferred interstadial, the sea level fell quickly while a high rate of terrigenous sediment input was maintained. This is implied by the slight increase in slope of the outer shelf and by the seaward change from upbuilding to steeper out-building foresets (Profiles I, J, K; Figs B22, B23). The steepening of the foresets near the shelf edge is probably due to increased sandiness of the progradational sediment which was deposited near the advancing shore.

When the sea stabilised at its lowest level during the last glacial maximum 18,000-20,000 yr ago (Curray 1965), it cut a bench in the newly deposited unconsolidated sediments of the shelf edge while progradation continued on the upper continental slope. The terrace, now at 110-150 m below sea level, was thus formed (Figs B5, B7, B26b). Along the south-east-facing portion of the terrace in the southern half of the study area, southerly storm conditions were favourable for the generation of second-order ridges (Figs B7, B22, B26b). In the north, the terrace surface remained smooth (Profile C; Fig. B20).

Coarse sediments accumulated on the beach at this time to form the large belt of gravel that now lies adjacent to the terrace (Fig. B12). Very fine (Mode IV) sand and mud were carried both seawards on to the continental slope and northwards along the narrow shelf towards Pukaki and Okains Submarine Canyons. The coarse beach sediments would also have been transported northwards into the submarine canyons by the dominant southerly swell. The loss is assumed to have been balanced by the input of longshore-drifted gravel and sand from the south.

With the onset of deglaciation the sea level rise was initially fast and the terrace was evidently drowned without much modification. It is assumed that the terrace once extended through Mernoo Saddle but was destroyed during the deglacial rise of sea level by constricted, high-velocity currents.

During the deglacial sea level rise, the coastal regime was one of erosion and retreat. As shown earlier, coastal retreat leads to the offshore transfer and accumulation of the coarse onshore sand and gravel, and the removal of mud and very fine (Mode IV) sand from the shelf system. Sediments eroded from the coastal plain, which probably consisted mainly of a beach-ridge dune terrain, were redistributed on the continental shelf. Gravel and Modes III and II sand would have formed a shelf transgressive sheet. Mud and (Mode IV) sand would have briefly entered the transgressing littoral system and been transported northwards away from the non-equilibrium sea bed and into the submarine canyons. As the retreating beach migrated westwards, gravel and sand carried north in the littoral drift would have poured into Pegasus Canyon at successive points along its length. The shoreline and sea bed configurations during the sea level retreat phase are discussed below.

When the rising sea had transgressed a short distance across the shelf, it encountered the great high of the old interstadial shore complex (outer first-order ridge) (Fig. B7). As the sea overstepped, the surface of the ridge would have been drastically reworked (Fig. B26c). This event would have taken place, according to the Curray (1965) curve, 17,000 yr ago.

In Canterbury Bight, the sea bed near shore was probably worked into low shoals by large waves and storm currents, generated mainly from the south (Profiles I, J; Figs B22, B23). These would have given rise to the present second-order ridges of outer Zone D in Canterbury Bight (Fig. B7; Profiles I, J K; Figs B22, B23).

Southeast of Banks Peninsula and adjacent to Mernoo Saddle, reworking was probably so intense, because of the constricted and accelerated tidal and storm currents, that the old high was completely destroyed and remoulded into high second-order ridges (Profiles G, H; Fig. B22). Obliteration of the shelf edge terrace probably continued.

Northeast of Banks Peninsula, where the offshore tidal and storm currents would have been reduced, reworking probably resulted merely in the formation of a transgressive gravel and sand sheet without shoal formation. As a consequence, the microbathymetry (Fig. B5) is not confused by second-order ridges, and stages in the overstepping of the spit can be deciphered.

It has been pointed out previously that the outer first-order ridge is forked near the head of Pegasus Canyon. The western fork is interpreted as a post-glacial modification of the earlier-formed interstadial spit which extends up the eastern side of the canyon. When the shore of the rising sea reached the vicinity of the old spit (the present eastern limb of the outer first-order ridge) there would have been a temporary return to the last interstadial situation of a barrier island (or spit) backed by an extensive lagoon (Fig. B26a). The lagoon opened northward into Pegasus Submarine Canyon. As sea level neared the crest of the spit, the spit was occasionally overtopped by storm washover. A permanent breach developed near the head of the submarine canyon (Fig. B26c), where washover sediment, carried across the spit, would have spilled into the canyon and been lost to the spit system. The breach is still preserved in the microbathymetry (Fig. B5). With the re-entry of the canyon head into the littoral system, the crest of the spit would have quickly shifted west to lead into the new sediment sink formed by the canyon head (Fig. 26c). This new spit alignment is also visible in the microbathymetry (Fig. B5). The spit segment north of the breach was abandoned to become an offshore shoal. The extensive infilling of the northern part of the lagoon that took place during this shift is evident in Profile F (Fig. B21) where the muddy lagoonal facies reflectors are rather deeply buried by a massive sandy unit. On the profile, the new ridge crest appears just to the east of the lagoon. A short distance to the south, where the spit crest did not migrate appreciably, the muddy lagoonal facies is still at the surface, only slight infilling (from the east) being apparent (Profile F, Fig. B21).

A further 10 m rise of sea level to about the present 76 m isobath (Fig. B5) was followed by a stillstand and the formation of the inner first-order ridge (Figs B5, B26d; Profiles E, F, Fig. B21). It is assumed to have been a barrier/lagoon complex similar to the outer one and according to radiocarbon dating it formed 15,100 yr ago.

During the formation of the barrier, conditions would have been considerably different from those of the present day. To the northeast, through Pegasus Canyon, lay deep open water. To the east, the outer first-order ridge, only 10 m deep, would have damped the ocean swell. To the southwest there was probably a shallow system of active shoals (second-order ridges) which also would have reduced the swell. The northward longshore drift may therefore have been much reduced and even, at times, replaced by southward drift.

South and southeast of Banks Peninsula no barrier/lagoon system formed during the stillstand. Instead, reworking of the shallow sea bed into second-order ridges probably continued off the cape that would have existed off present day Banks Peninsula. Further south, where the slope of the shelf is steeper, the shore would have still been in the vicinity of the first-order ridge that marks the old interstadial shore. Nearshore, storm-dominated shoals probably continued to form.

Shortly after the renewed rise of sea level from the 15,100 yr shore, the supply of littoral gravel to Pegasus Canyon would have ended.

Subsequent events of the deglacial transgression are less clear.

A radiocarbon age of 11,800 yr was obtained for shallow water shells at a depth of 53 m in Canterbury Bight (H790, Table B3). Assuming that the animals (Zethalia zelandica) were living near sea level, a tentative shoreline position for that time can be drawn on the surface of the Canterbury Bight Formation (Fig. B26e). In Canterbury Bight, the arcuate shapes of the Rakaia and Rangitata fans are visible. Their good preservation implies that there was no stillstand but that sea level was rising rapidly. Banks Peninsula was already a promiment headland by this time, preventing the northward movement of gravel into Pegasus Bay. Second-order ridges are assumed to have been active southeast of Banks Peninsula since they are inferred to be so today. The inner belt of second-order ridges southwest of the peninsula may have been forming at this time.

A continued rapid rise of sea level to a line west of the 25 m isobath in Canterbury Bight (Fig. B2) is inferred from the good preservation of the fan morphology. Evidence from Foveaux Strait (Cullen 1967) supports a very rapid sea level rise during this period, ending about 9,300 yr ago.

Subsequent shore retreat in central Canterbury Bight was by cliffing (Fig. B17). It is assumed that the greywacke gravel now exposed on the sea bed of inner central Canterbury Bight is that part of the eroded fans which was not moved northward along the transgressing coast.

The final phase of sea level rise (10,000 yr to present) along the Canterbury coast has been described by Jobberns (1926, 1927), Speight (1930, 1950), Blake (1964), Suggate (1968), Kirk (1969), Armon (1970).

Shelf Sedimentation During the last 6,000 years

During the last 6,000 years sea level has stabilised near its present level. Modern sediment has accumulated on the continental shelf and relict sediments have adjusted to the modern shelf hydraulic regime.

Dispersal of Modern Input Sediment

Sediment that has been added to the continental shelf system during the last 6,000 yr is considered to be forming deposits that are in equilibrium with the present hydraulic regime. They consist of very fine Mode IV sand and mud and constitute the Pegasus Formation.

A shelf-wide blanket of sediment derived from the rivers south of the study area and identified as modern by its fauna and grain size modes (Modes IV sand and mud), has accumulated on the older transgressive sand and gravel sheet in southern Canterbury Bight.

A thick prism of modern muddy sand has accumulated in the northern part of Canterbury Bight. There, a secondary landward component of transport created by wind drift (Chapter A) and probably onshore waves, confines the modern deposit to the inner shelf. The shallow upper portion of the deposit is kept mud free (Fig. B11) by swell and storm waves. From it, sand is transported eastwards then northwards around Banks Peninsula.

Pegasus Bay is in the lee of Banks Peninsula, and the sediment that moves around the peninsula accumulates there along with sediment entering from the rivers to the west. Sand and mud have built up the floor of the southern part of the bay by at least 28 m (Figs B5, B14, B20) and sand has formed a banner bank at the mouth of the bay (Figs B2, B10). The sand on the bank does not cross to the western shore.

Tendency of Shelf Sediments Towards Hydraulic Equilibrium

The relict sediments on the shelf are adjusted to the present hydraulic environment. The adjustment is shown most clearly by belts of palimpsest sand, and by deposits of gravel that are stripped of sand.

The coarse lithic gravel of the inner part of central Canterbury Bight, is considered to have been derived from underlying gravel outwash fans, and lies within the depth range that is frequently swept by wave-induced currents (Chapter A). Dispersal paths inferred from sea-bed drifters (Chapter A) are all away from this area. Sand and mud is thus continually swept out of the area and the gravel that remains is a lag deposit.

To the northeast, the Mode III/II sand on the shelf edge terrace and upper continental slope is ascribed to past or present sand spillover. Clean Mode III sand on the walls of the westernmost tributary of Pegasus Canyon suggests that spillover is taking place now.

To the south, on the middle shelf, gravel is extremely rare (Figs B10, B12), implying that the currents are slower. Second-order ridges are low and their state of activity is undetermined. Sand is mud-free and found as a traction zone up to 1.7 m thick in cores (Appendix IV), and is assumed to be mobile. The sand is made up of relict Mode III except near the southern margin of the mud-free belt where it is frequently bimodal (Fig. B14), containing Mode IV sand derived from the Pegasus Formation to the south. On the southern part of the inner zone of second-order ridges, the surface sediment is clean, almost unimodal Mode IV sand. The clean Mode IV sand is assumed to be the northern edge of the Pegasus Formation of southern Canterbury Bight. The edge of the modern mud blanket thus changes north of latitude 44°20'S to a mobile, clean Mode IV sand facies which is mixing with and ultimately replacing the coarser palimpsest Mode III/II sands.

The belt of relatively clean sand at the edge of the continental shelf is unexplained. The energy to shift sediment there may come from internal waves or from accelerated tidal currents that are expected at the shelf edge (Chapter A).

CHAPTER C

SUBMARINE CANYONS AND SUBMARINE SLIDES ON THE CONTINENTAL SLOPE OFF CANTERBURY, NEW ZEALAND

ABSTRACT

The present continental slope off the Canterbury Plains is a progradational feature that is dissected by submarine canyons to the north and by submarine slides to the south.

To the north, during Pleistocene lowered sea levels, streams of fine sand, transported from the continental shelf to the upper continental slope by strong, northward-flowing bottom currents, initiated the erosion of submarine canyons. Interception of longshore-drifted gravel by established canyons reaching Pleistocene strand lines probably accelerated canyon erosion. The present morphology of the submarine canyons indicates that they are now largely dormant.

To the south, deposition of fine sediment with minimal spill-over of coarse bed material has dominated the Late Pleistocene development of the slope. This slope is consequently free of deeply corrasional features like submarine canyons but is prone to failure by gravity sliding. A number of the slides have occurred within the last 18,000 yr.

Those portions of the slope not incised by canyons or slide scars are locally cut by small gullies.

None of these physiographic features are fault controlled.

INTRODUCTION

Submarine canyons are common on the present continental slope of New Zealand (see N.Z. Oceanographic Institute Charts, Coastal Series Bathymetry, 1:200,000) and it is now evident that submarine slides are also common, yet very little research has been done on either (Lewis 1971; Pantin 1972, and in press; Herzer 1973).

In 1971, the author participated in an air-gun seismic survey of the upper continental slope of the central third of the eastern South Island by the Mobil Oil research ship M.V. *Fred H. Moore*; and in 1973 and 1975 conducted 3.5 kHz seismic surveys in the same area from the N.Z. Oceanographic Institute vessel R.V. *Tangaroa*. Profiles A, B, C and G presented here are 70 Hz - 200 Hz profiles from the Mobil Oil records. Profile H is a lower frequency profile from the same source. Profiles D, E, F, H and I are 3.5 kHz profiles run by the author. Profiles J and K are echo-sounding profiles from the collections of the N.Z. Oceanographic Institute. Additional seismic profiles by Gulf Oil and BP Shell Todd were examined but are not illustrated here. The echo soundings used in constructing the bathymetric chart are from the N.Z.O.I. collections and from Royal N.Z. Navy collector sheets.

The area studied here lies off central and southern Canterbury between latitudes 43°00'S and 44°50'S (Fig. C1). The continental shelf is about 90 km wide, much wider than elsewhere on the east coast of New Zealand. It is backed by a smooth coastline broken only by a large volcanic peninsula - Banks Peninsula (Fig. C2). Behind this, stretching over 50 km inland to the foot of the Southern Alps, are the Canterbury Plains, a complex of glacial outwash fans. To the east, the Chatham Rise, with a relatively shallow crestal depth of 32 m to 550 m abuts against the continental slope and divides it into two parts. The southern part descends very gradually (2.0° - 0.3°) into the Bounty Trough where the depth is over

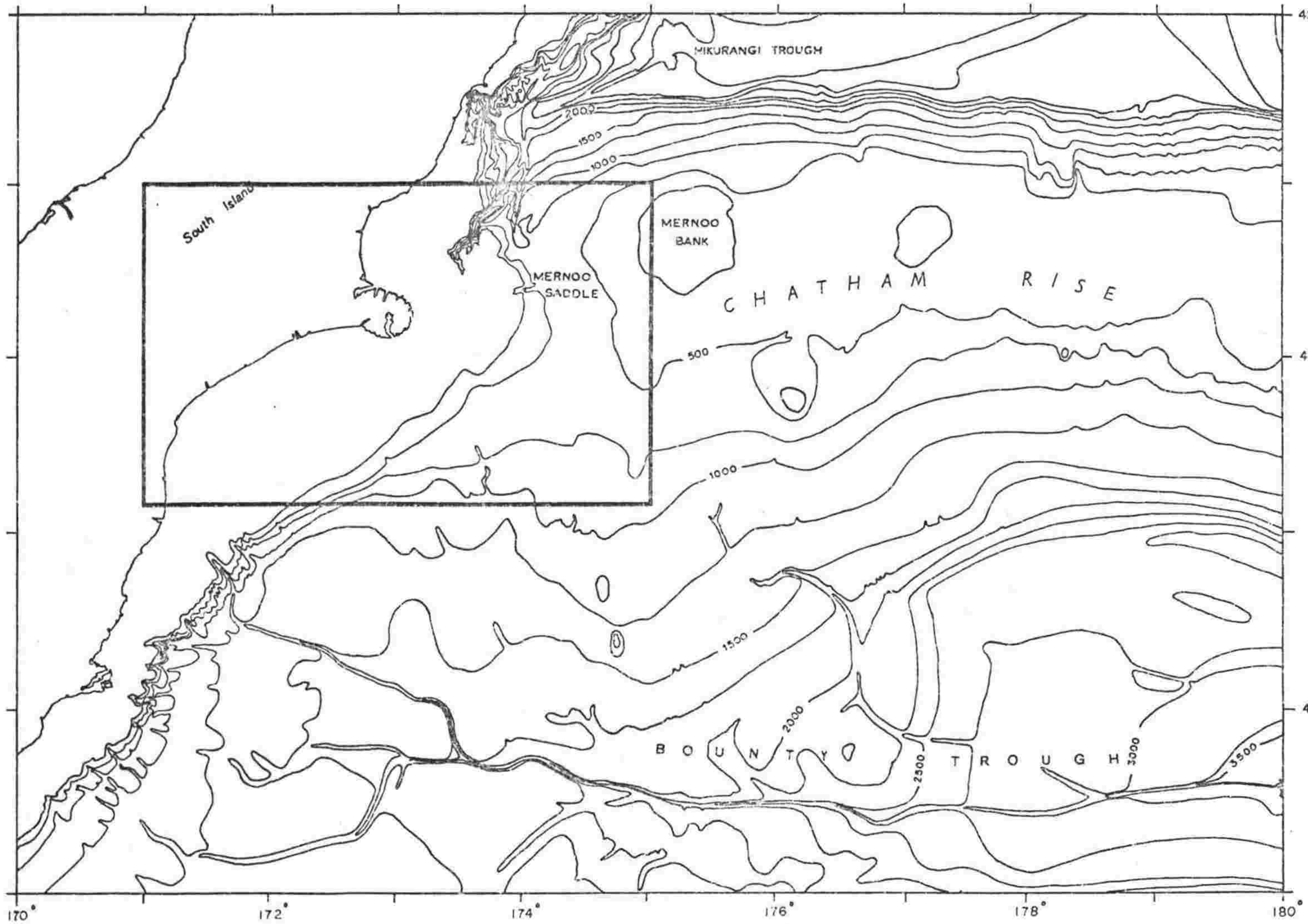


Figure C1. Regional bathymetry (after Krause and Cullen, 1970) of part of the ocean off the eastern South Island. The study area is outlined in black. Contours in metres.

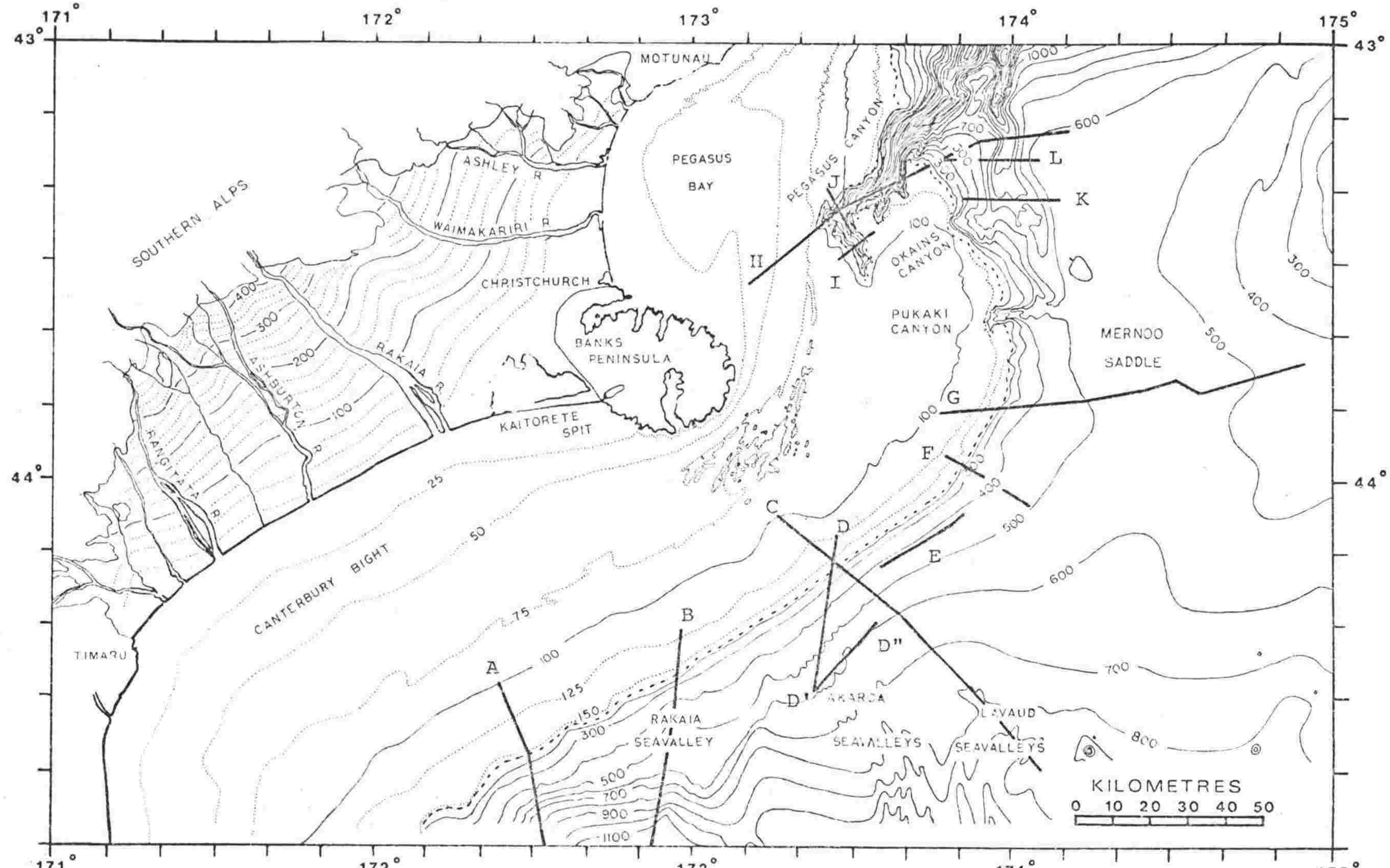


Figure C2. Bathymetry of the continental slope and location of seismic profiles and echograms that appear in the text. Contours in metres.

2,000 m and the northern part descends rather more steeply (3^{o}) into the equally deep Hikurangi Trough (Fig. C1).

SUBSURFACE GEOLOGY

Unpublished petroleum company seismic profiles and drill hole data (P.J. Hill and P. Dean, BP Shell Todd (Canterbury) Services Ltd., pers comm.), and seismic profiles presented here (see e.g. Profile C, Fig. C7) reveal that the continental shelf off the Canterbury Plains is underlain by the following stratigraphic sequence.

Unit (c) which forms the acoustic basement in this region, is Permo-Jurassic greywacke which outcrops on Mernoo Bank (Norris 1964) and again in the Southern Alps (Grindley et al. 1959 and N.Z. Geological Survey 1972). The surface of the basement is a regional unconformity, probably the Cretaceous to early Cenozoic peneplain that once existed over much of the South Island (Cotton 1917; Benson 1935; Fleming 1949). The basement is locally faulted. Directly overlying Unit (c) is a sequence (b) that is thought to be of mainly shallow marine sediments of Late Cretaceous to Oligocene age which cover the peneplain and locally fill fault-angle depressions (cf. Fleming 1949 and 1962; Grindley et al. 1959, and others). The top unit (a) is a progradational sequence 1 km to 1.5 km thick. Drill-hole data (P.J. Hill and P. Dean; BP Shell Todd (Canterbury) Services Ltd., pers comm.) and the regional land geology (Grindley et al. 1959, and others) indicate that it consists mostly of clastic sediments that have been accumulating since the Early Miocene.

BATHYMETRY

The bathymetric chart of the continental slope (Fig. C2) is based on a compilation of all available echo soundings (Herzer 1977 and in press a and b). The sounding lines on the continental slope are shown in Figure C3. There is much better coverage to the north of latitude 44°00'S than to the south. North of 44°00'S there has been a systematic, radar-positioned, hydrographic survey by the Royal N.Z. Navy. To the south there have been only incidental echo-sounding traverses by research ships. About half the lines south of latitude 44°00'S are satellite positioned, and intersecting celestially positioned lines have been adjusted to fit them.

It is seen in Figure C2 that, off Canterbury, the strike of the shelf edge north of approximate latitude 43°45'S is roughly northwest, while to the south of this latitude it is roughly northeast. The northern slope is dominated by submarine canyons which incise the shelf and contribute to the slope's relative steepness. The southern slope has no submarine canyons. From 43°45'S to 44°20'S the southern slope is smooth and apparently featureless. South of 44°20'S it is crossed by shallow, complex sea valleys. Stretches of smooth slope occur between sea valleys.

Smooth slope, sea valleys and submarine canyons are discussed separately. The locations of the profiles presented in this paper are shown in Figure C2.

THE SMOOTH CONTINENTAL SLOPE

Where the slope is smooth, sub-bottom reflectors shown on 3.5 kHz profiles are evenly bedded to broadly lenticular and parallel to the surface (Plate C1).

An intermittent, strong, uneven reflector was traced in several lines to a well defined reflector under the continental shelf, which defines the base of the progradational lower member of the Canterbury Bight Formation (thought to be of Last Glacial age) (Chapter B). It is thus possible to define

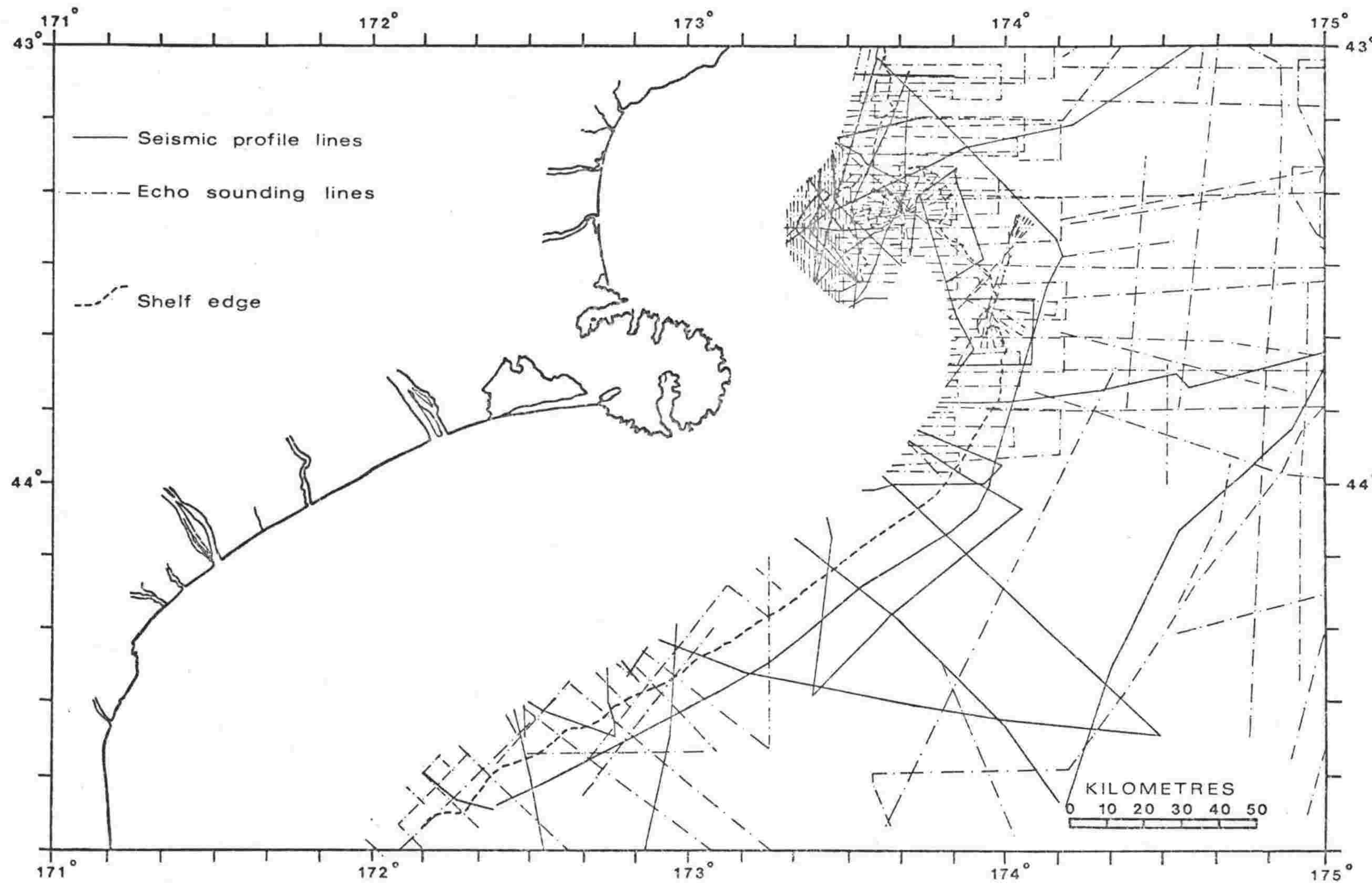


Figure C3. Echo sounding coverage of the continental slope.

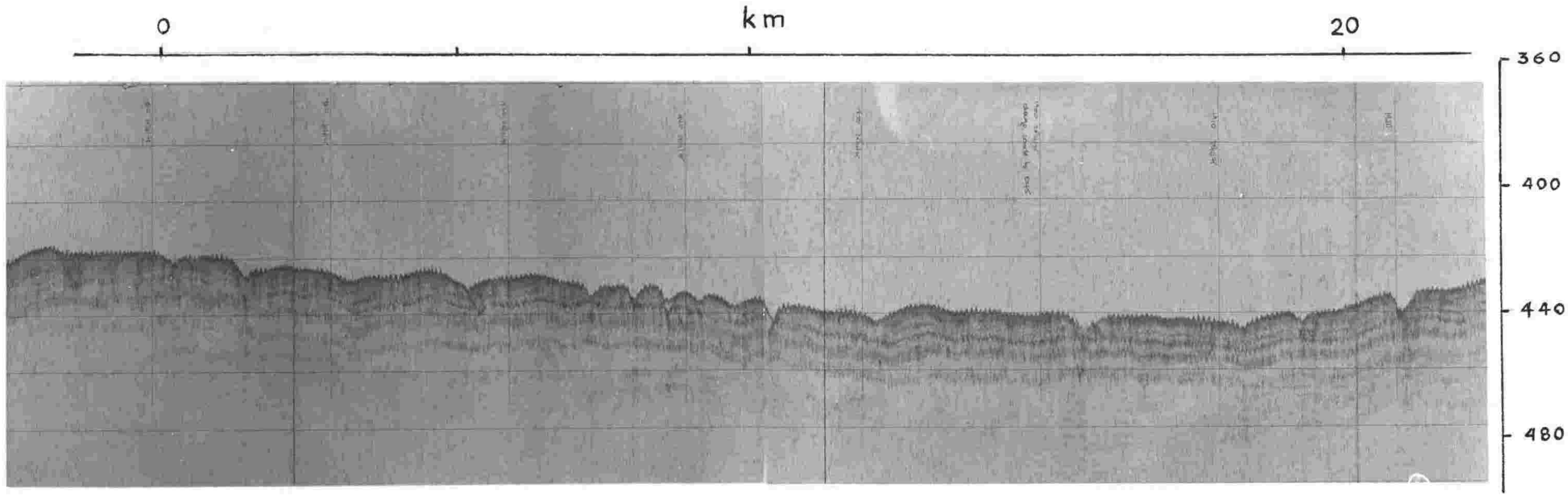


Plate C1. 3.5 kHz profile E parallel to the strike of the upper continental slope. Vertical scale in metres.

the base of the Last Glacial formation under the continental slope. The base of the formation is not distinguishable on air-gun seismic profiles.

The sediments of the continental slope range from muddy sand (locally sand) near the shelf edge, through sandy mud, to mud on the upper slope (Folk 1968 textural classification) (Chapter B).

A great number of small, sharply indented V-shaped depressions, 5 m - 10 m deep and approximately 500 m wide, occur on the "smooth" portions of the continental slope (Profile, Plate C1). They are most abundant on profiles parallel to the strike of the slope and are therefore assumed to be "gullies" (Shepard 1965) and not pits. The gullies cut the youngest strata and are hence young features. Filled, partly filled and buried gullies are less common. The mode of origin of the gullies is unknown.

SEA VALLEYS AND SUBMARINE SLIDING

The bathymetric chart (Fig. C2) is not detailed enough to show the true shape of the sea valleys. It does show, however, that they have downslope continuity. Seismic profiles show that most of them are slide scars. Submarine sliding is a common feature of continental slopes, particularly where the rate of sedimentation is high and earthquakes are frequent (Shepard 1955; Heezen and Drake 1964; Uchupi 1967; Stanley and Silverberg 1969; Stride et al. 1969; Moore et al. 1970; Walker and Massingill 1970; Lewis 1971; Herzer 1973; Normark 1974, and others).

On Profile A (Fig. C4) it is seen that slumping on a large scale has occurred. The slumping has taken place along numerous shear planes that extend down through most of the Miocene-Recent progradational sequence. Pre-Miocene reflectors have not been displaced. The slump is thus a gravity slide not a fault.

The displacement of the down-dropped slump blocks has apparently been accommodated by decollement along the top of the Pre-Miocene unit (b), and folding of the entire Miocene-Recent unit (a) at the toe of the slump, 40 km below the head. The amplitude of the fold is uniform throughout most of its thickness, dying out upwards in only the top 150 m of the section. There is no trace of a fold in the present sea floor. This implies that most of the sliding took place during a single short episode, that very gradual sliding continued for a long period afterwards, and that the sliding has since ceased.

Slumping was also detected in Profile B (Fig. C5), 40 km east of Profile A. The blank at the lower end of the profile is caused by a malfunction of the 70 Hz - 200 Hz band, but the low frequency band (not shown) shows a fold at the toe of the slump, similar to that in Profile A. The two profiles thus indicate that the slump extends along the slope for at least 40 km.

Profile B runs obliquely down the slope and crosses a broad, partly infilled valley (Rakaia Sea Valley) north of the head of the slump. Underlying the valley, a number of scour-and-fill structures are buried at different levels in the sequence, implying that sea valleys, that were channels for downslope sediment transport, have been intermittently cut and infilled again in this locality throughout the development of the slope.

Profile D - D' (Fig. C6) is a 3.5 kHz profile that runs obliquely down the slope across a region of uneven terrain called the Akaroa Sea Valleys (Fig. C2). The reflector underlying the shelf edge is the base of the Canterbury Bight Formation. It is seen that the roughness of the terrain on the slope is due to slumping. Profile D' - D", parallel to the strike of the slope, crosses the northeastern edge of the slump. Disturbed strata of the slump sheet are visible on the left, and the undisturbed strata of the continental slope, cut by small shallow gullies, are visible on the right. Echo-soundings in the records of the N.Z. Oceanographic Institute indicate that the slide terrain extends well south of the study area.

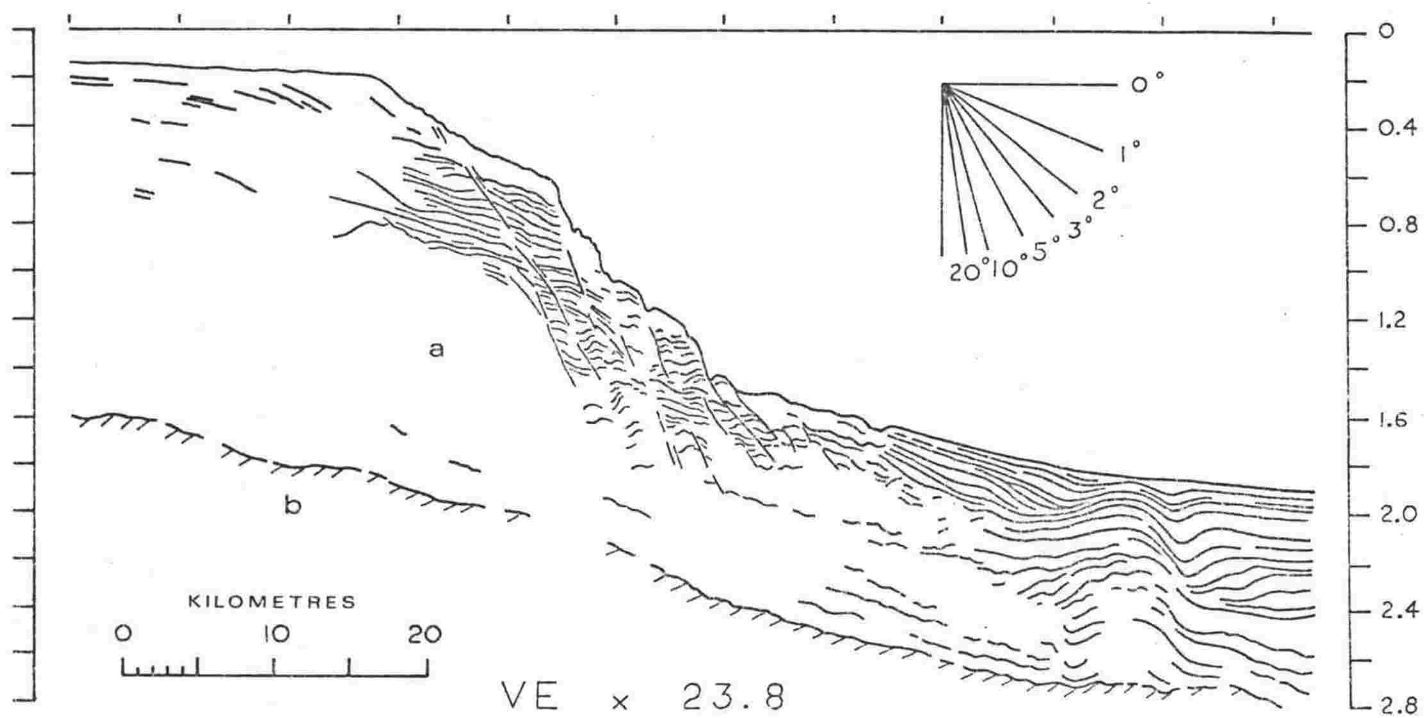


Figure C4. Air-gun seismic profile A. Vertical scale - two-way travel time in seconds.

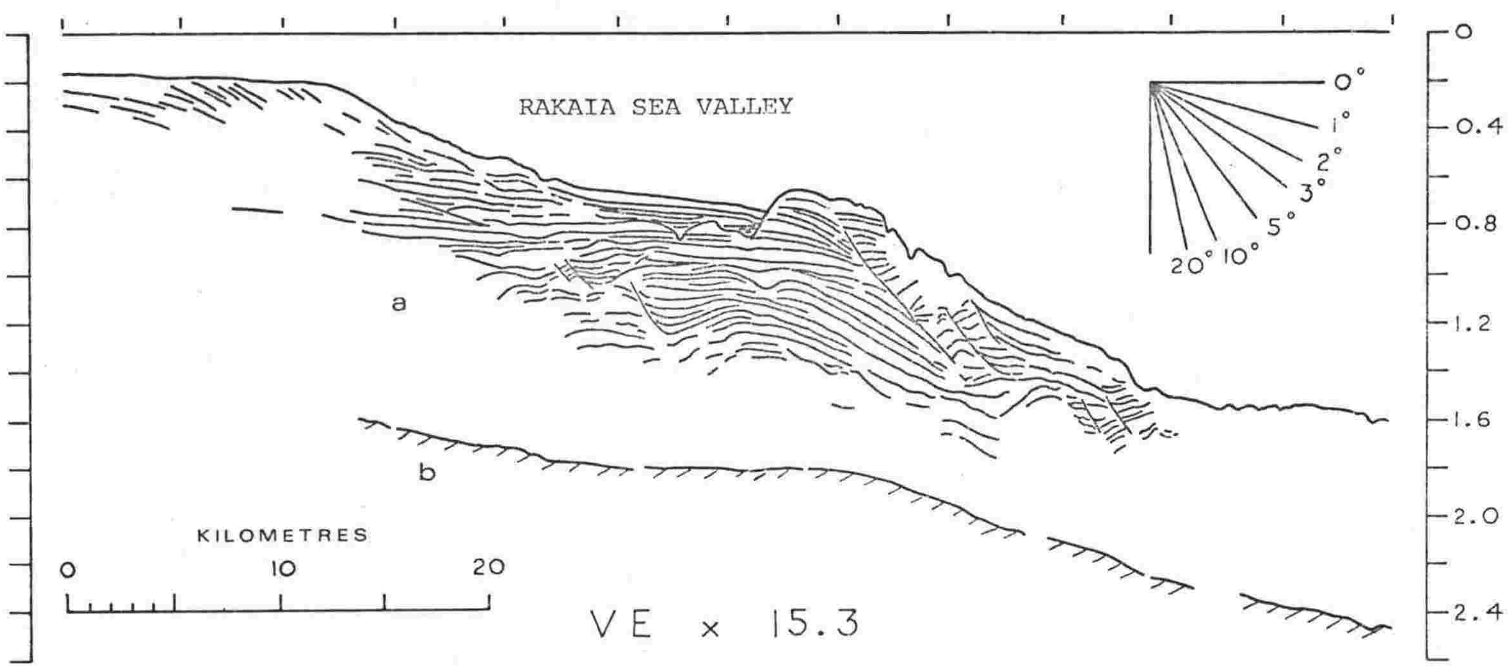


Figure C5. Air-gun seismic profile B. Vertical scale - two-way travel time in seconds.

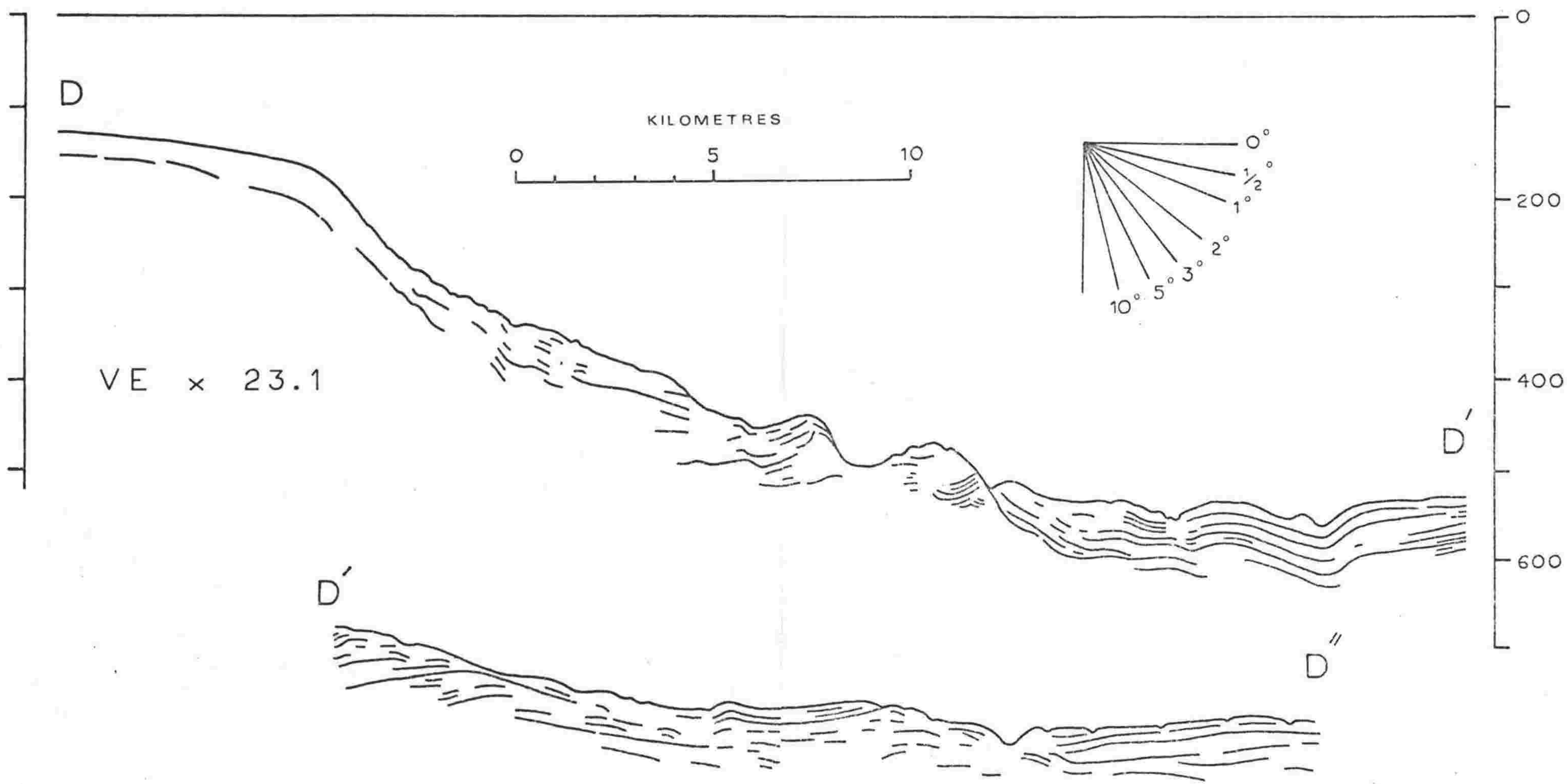


Figure C6. 3.5 kHz profile D. Vertical scale in metres.

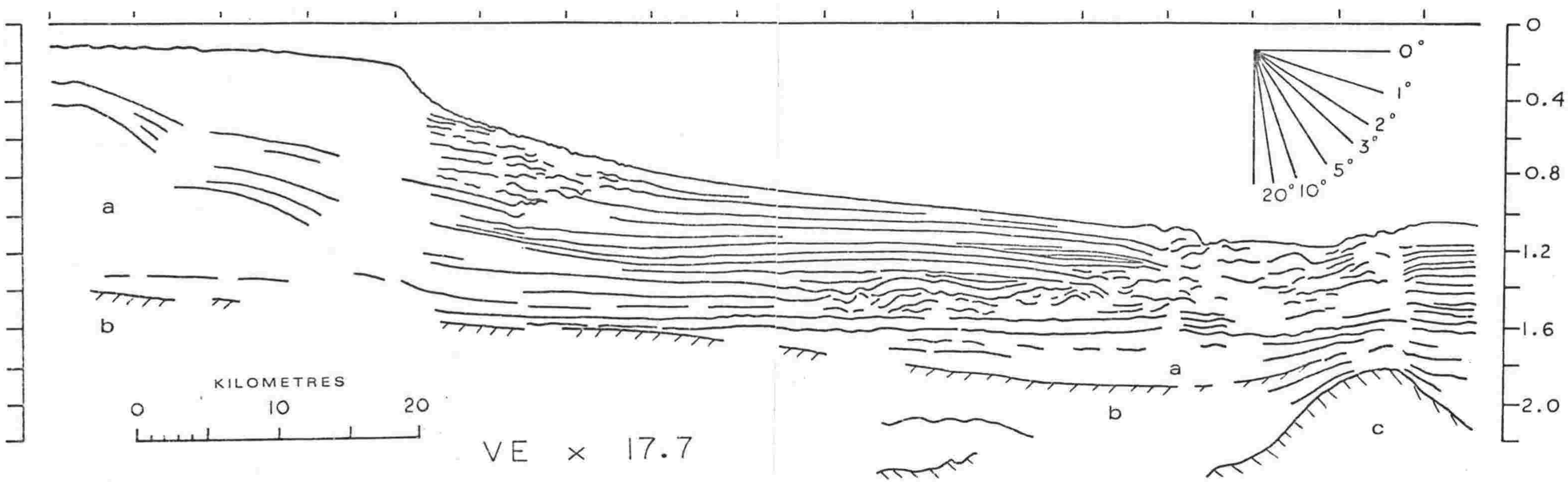


Figure C7. Air-gun seismic profile C. Vertical scale - two-way travel time in seconds.

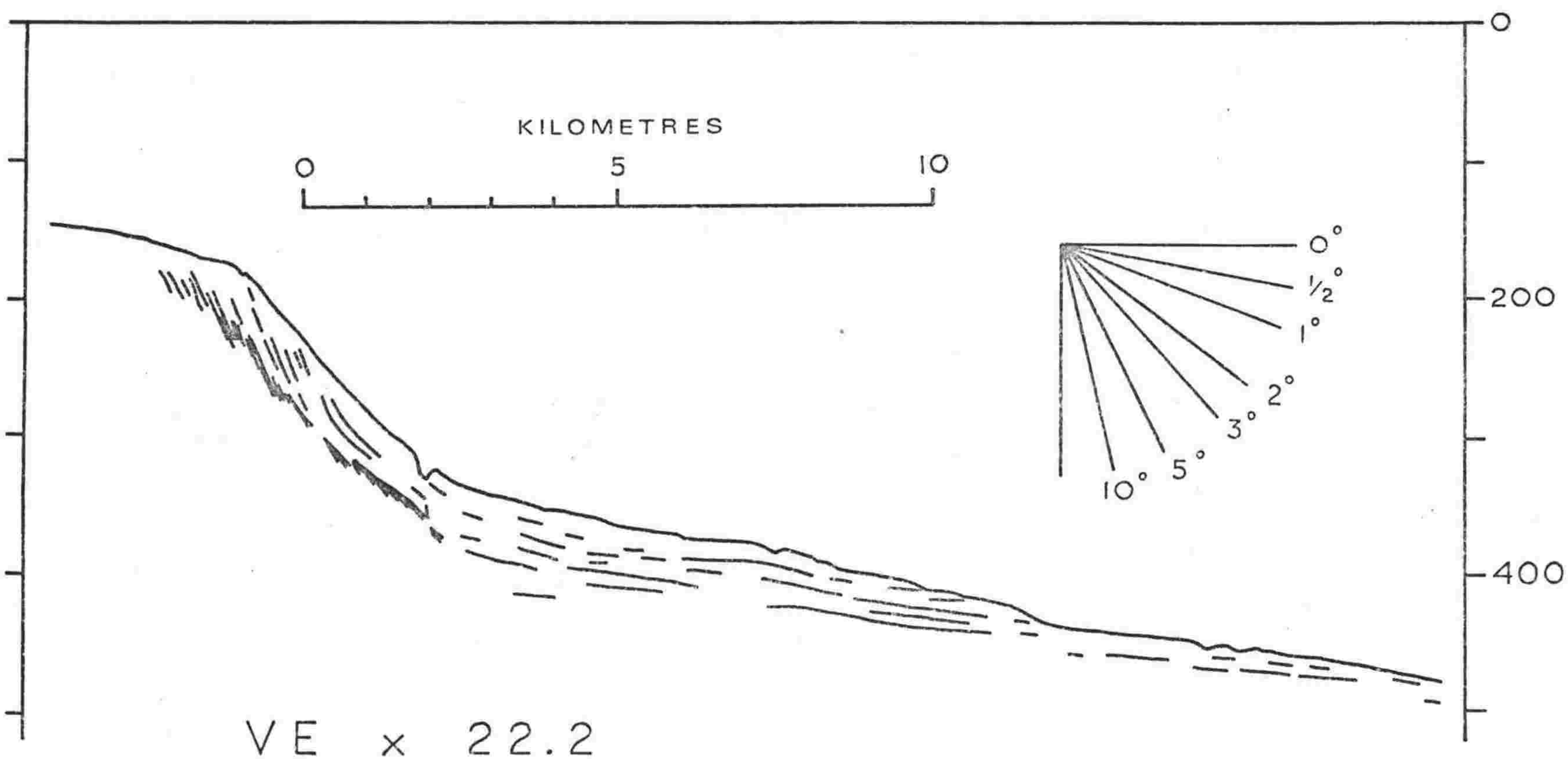


Figure C8. 3.5 kHz profile F. Vertical scale in metres.

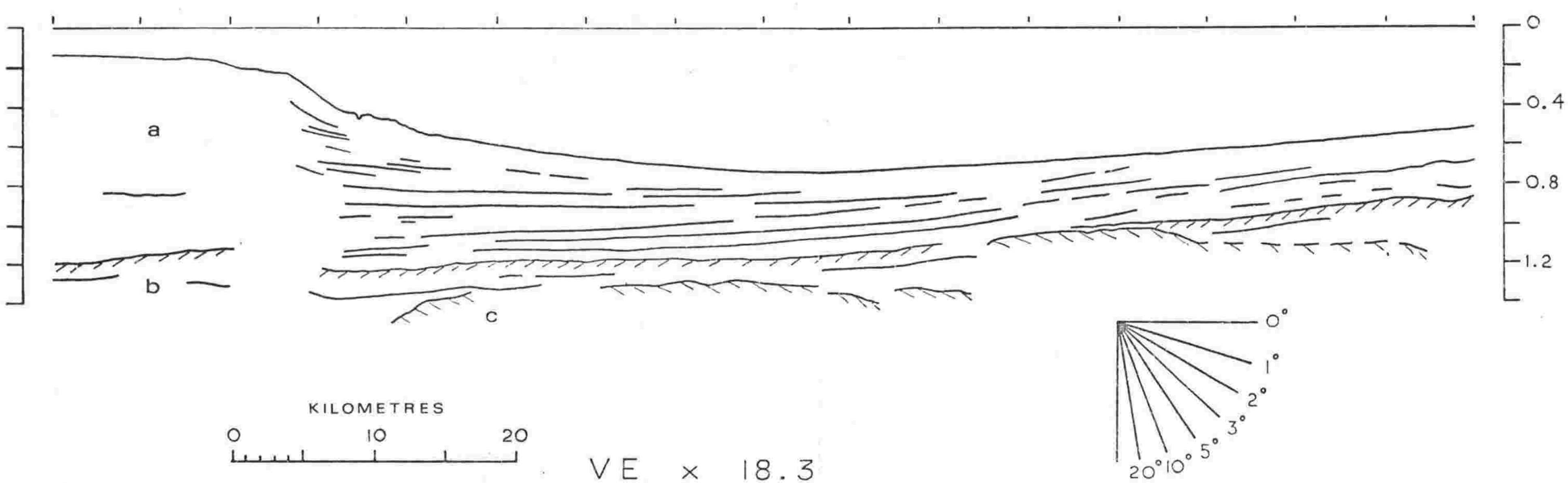


Figure C9. Air-gun seismic profile G. Vertical scale - two-way travel time in seconds.

Northeast of the Akaroa Sea Valleys the slope is smooth, compared to the chaotic terrain to the southwest and there is no evidence of major sliding in seismic profiles C, F and G, (Figs. C7, C8 and C9). However, a thin bedding plane slide shows in 3.5 kHz Profile F (Fig. C8). The heavy reflector under the steep upper continental slope is the base of the Canterbury Bight Formation. The slide has taken place at the base of the steep slope. The head of the slide, is marked by a tensional crevasse, while the toe, a zone of compression, rises above the plane of the slope 10 km below the head. The main body of the slide has undergone minimal deformation. A similar slide origin is inferred for the small uneven area on the upper slope in Profile G (Fig. C9) and for the crenulated reflectors underlying the upper slope in Profile C (Fig. C7).

The bedding plane slide in Profile F and the slump that forms the Akaroa Sea Valleys in Profile D have both displaced the uppermost sedimentary unit (Canterbury Bight Formation) of Last Glacial age, and show no signs of subsequent burial. They therefore postdate the formation and are less than 18,000 years old.

SUBMARINE CANYONS

On the northwest-striking slope off Pegasus Bay, four evenly spaced submarine canyons dominate the slope. From south to north they are: Pukaki Canyon, Okains Canyon, Pegasus Canyon and a small nameless canyon that was not studied.

Many deep seismic profiles cross the submarine canyons (Fig. C10). The profiles show that the canyons are cut into the Miocene to Recent sequence (a), and that reflectors within and below the Miocene to Recent strata extend beneath the canyons without interruption by faults (e.g. Profile H, Fig. C11). Thus faulting does not appear to control the location and course of the canyons.

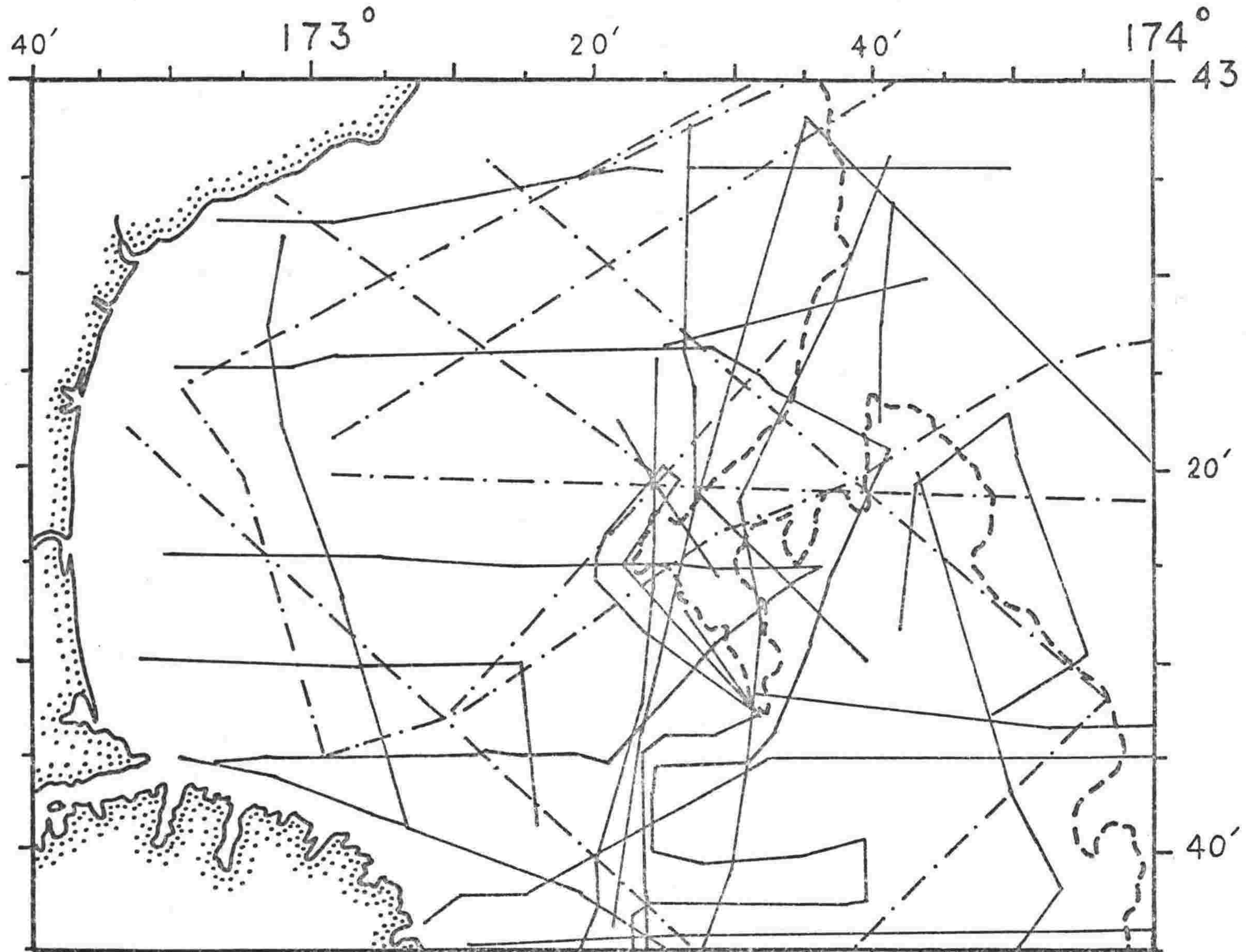


Figure C10. Seismic profile coverage in the region of submarine canyons. Solid line - 3.5 kHz tracks. Broken lines - air-gun, gas exploder and explosion seismic tracks.

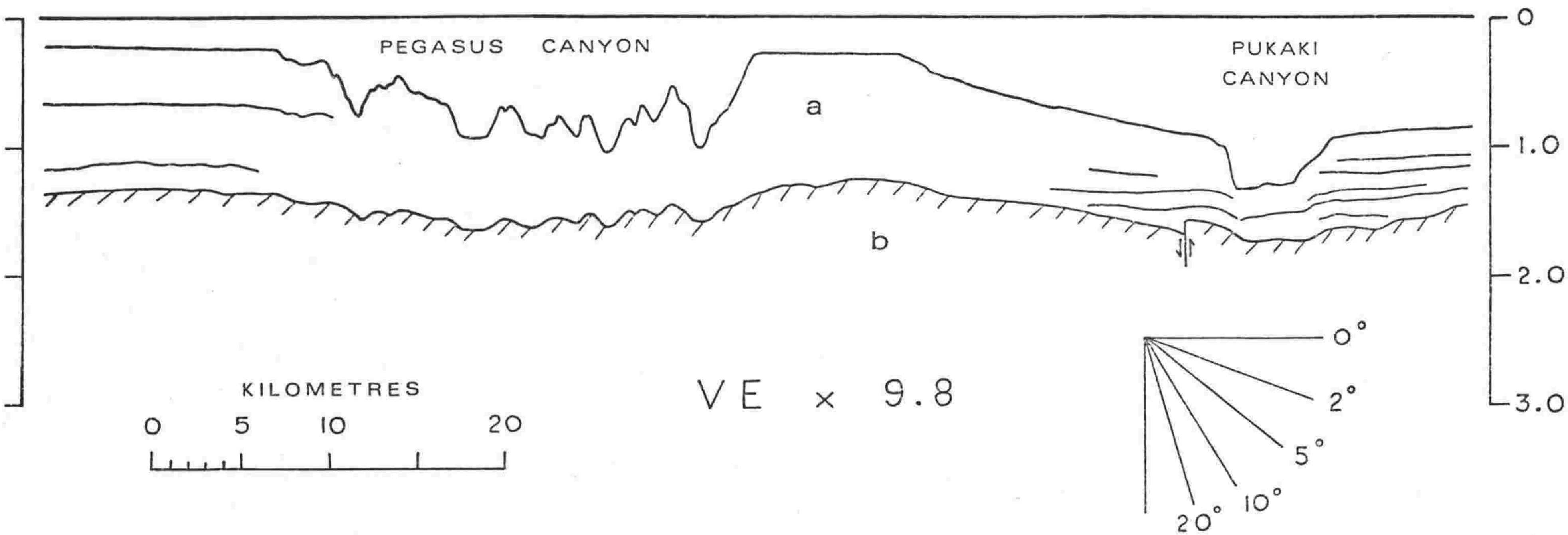


Figure C11. Air-gun seismic profile H. Vertical scale - two-way travel time in seconds.

The vertical displacement of the Pre-Miocene reflector under the canyons is an artifact (due to the differential velocity of sound in water and sediment) of the depth of water in the canyons.

Pegasus Canyon

Pegasus is the largest and best surveyed canyon. From its head, 46 km inside the continental shelf, it follows a sinuous course for 100 km, ending at a depth of 2,300 m in the Hikurangi Trough. There is a major deep sea channel in the trough (Houtz et al. 1967) and Pegasus Canyon is assumed to be one of its tributaries. The head of the canyon points south and several small tributaries on the shelf enter it, mainly from the south.

The long, dendritic pattern of the canyon and its isolation on the outer shelf point to an erosional origin during past low sea levels. The present geology of the canyon, inferred from analysis of echograms and from a few sediment samples, implies that it is now relatively dormant.

In the upper 10 km of the main canyon and in the short westernmost tributary, the axial gradient is steep (3% - 10%) and the cross-sectional profile is V-shaped (Profile I, Plate C2). Downstream the axial gradient is more gentle (1.5% - 3%) and the profile is U-shaped to flat bottomed (Profile J, Plate C3).

The bottom, where flat, represents sediment fill. The U-shape of transverse profiles (an example of which is shown in Profiles K and L (Plate C4) across Pukaki and Okains Canyons) is thought to be produced by accumulations of slope-foot debris derived from the canyon walls. Rockfalls, debris flow, slumping and creep of material on canyon walls are common phenomena (Dill 1964 a, b and c; Nesteroff 1965; Glangeaud et al. 1968; Got and Stanley 1974, and others).

Mud-free sediments, sand and gravelly sand, occur locally on the walls at the head of the canyon and in the most landward tributary. The sand, with a grain-size mode of 1.9Ø to 2.6Ø, and the gravel, composed of well-rounded quartz and

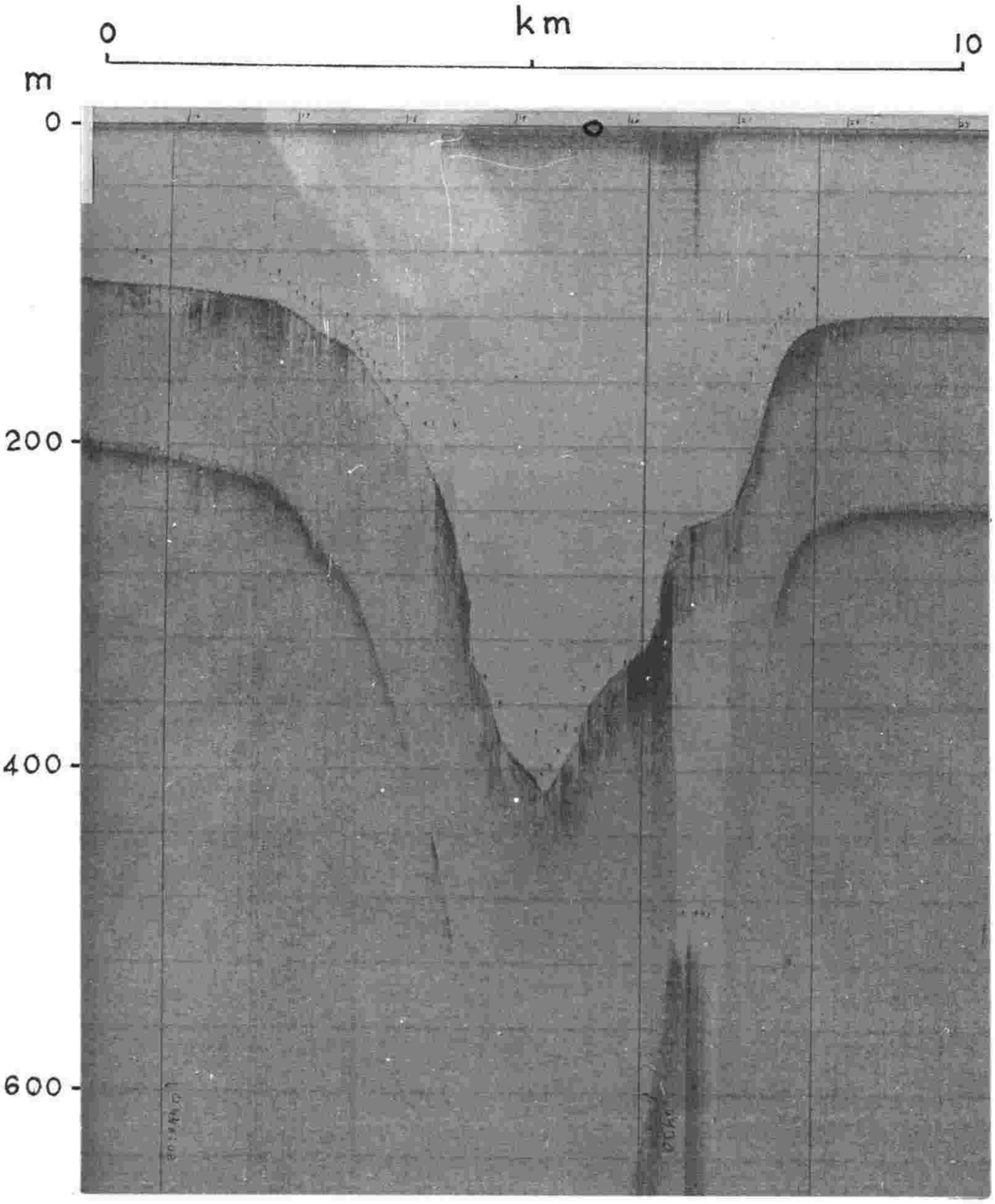


Plate C2. 3.5 kHz profile I across upper Pegasus Canyon showing V-shaped canyon cross section.

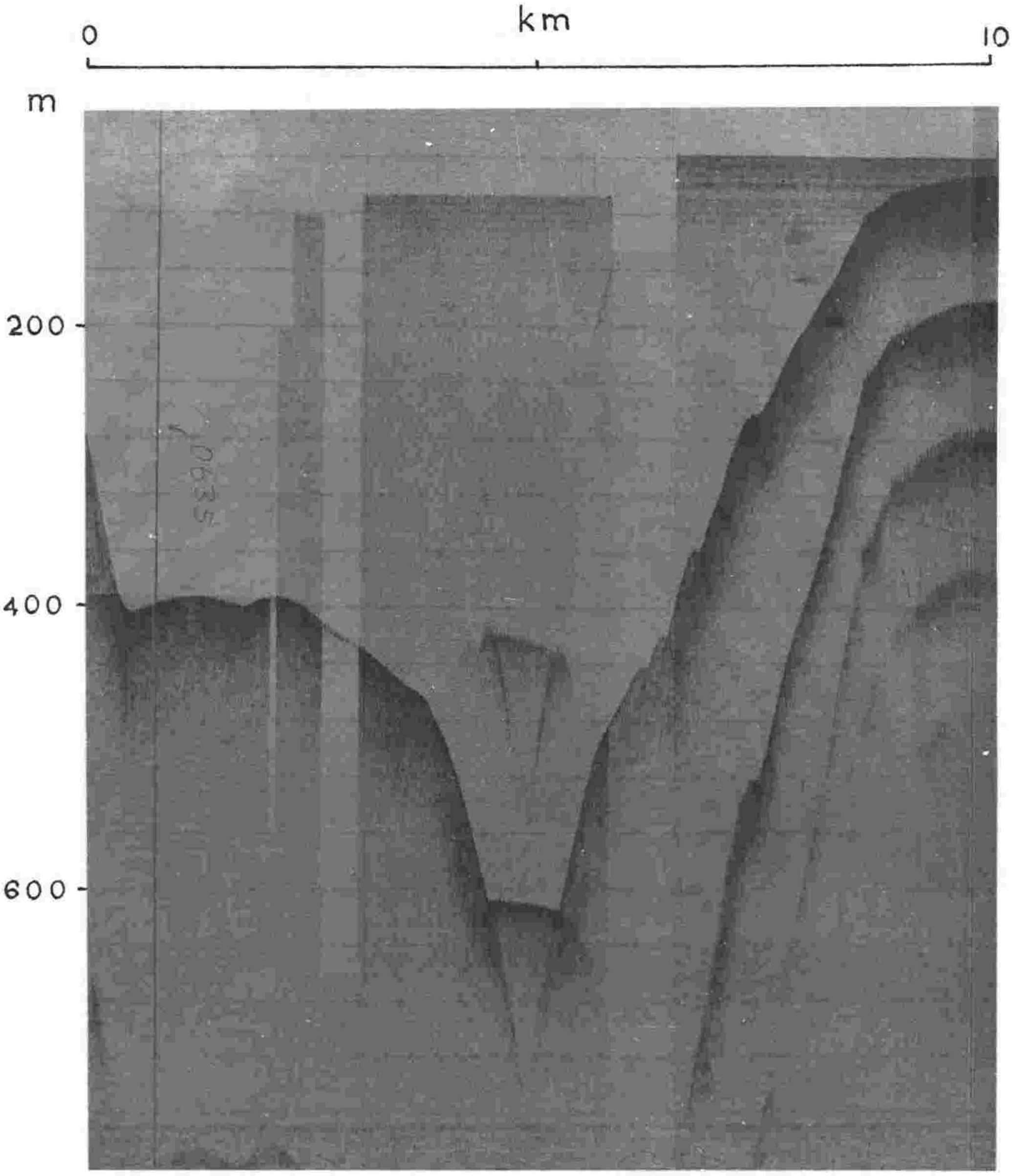


Plate C3. 3.5 kHz profile across Pegasus Canyon showing flat canyon floor produced by sediment fill.

greywacke pebbles, are identical to the palimpsest sediments on the adjacent continental shelf (Chapter B), and are considered to be modern spillover. Except in these areas and on exposed rock faces (revealed by dredging) muddy sediments predominate. They are commonly associated with a gravel of polygenetic origin - well-rounded quartz and greywacke pebbles, (described above), and angular bio-eroded chunks of sandstone and mudstone that have fallen from the canyon walls.

Sixty kilometres below the canyon head, at latitude $43^{\circ}07'$S, the canyon is dammed to a height of 200 m - probably by a slide - and a long, flat-floored basin of ponded sediments has developed (Fig. C2). Thirteen kilometres downcanyon there is another closed basin. Samples from the fill in the upper basin consist of sandy mud.

The apparent absence of axial fill in the upper reaches, and its presence in the lower reaches of the canyon, suggest that the axial sediment is carried down the canyon and ponded behind the dam. Currents may keep the axis of the upper canyon clear of fill and cause down-canyon transport of fine sediments (cf. Fenner et al. 1971; Cannon 1972; and Shepard 1975), or the axial sediment may simply move down-canyon by gravity flow (cf. Got and Stanley 1974; and Stanley 1974).

The presence of closed basins in the canyon axis suggests that the present rate of down-canyon sediment transport is very much lower than in the past, and that the canyon is effectively dormant.

Pukaki Canyon

Pukaki is the second largest canyon. It lies at the eastern limit of the shelf (Fig. C2). It is 90 km long, (almost as long as Pegasus Canyon) but cuts only 6 km into the continental shelf. Like Pegasus Canyon, its head points south. From its head, the canyon runs north for 2 km, then east for 20 km down the relatively steep Canterbury upper continental slope. In the northern part of Mernoo Saddle, it turns north and follows a slightly sinuous course as a relatively shallow channel down the gentle northern slope of the saddle. North of latitude $43^{\circ}10'$S the slope is steeper and it becomes a deep canyon once again, joining Pegasus Canyon just above the Hikurangi Trough.

The steep upper 30 km of Pukaki Canyon has a V-shaped cross section. The middle and lower canyon, north of the elbow at 43°35'S, is flat floored, and locally there are features inferred to be slope-foot debris deposits (profiles K and L, Plate C4).

Sediments on the shelf around the head of Pukaki Canyon are gravel and sand, similar to that around the head of Pegasus Canyon (Chapter B).

There are at least two closed basins in the canyon, which are considered to be dammed by slides. The existence of the basins implies that the canyon is dormant.

Okains Canyon

Okains Canyon (named after nearby Okains Bay), cuts into the continental shelf edge between Pegasus and Pukaki Canyons. The axis of the canyon descends steeply through a comparatively narrow waist into Pukaki Canyon. The canyon's amphitheatre-like head suggests a gravity slide origin but a 3.5 kHz profile run by the author across the canyon head reveals that it is made up of several steep-sided V-shaped and flat-bottomed gorges typical of submarine canyons.

DISCUSSION

It has been stated that none of the slides or canyons are fault controlled. The development of the slide terrain to the south and the canyon terrain to the north is thus thought to be due to different types of sedimentation.

Submarine canyons on the edges of continental shelves are thought to have formed near shore during glacially lowered sea levels, where sand and gravel, supplied either by a river mouth or by longshore drifting, was deflected offshore and down the slope. The rivers north of Banks Peninsula are no larger than those south of it. The head of Pegasus Canyon

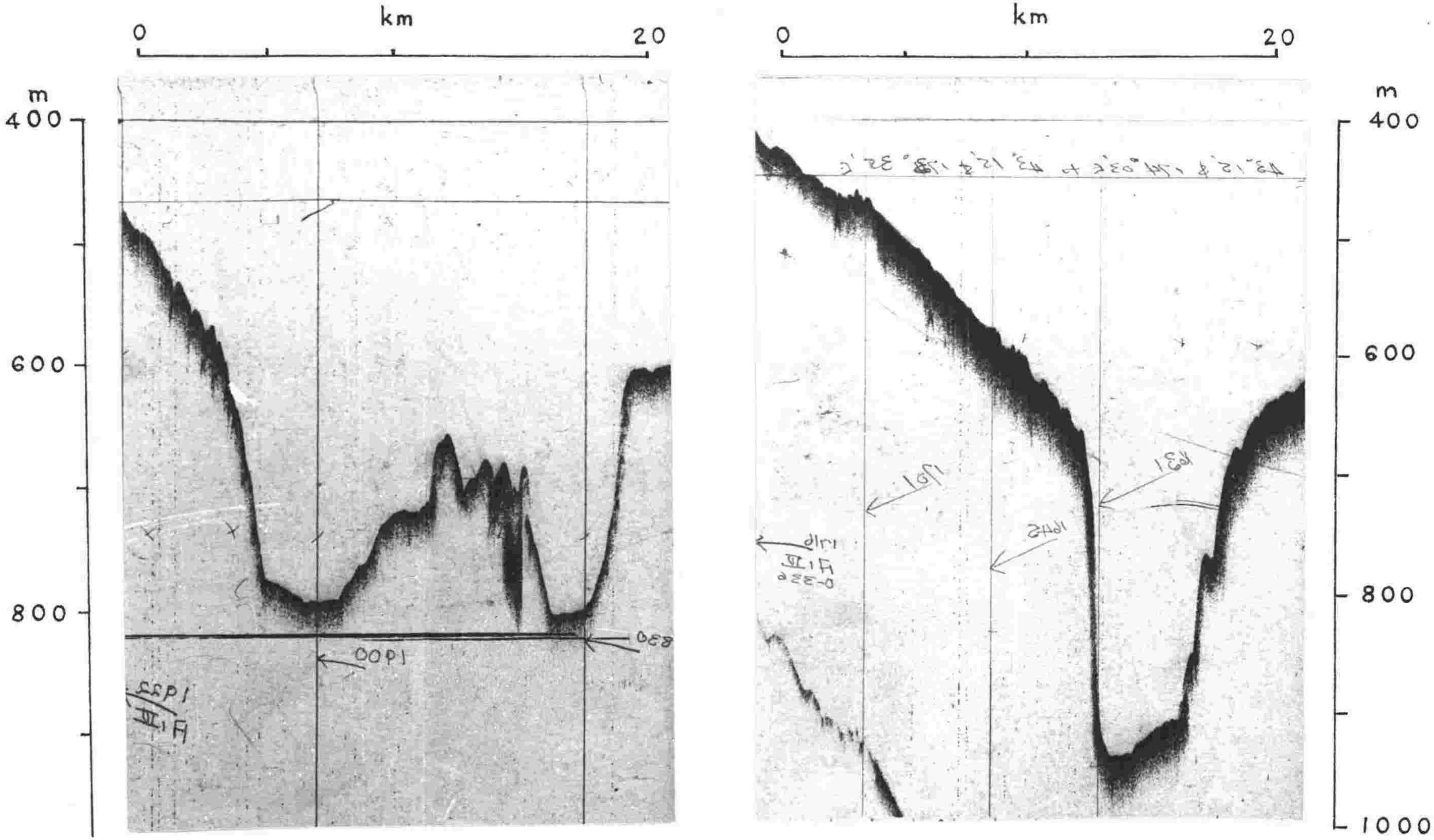


Plate C4. Echo-sounding profiles showing sloping deposits of slope-foot debris on the flat canyon floors. Profile K is across Okains Canyon (left) and Pukaki Canyon (right). Profile L is across Pukaki Canyon below the junction with Okains Canyon.

does not point to a major river; in fact it does not point to shore at all. The smaller canyons - Pukaki and Okains - are isolated on the eastern edge of the continental shelf, far from any logical former river courses. The canyons on the Canterbury shelf are therefore presumed not to have been formed off Pleistocene river mouths, but to have been eroded by sand and gravel carried along Pleistocene shorelines.

During the lowest sea level of the last glaciation, gravel and sand were carried northeastwards by littoral drift along a beach about 4 km - 9 km west of the shelf edge (Chapter B). Established canyons, intercepting this stream of gravel and sand, would have been maintained or enlarged. Slump scars cutting far enough into the continental shelf to intercept the stream would probably have been eroded into canyons. Since slumping has been commonplace on the continental slope, this process would be expected to form canyons all along the shelf edge. However, they are restricted to the northern part.

A process is required which prevents coarse sediment from spilling over the shelf edge south of Banks Peninsula and which causes coarse sediments to spill over north of Banks Peninsula. The process proposed, based on the results of Chapters A and B, is shown in Figure C12. The modern near-shore sediment dispersal path is shown on the left-hand side of the figure and the Pleistocene path on the right-hand side.

Sediments presently supplied to the inner shelf of Canterbury Bight are distributed thus: gravel and the coarser sand are carried northeastwards along the beach by prevailing swell from the south, but are stopped by Banks Peninsula. The gravel is not carried offshore. The finer sands are carried northeastwards on the inner shelf within 15 km of shore by mainly northgoing ambient currents, and are prevented from dispersing on to the middle shelf by a continual shoreward component of flow (Chapter A). Around Banks Peninsula the currents are accelerated by the constriction caused by the peninsula to the west and Mernoo Bank to the east (see Fig. C1),

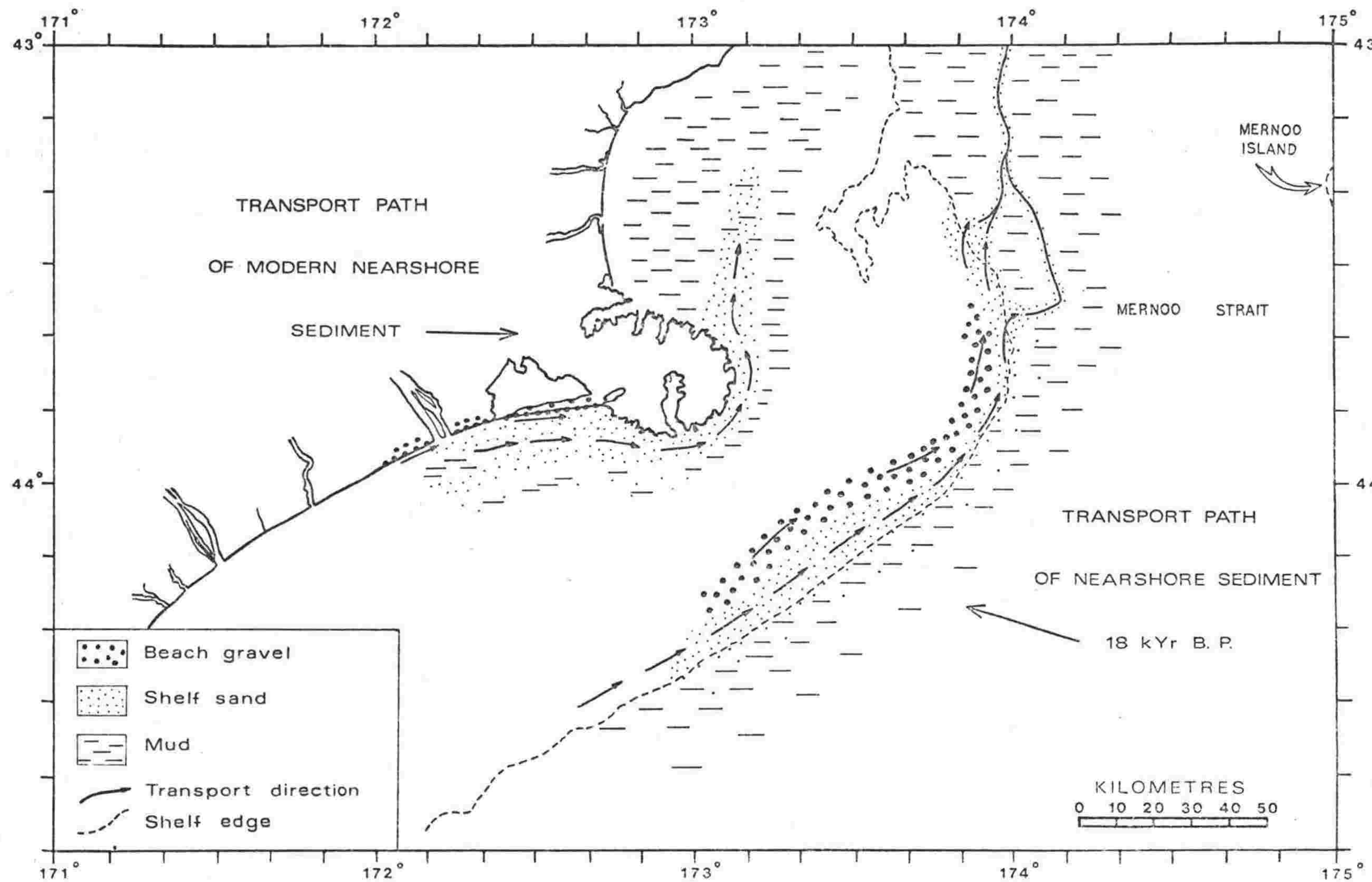


Figure C12. Modern and Pleistocene sediment dispersal paths on the continental shelf.

and the nearshore sand belt thins to 6 km. North of Banks Peninsula the coast swings away to the west, easing the constriction, and the northgoing currents decelerate, depositing their load of fine sand on a long banner bank extending offshore. The sand is not carried west into Pegasus Bay.

During the lowest sea level of the Last Glacial stage, 18,000 years ago, an analageous sediment dispersal path probably existed (Fig. C12). Mernoo Bank was an island and the adjacent mainland coastline bulged eastwards as a cape. Mernoo Saddle was thus a strait. The flow of water on the shelf adjacent to the strait would have been accelerated just as it is today off Banks Peninsula.

South of the strait, where the strike of the coast was northeast, gravel would have been carried by littoral drift northeastwards along the mainland beach without being transported to the shelf edge which was 4 km - 9 km to the southeast; fine sand would have been transported mainly northeastwards along the shelf with only a relatively small amount spilling over onto the continental slope; mud would thus be the main deposit on the continental slope.

North of the strait, the sea deepened and the Pleistocene mainland coast curved away to strike north-northwest, away from the direction of the northgoing currents. On passing the constriction, the fine sand would have been carried northwards over the shelf edge and deposited on the upper slope. A continuous stream of sand is thus presumed to have been supplied to the shelf edge and upper slope to the north, while mainly muddy sediments were supplied to the slope to the south. The offshore sand stream is assumed to have eroded submarine canyons by the processes described by Dill (1964 a, b and c) and Chamberlain (1964). Fed by this stream, the head of a canyon would have eroded landward eventually reaching the coarser sands and gravels that were being transported along the shore. Canyon cutting would then be most rapid.

If the shoreline were stable, the canyon head would erode southwards in the direction of sediment supply, and the south-pointing heads of Pegasus and Pukaki Canyons are ascribed to southward erosion during different times of stable sea level.

The further a canyon penetrates across the shelf, the greater its capacity to intercept sediment, and the more it will be eroded. Pegasus Canyon, which penetrates halfway across the shelf, will have continued to intercept littoral-drifted gravel and sand (and mobile shelf sand) during intermediate Pleistocene sea levels. Its south-pointing tributaries were probably eroded thus during intermediate stillstands.

The absence of submarine canyons on the northeast-striking continental slope south of 43° 45'S is attributed to a relative lack of coarse material in the sediment carried over the shelf edge during lowest Pleistocene sea levels. During intermediate sea levels, even less coarse sediment would have reached the slope. Without coarse bed material, channel erosion would not have been severe enough to erode canyons.

Rakaia Sea Valley may be related to the mouth of the glacial Rakaia River. When sea level was lowest during the Last Glacial stage, the shelf edge would have been just over 9 km offshore (Chapter B). Direct spillover of suspended sediment from the river in flood (cf. Gennesseaux et al. 1971), or spillover of fine sediment that was temporarily deposited on the shelf off the river mouth and then resuspended, may have caused fine-sediment turbidity currents to flow down the slope producing a shallow eroded channel and overbank deposits. This is envisaged to have taken place during the successive glacials of the Pleistocene, giving rise to the succession of buried cut-and-fill structures under the present valley (Fig. C5).

The instability of the continental slope south of 43° 45'S is attributed to the following factors. Outbuilding of the continental slope was restricted to periods of low glacial sea level when the shore was near the shelf edge and the rate of sedimentation was high (Chapter B). The sediments deposited on the slope are inferred to have been mainly muddy (see also Chapter B). The slope has thus prograded mainly by periodically overrapid deposition of fine sediments, and it may thus be intrinsically unstable. Profiles A, B, C and G (Figs. C4, C5, C7 and C9) show that the slope off Canterbury Bight has built out into a deep trough (the Bounty Trough), whereas the slope off Banks Peninsula has built out onto a shallow saddle (Mernoo Saddle). The load of sediment is thus greater, and the lateral support less, on the high slope facing Bounty Trough than on the low slope facing Mernoo Saddle. Slides on the former slope are accordingly large and deep-seated while those on the latter slope are small and shallow.

CONCLUSIONS

1. North of 43°45'S the continental slope off Canterbury strikes northwest; south of this line it strikes northeast. The slope to the north is cut by submarine canyons while that to the south is cut by small thin bedding-plane slides and large, deep-seated slumps.

2. The continental slope is a progradational structure and neither the canyons nor the slides are fault controlled.

3. Canyons have developed preferentially to the north and slides to the south in response to the sediment dispersal path on the adjacent shelf during low Pleistocene sea levels. Sand, moved by northward-flowing bottom currents along the shelf, and over the shelf edge on to the upper continental slope to the north, eroded canyons. Mud, deposited rapidly on the continental slope to the south, during low glacial sea levels, has built up a large foreset slope which is prone to sliding.

4. Modern and buried shallow sea valleys, on the slope opposite the Rakaia River (Rakaia Sea Valley), were probably channels for fine-sediment turbidity currents generated at the river mouth during low Pleistocene sea levels.

5. The thin bedding plane slides, in the central part of the slope, and the slump forming the Akaroa Sea Valleys, have displaced beds of Last Glacial age, and are therefore less than 18,000 years old. The huge slump at the south of the study area is older and now inactive.

6. The submarine canyons are thought to be now dormant.

CHAPTER D

THE INFLUENCE OF PLESTOCENE SHORELINE POSITIONS ON THE MORPHOLOGY OF PEGASUS SUBMARINE CANYON

ABSTRACT

The history of growth of Pegasus Submarine Canyon is investigated with the aid of seismic profiles and microbathymetry. The trend of the upper canyon is thought to be along the strike of a resistant bed. The canyon is otherwise free of structural influence. As well as growing landwards, the canyon and its tributaries have, during Pleistocene sea level stillstands, grown southwards along shore towards the supply of littoral-drifted gravel and sand. A buried tributary, of Penultimate Glacial age or older, on the canyon's west side, once brought the canyon 7 km closer to the present shore. The ages of the south-trending arms of the canyon are deduced by their relationship to known Last Glacial shorelines, that are preserved on the shelf, and by their positon with respect to a regional subsurface unconformity of Penultimate Glacial age. Of the three south-trending arms, the eastern one may be 28,000 years old; the middle one is of Penultimate Glacial age; and the western and largest one is of an unknown age that is greater than 18,000 years. Canyon erosion was nevertheless concentrated in the largest arm during the last deglacial rise of sea level, and shallow channels, interpreted as feeders, are common around its rim. A small new tributary is thought to have been cut 15,000 years ago into the fill of the buried tributary on the canyon's west side.

INTRODUCTION

Active submarine canyons that have heads near to shore have usually been found to be related to a sediment source such as a river mouth or a point of seaward deflection of longshore-drifted sand. (Heezen et al. 1964; Shepard and Dill 1966; Dietz et al. 1968; Reimnitz and Gutierrez-Estrada 1970; Felix and Gorsline 1971, and others). Canyons now stranded on the outer continental shelf are presumed to have been eroded when sea level was lower, and they are difficult to relate to their past sediment sources. However, if the relict geomorphology of the adjacent continental shelf is well preserved and well known, it should be possible to relate a canyon to a former river mouth (e.g. Veatch and Smith 1939; Ewing et al. 1963) or to former shore lines. An attempt is made here to explain the growth of Pegasus Canyon (Fig. D1) in terms of changing Pleistocene shore lines.

DATA

The work is based on seismic surveys and on detailed bathymetry around the upper canyon.

A net of shallow 3.5 kHz seismic profiles was run around and across the canyon by the author during cruises of R.V. Tangaroa in 1973 and 1975. This information was augmented by low-frequency, deep-penetration seismic reflection profiles provided by petroleum exploration companies (Fig. D2).

The bathymetry (Figs. D3 and D4) was contoured by the author from the collector sheets of a regional bathymetric survey carried out in 1952 and 1953 by the Hydrographic Branch of the Royal N.Z. Navy. West of longitude 173°30'E and south of latitude 43°35'S echo-sounding lines were spaced 0.1 km to 1.0 km apart. West of 173°30'E and north of 43°35'S lines were spaced 0.5 km to 1.0 km apart. East of 173°30'E lines were spaced 1 km to 3 km apart.

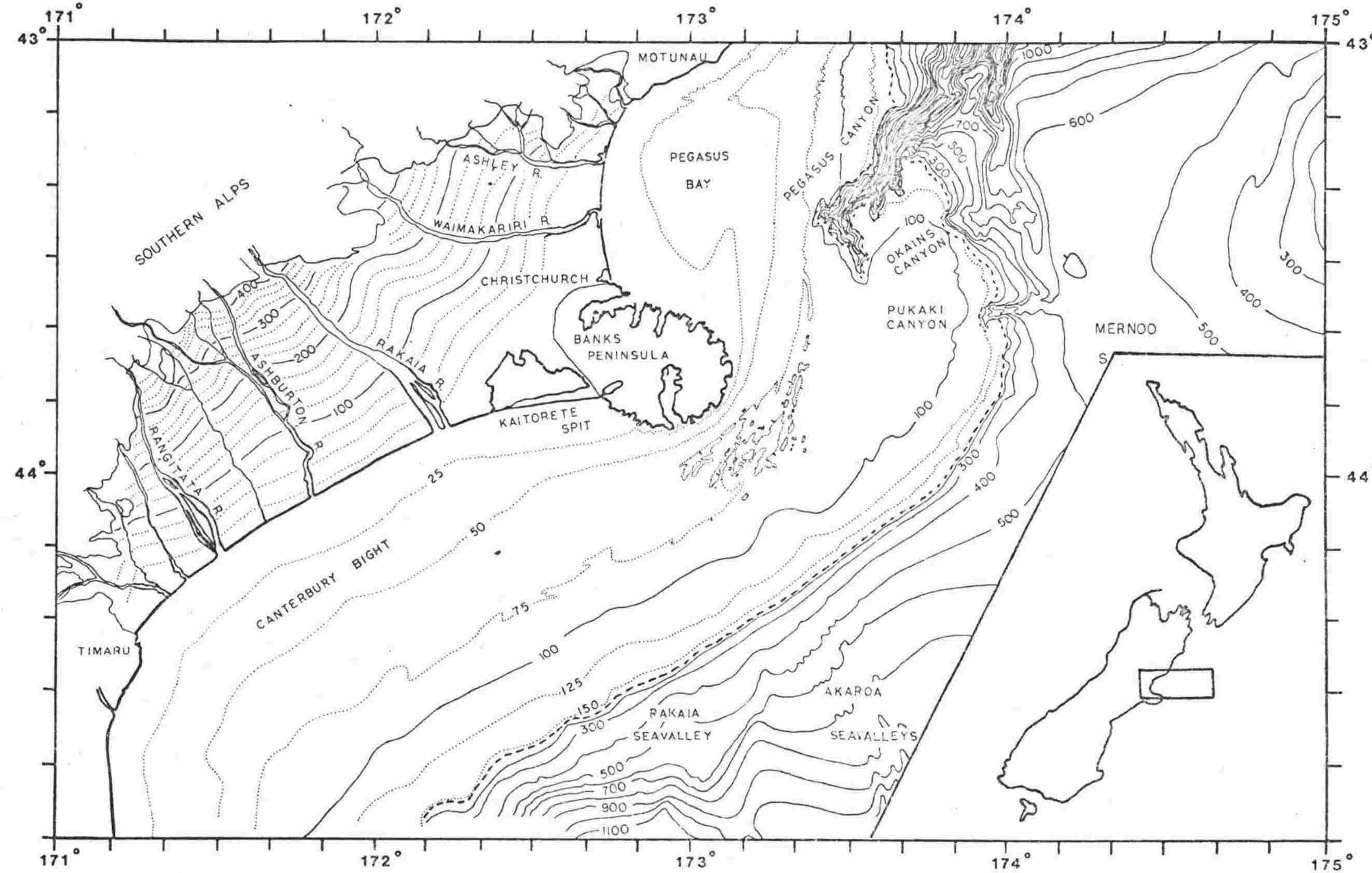


Figure D1. Location of Pegasus Canyon and regional bathymetry. Contours in metres.

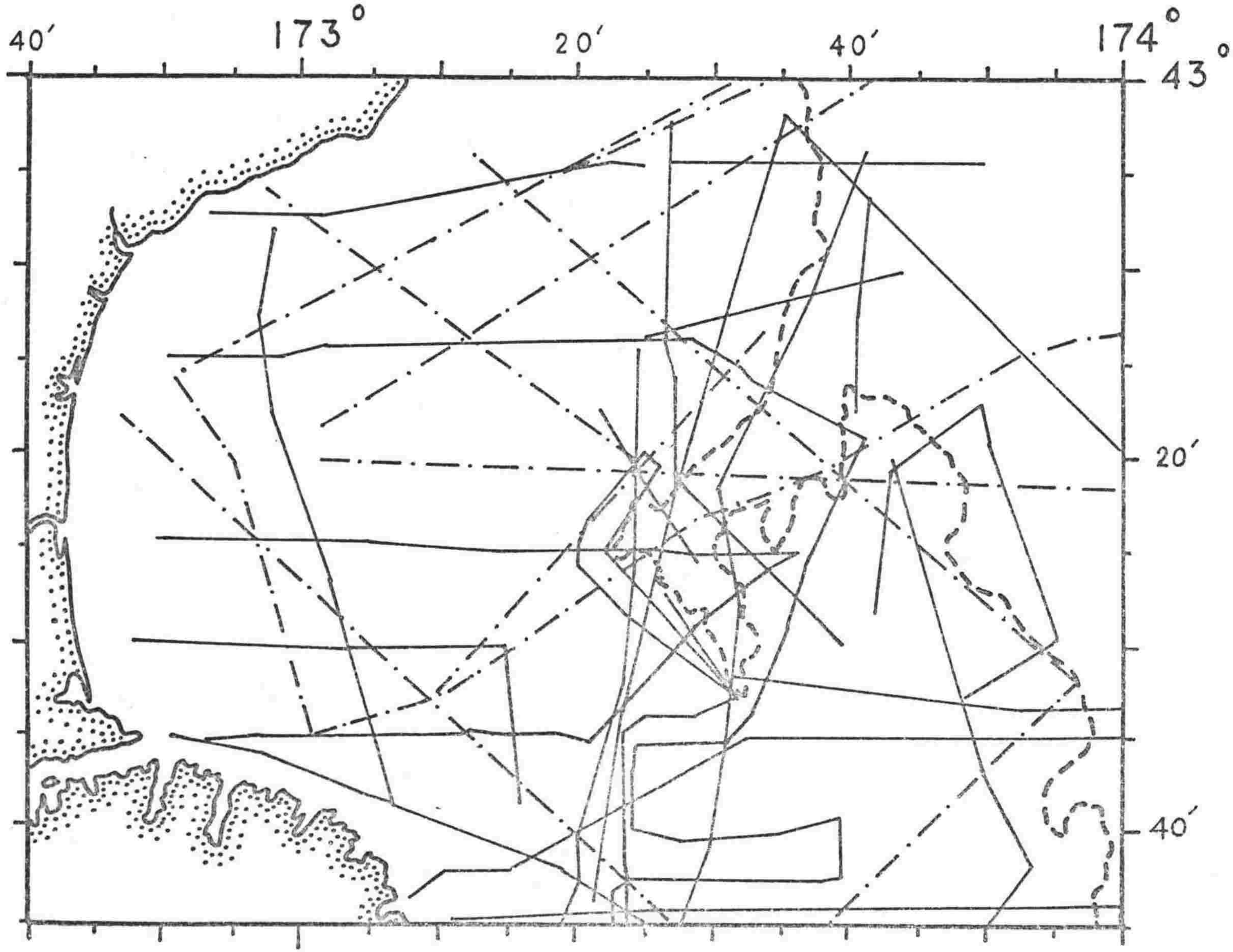


Figure D2. Location of existing seismic profiles in the region of Pegasus Canyon. Solid lines - 3.5 kHz profiles; Broken lines - air-gun, gas exploder and explosion seismic profiles.

SETTING AND TOPOGRAPHY OF THE CANYON

Pegasus Canyon is the largest of a group of submarine canyons on the outer shelf off Pegasus Bay, New Zealand (Fig. D1). The others are Pukaki Canyon and Okains Canyon to the south, and a small nameless canyon north of the study area. The continental shelf into which Pegasus Canyon is cut lies off a broad, Pleistocene, fluvio-glacial outwash plain - the Canterbury Plains. A solitary complex of basaltic volcanoes, 6 to 12 million years old (Stipp and McDougall 1968) extends from the plain out to sea as a large peninsula - Banks Peninsula. The peninsula comes to within 40 km of Pegasus Canyon and is the closest point of land to it (Fig. D1).

Pegasus Canyon originates midway across the continental shelf, which in this area is approximately 80 km wide. From its head, it follows a zig-zag course across the shelf (Fig. D3); it extends northwest for 17 km roughly parallel to the strike of the shelf edge; then northeast for another 17 km toward the shelf edge; then north for 9 km, again roughly parallel to the shelf edge; and finally northeast again for 3 km, crossing the shelf edge 46 km below the canyon head. Several prominent tributaries enter from the continental shelf at intervals along this length, all but one entering from the south. On the continental slope the canyon follows a slightly sinuous course for a further 55 km before opening into the Hikurangi Trough.

In the main arm, that is the northwest-trending upper 17 km, the walls are furrowed by a number of steep gullies. At the heads of the gullies are short, shallow channels entering from the continental shelf. Some of these channels are visible in Figure D4. The longest one mapped is 13 km, and the shortest one less than 2 km long. Smaller channels that cannot be resolved with the available data, may exist. The channels at the heads of gullies enter the main arm from the east, from the south and from the southwest. There are several channels connected to the canyon head itself. The

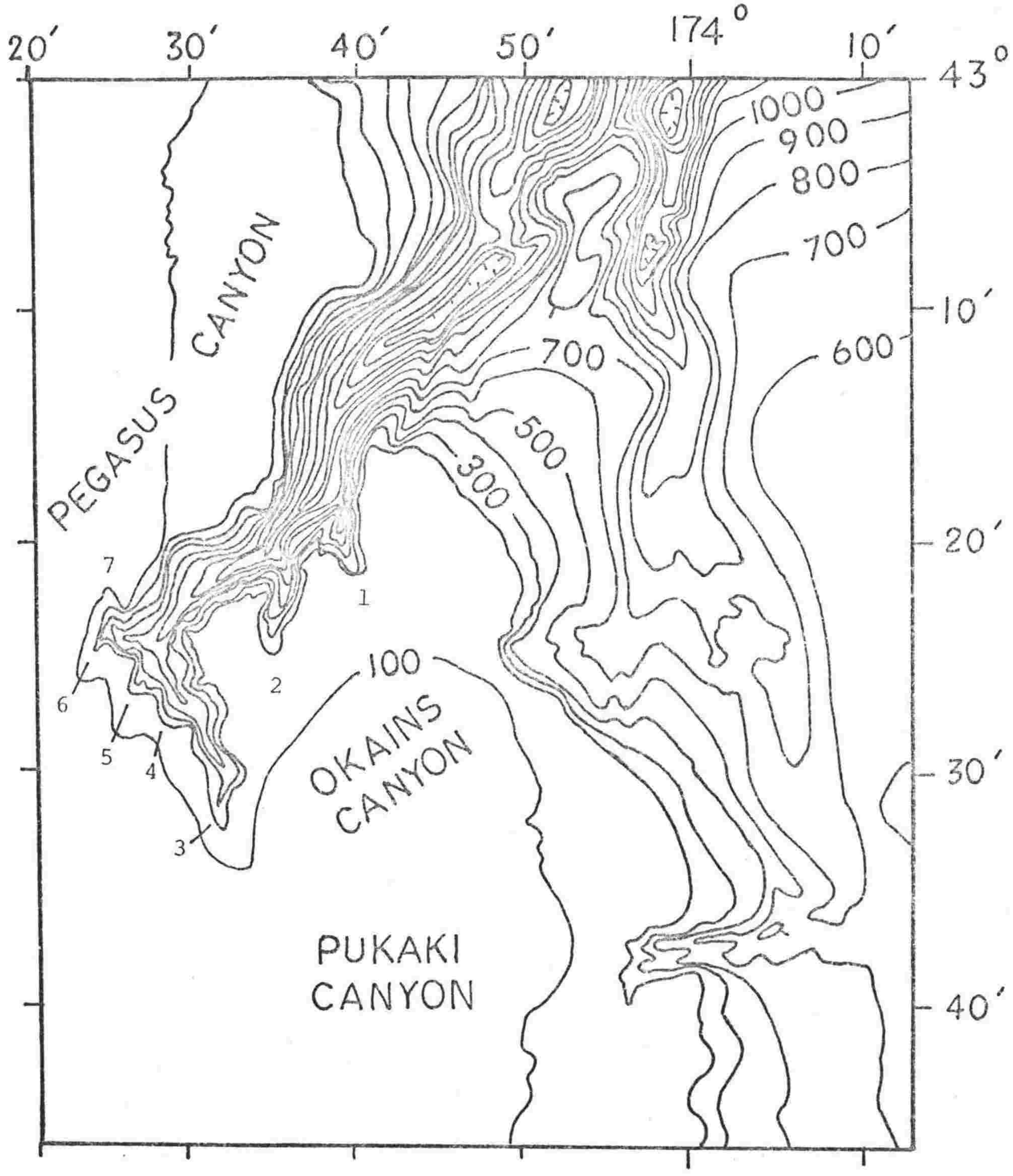


Figure D3. Bathymetry (100 m contour interval) of Pegasus, Okains and Pukaki Canyons. Numbered features are referred to in the text.

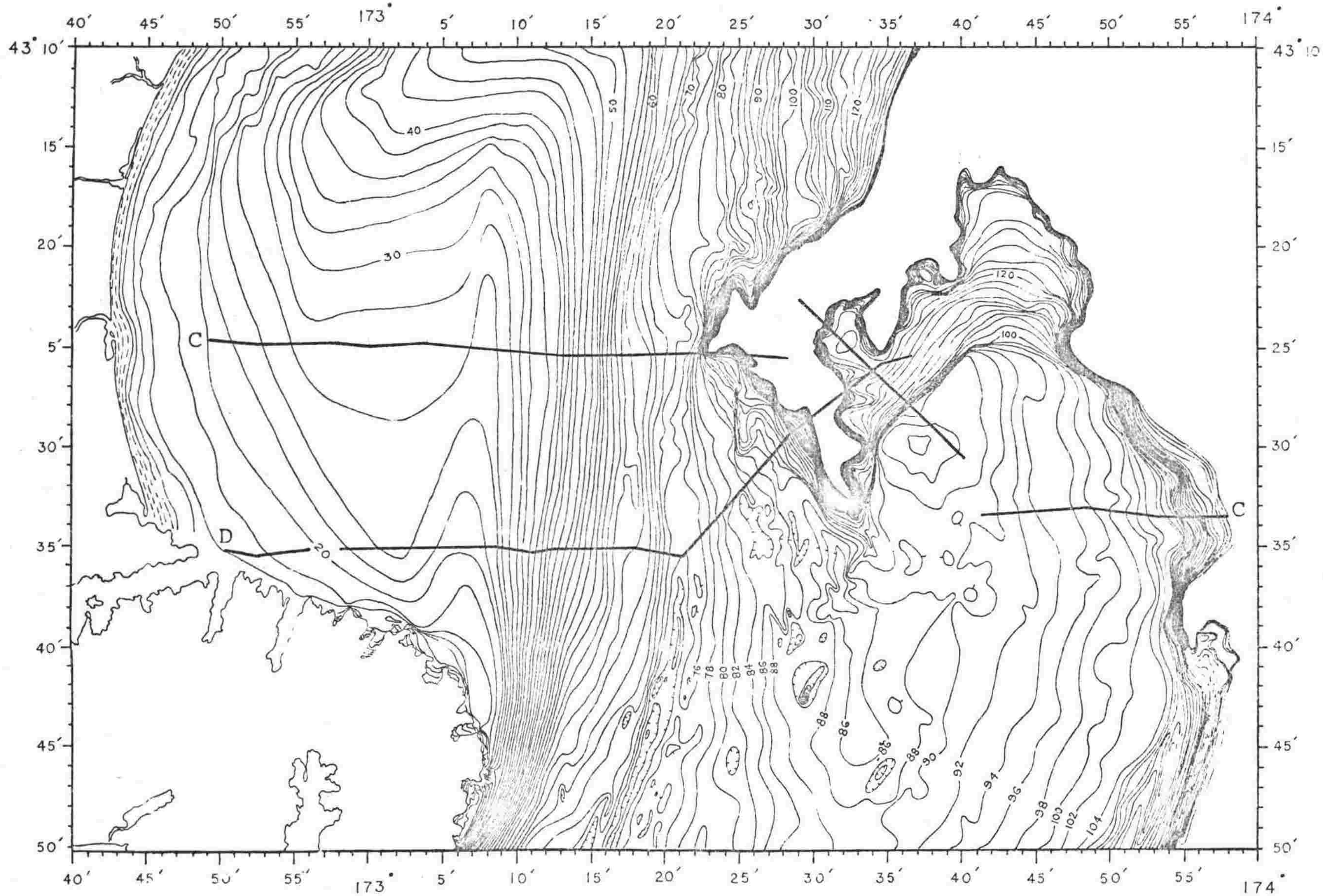


Figure D4. Microbathymetry (2 m contour interval) of the continental shelf around Pegasus Canyon. Seismic profiles used in the text are shown.

gullies and their channels are thus considered to be tributaries of the canyon. The shallow channels, which are presumed to be feeders, analagous to the shallow valleys reported by Shepard (1951) and Dill (1964a and c) at the heads of Scripps Canyon, are referred to here as "canyon-head channels". Canyon-head channels are not found at the heads of the two large tributaries east of the main arm.

SUBSURFACE GEOLOGY

From seismic profiles, the former extent of Pegasus Canyon was mapped and possible structural controls of its course were investigated.

The middle south-pointing arm of the canyon was found to have a buried southward extension 3 km long (Fig. D5).

A number of buried, shallow channels, of undetermined trend, which are interpreted here as former canyon-head channels were discovered along the southwestern side of the main arm.

A buried arm of the canyon at least 7 km long, was discovered west of the canyon's present most western point - the elbow where the northwest-trending main arm joins the northeast-trending trunk (Fig. D5). It is calculated to be about 450 m deep, assuming a velocity of sound in sediment of 1,700 m/sec. (Shumway 1960; and petroleum company velocity measurements).

It was found that no buried tributaries or canyon-head channels exist on the northeast side of the canyon. A former major canyon 700 m deep (now buried) was discovered 20 km northwest of Pegasus Canyon, but it did not connect with the portion of Pegasus Canyon that cuts the present continental shelf.

It was found that the 9 km wide, 18,000 yr old, shelf edge terrace on the southeast side of the canyon (Figs. D4

Figure D5. Features of the subsurface geology in the region of Pegasus Canyon. Hatched areas - buried canyon arms. Heavy dotted line - limit of strong seismic reflections from Banks Peninsula volcanics. Light dotted line - approximate limit of magnetic anomalies assumed to be from Banks Peninsula volcanics. Late Tertiary fault, down-thrown on the western side, (the strike shown is assumed).

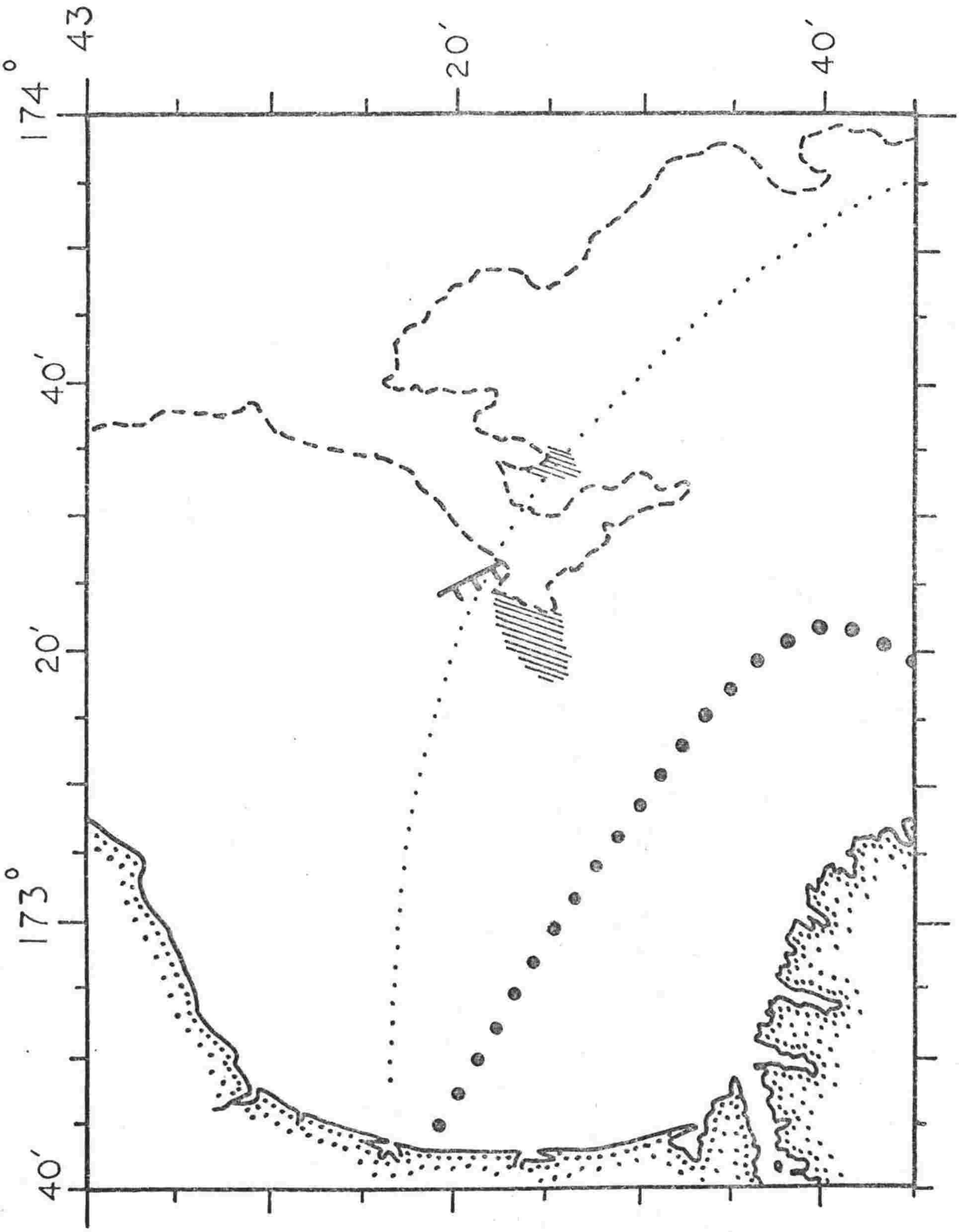


Figure D5

and D6) is fully exposed and has undergone no phase of burial. On the northeast side of the canyon there is no evidence of a former terrace. Instead, where the terrace should have been, a short, gentle slope (now locally buried) was cut into the canyon rim.

Seismic profiles (not shown) reveal that the continental shelf is underlain by a thick sequence of flat-lying and gently seaward-dipping sediments. Petroleum exploration company records (P.J. Hill and P. Dean, BP Shell Todd (Canterbury) Services Ltd., pers comm.) indicate that:-

> The upper 1.3 km of sediments (through which the canyon has cut) are mainly clastic, and have accumulated from the Early Miocene to the present with little tectonic disturbance. They include mudstones, sandstones, some shelly limestones and conglomerates, the conglomerates being most common towards the top. Impenetrable seismic reflections from lava flows of the Banks Peninsula volcanoes have been traced in seismic profiles to within 20 km of Pegasus Canyon (Fig. D5).

Assuming a velocity of sound in sediment of 1,700 m/sec. the impenetrable volcanic reflector is calculated to be about 450 m below sea level at its limit, 20 km southwest of the canyon. Magnetic anomalies, assumed to be due to Banks Peninsula volcanics continue northeastward right up to and under Pegasus Canyon (Fig. D5), ending in the vicinity of the middle arm at longitude 173°35'E (Gerard 1953, and unpublished petroleum company magnetic records).

Faults affecting the Late Tertiary sequence are scarce. A small fault in the base of the Miocene sequence, downthrown to the west and of unknown strike, exists 3 km north of the elbow of Pegasus Canyon (Fig. D5) (P. Dean, BP Shell Todd (Canterbury) Services Ltd., pers comm.) No faults have been detected under the canyon.

Thus the course of Pegasus Canyon and its tributaries appears to be free of fault control and the canyon's southward

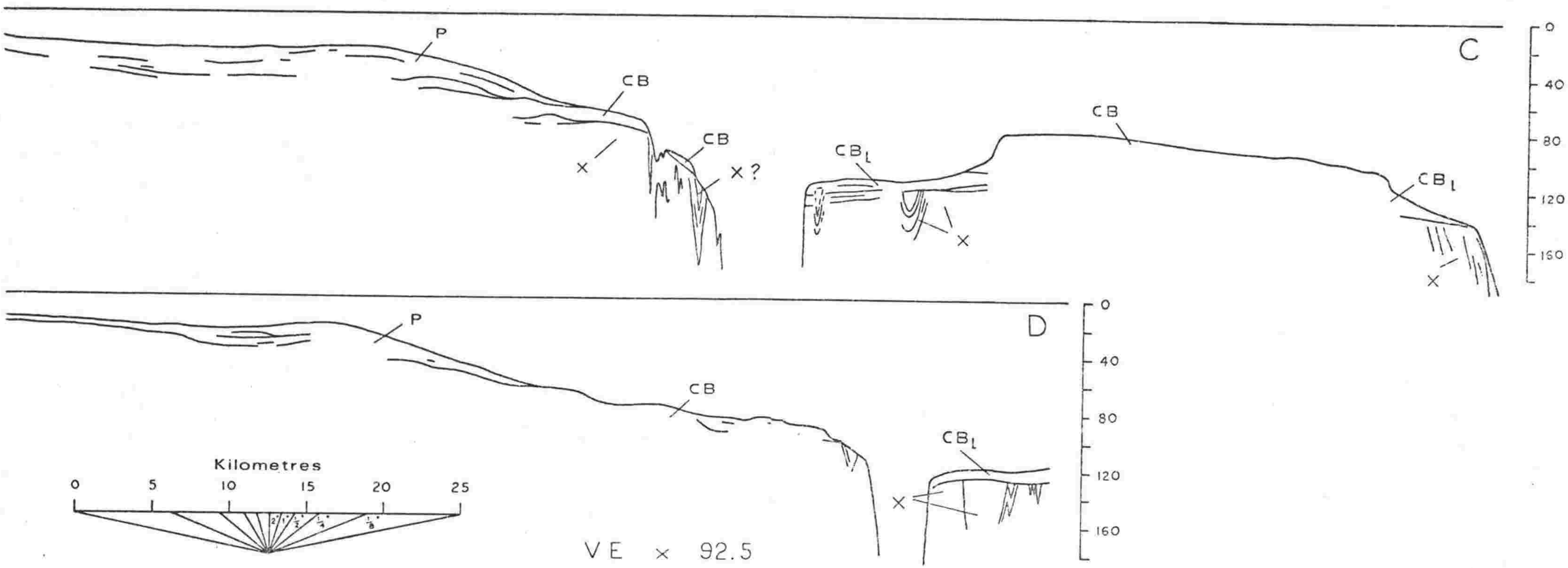


Figure D6. 3.5 kHz profiles across Pegasus Canyon. See Fig. D2 for profile locations. Vertical scale in metres.

asymmetry is not due to burial of supposed tributaries on its northwestern side. Any explanation for the origin of the canyon must explain the southward asymmetry.

EXPLANATION OF SOUTHWARD ASYMMETRY

Pegasus Canyon cannot be directly related to any particular river on shore. However, it is likely that the rivers entering Pegasus Bay did flow into the canyon from the west at some time in the past, and a share of the canyon's landward erosion has, no doubt, resulted from this. Except for the buried west arm, which points directly towards shore, the canyon and its tributaries show a pronounced trend parallel to shore. For this reason, it is felt that the canyon must have been eroded principally by streams of coarse sediment carried along Pleistocene beaches, and that the influence of rivers has been secondary.

During the late Pleistocene, gravel and sand (traced to a source at least 300 km to the southwest) were carried along the beaches to the vicinity of Pegasus Canyon by strong northeastward littoral drift (Chapter B). It was suggested in Chapter C that the submarine canyons were initially cut into the shelf edge during the Pleistocene, when shelf sand, carried northwards by strong, north-flowing currents, spilled over the shelf edge in this area. The canyons then grew to intercept the supply of sand and gravel carried north along the beach.

It was further suggested in Chapter C that with a stable shoreline, headward canyon erosion would proceed towards the sediment supply, that is, southwards along shore, eventually creating a south-pointing canyon head. In other parts of the world, small shore-parallel arms at the heads of submarine canyons have been explained in the same way (Dill 1964c; Yerkes et al. 1967; and Dietz et al. 1968). It is assumed here that the south pointing arms of Pegasus Canyon were formed by shore-parallel erosion during different sea level stillstands. Thus, if the locations of Pleistocene stillstand shorelines on the adjacent shelf are known, it should be possible to relate them to the development of tributaries of the canyon.

KNOWN LATE PLEISTOCENE SHORELINES

Four late Pleistocene shorelines have been discovered on the shelf south of Pegasus Canyon (Chapter B). Their positions are shown in Figure D7. They have been defined on the basis of bathymetry, 3.5 kHz profiles, sediment character and fauna. Two have been dated by radiocarbon ages of the shells of the dominant littoral species. The shorelines in Figure D7 can be traced in the microbathymetry of Figure 4.

The oldest shoreline was dated by radiocarbon as 28,000 yr old and is interpreted as the interstadial shoreline that preceded the main Last Glacial advance (Chapter B). It is thought to have been a spit/lagoon complex (Fig. D7a). The former positon of the spit is marked by a broad, poorly-defined high lying just west of the present 90 m isobath, south and east of the main canyon arm (Fig. D4). Part of the trough, occupied by the former lagoon, is visible south of the main canyon arm. The poor definition of these features has been explained in Chapter B as being due to later reworking during the deglacial transgression.

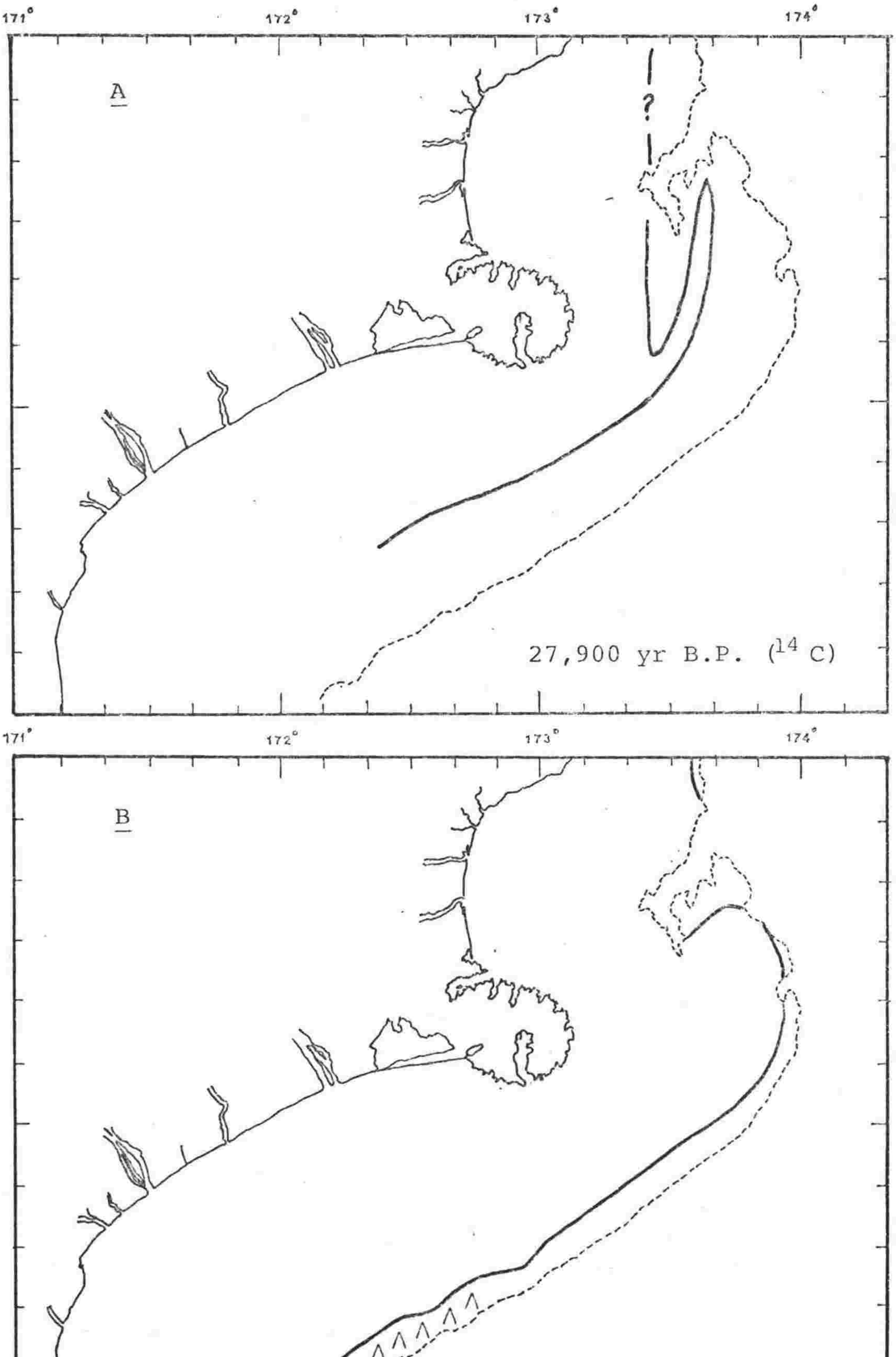
The next oldest shoreline (Fig. D7b), that of the Last Glacial lowest sea level about 18,000 yr ago (Curray 1965), is preserved as a terrace skirting the shelf edge and the 110-150m southwest side of Pegasus Canyon (Fig. D4). The terrace is narrow along the eastern shelf edge and wide in the canyon. It is seen in Figure D4 that the terrace truncates the northern part of the 28,000 yr shore.

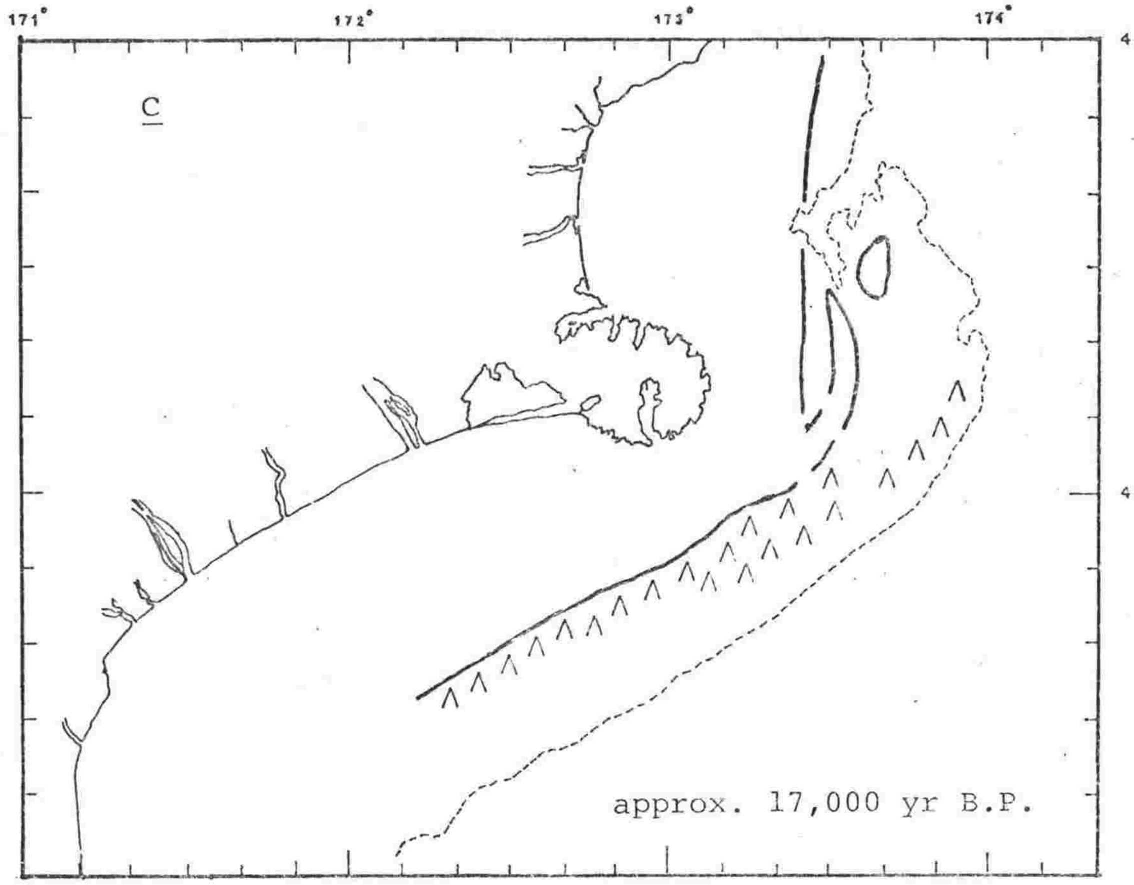
The terrace along the side of Pegasus Canyon is cut into fine sand and mud, and is gravel free (Chapter B). The

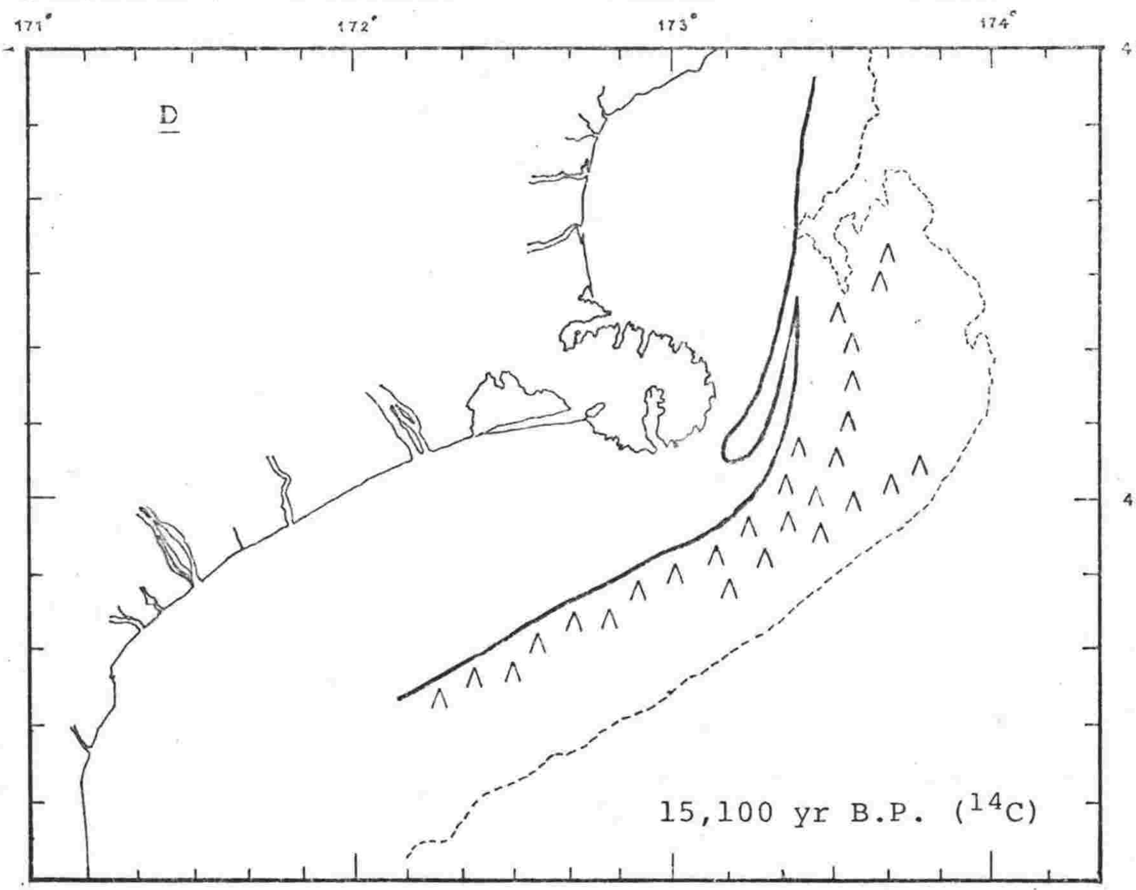
Figure D7 (a,b,c,d).

Positions of successive Late Quaternary shorelines. Shoreline ages that are based on radio-carbon-dated shells are indicated by: (^{14}C). Other shoreline ages are inferred from the sea level curve of Curray (1965).

ΛΛΛΛ - Inferred active offshore shoals or submarine ridges.


171°
172°
173°
174°
43°
44°
A
?
27,900 yr B.P. (^{14}C)
B
approx. 18,000 yr B.P.


171°
172°
173°
174°
43°
44°
C
approx. 17,000 yr B.P.


171°
172°
173°
174°
43°
44°
D
15,100 yr B.P. (14C)

terrace along the shelf edge to the south is fringed with a dense deposit of relict gravel interpreted as former beach gravel. Okains and Pukaki Canyons, which lie just south of Pegasus Canyon, both cross the terrace to the gravel belt. There is no gravel between Okains Canyon (the more northern of the two) and Pegasus Canyon.

Two shorelines of the subsequent deglacial transgression are recognized. The oldest, marked by a ridge trending almost due north into the head of the canyon, is superimposed on the 28,000 yr shore, and is thought to have been a similar barrier/lagoon complex. The lagoon occupies the trough of the former interstadial lagoon (Figs. D7c and D4). The shore is estimated, by comparing its present depth below sea level (86 m) to the Pleistocene sea level curve of Curray (1965), to be approximately 17,000 yr old.

The youngest deglacial shoreline (Fig. D7d) has been dated by radiocarbon as 15,000 yr old (Chapter B) and was apparently another spit (or barrier) backed by a lagoon. It is preserved as a low, narrow, ridge and trough, enclosed by the present 78 m isobath, about 15 km east of Banks Peninsula (Fig. D4).

Pleistocene features on the continental shelf west of the 15,000 yr shore and north of Pegasus Canyon are buried by Holocene sediments.

LATE PLEISTOCENE EROSIONAL HISTORY OF PEGASUS CANYON

For ease of identification, the canyon arms, short canyon-wall gullies and canyon-head channels, referred to in the text, are numbered in Figure D3.

Canyon erosion prior to the Last Glacial stage

The existence of the 18,000 yr B.P. shelf edge terrace on the side of Pegasus Canyon establishes that the greater part of the canyon, including most of the main arm, is more than 18,000 yr old.

Some of the Late Pleistocene stratigraphy in the region of the canyon is presented in Profile C (Fig. D6). Unit P (Pegasus Formation of Chapter B) is sediment of mainly Holocene age in Pegasus Bay and unconformably overlies unit CB. Unit CB (Canterbury Bight Formation of Chapter B) is mainly of Last Glacial age and unconformably overlies an unnamed unit - X. The unconformity between units CB and X is thought to be part of a shelf-wide regional unconformity of Penultimate Glacial age (Chapter B). It is therefore inferred that unit X is of Penultimate Glacial age or older.

It is seen on Profiles C and D (Fig. D6) that the Penultimate Glacial unconformity has truncated the fill of a buried valley east of the canyon. This is seen in Figures D3, D4 and D5 to be the buried portion of tributary arm 2 east of the main arm. Because it underlies the Penultimate Glacial unconformity, this arm would have been cut, at the latest, during an interstadial of the Penultimate Glacial, and partly infilled before the final phase of low sea level of the Penultimate Glacial.

The position of the buried western arm in the canyon stratigraphy is inferred only tentatively at this stage. The 3.5 kHz profiler cannot penetrate deep enough to detect the infilled arm, except on the edge of the canyon where the overlying sediment is thin or absent; and the upper 300 m of the low-frequency seismic record, on which the buried arm was discovered, is too noisy to be useful. The entry point of the former western arm is likely to be the present embayment occupied by the small tributary arms 8 and 9 at the elbow of the canyon (Figs. D3 and D5). Canyon fill, assumed to be that of the buried arm, is seen on Profile C (Fig. D6) on the western edge of the canyon. The fill underlies an unconformity that appears to correlate with the Penultimate Glacial unconformity across the canyon. The arm would therefore have to have been cut and completely infilled again, at the latest before the episode of erosion that created the unconformity, that is before the final phase of low sea level of the Penultimate Glacial stage.

Canyon erosion between 28,000 yr and 18,000 yr ago

Two major Last Glacial shorelines have been described - the last interstadial spit/lagoon complex (28,000 yr old) and the lowest glacial shoreline, the shelf edge terrace (about 18,000 yr old).

The broad bathymetric high that marks the 28,000 yr old interstadial spit is truncated by the shelf edge terrace on the side of Pegasus Canyon (Fig. D4). Thus the point of intersection of the interstadial shoreline and the canyon is not precisely known. (Fig. D3). However, the entire volume of sand and gravel that was transported northwards along shore during the interstadial, would have poured into the canyon at the point of intersection, and would probably have excavated a tributary. Tributary 1 may have been cut at this time and tributary 2, which is known to predate the Last Glacial stage, may have been partly re-excavated.

The terrace on the side of Pegasus Canyon is anomalous. During the Last Glacial minimum sea level 18,000 yr ago, the sea cut deeply into the southeastern side of the inlet formed by Pegasus Canyon without severely eroding the other sides. The resion for this is not fully understood, but the following explanation is suggested.

It was noted earlier that gravel was not found between Pegasus Canyon and neighbouring Okains Canyon to the south. At the time that the terrace was cut, the gravel and sand carried northwards along the open coast by the prevailing littoral drift would have been pirated by Pukaki and Okains Canyons, which both completely cross the terrace. Thus very young, unconsolidated, easily erodable beds of sand and mud would have been left exposed on the sides of the inlet formed by Pegasus Canyon.

Because of the deep water in the inlet, conditions may have been analagous to those of the present northeast-facing bays of Banks Peninsula (cf. Dingwall 1974). Frequent northeasterly storm waves would have proceeded undamped up the deep inlet, eroding the walls of soft Pleistocene sediment. The eroded material would have been lost to the deep canyon, thus preventing the formation of a protective beach. The direction of wave attack must have been such that the south side of the canyon was exposed and the northwest side sheltered, allowing a terrace to form on one side and not the other.

Canyon erosion during the deglacial transgression

Rapid drowning of the terrace during the last deglacial sea level rise is implied by the terrace's good preservation on the side of Pegasus Canyon (Fig. D4). Sediment from the adjacent shelf to the south (distinguished by its coarse grain sizes) has not spilled northwards on to the terrace on the side of Pegasus Canyon (Chapter B). This implies that during the early stage of sea level rise, after the terrace was drowned, littoral-drifted sediment from the south continued to be deflected eastwards into Okains Canyon.

Two well défined shorelines of the deglacial transgression have been described - a barrier/lagoon complex formed about 17,000 yr ago on the remains of the 28,000 yr old interstadial spit/lagoon complex; and another barrier/lagoon complex formed landward of this about 15,000 yr ago. The geography of the 17,000 yr shore is thought to have been complex (Chapter B). Features of it that are relevant to the history of Pegasus Canyon are outlined below. When the transgressing sea reached the vicinity of the present 86 m isobath (Fig. D4) 17,000 yr ago, the ridge of the old 28,000 yr spit is thought to have been breached by storm washover at its closest point to Pegasus Canyon, forming the saddle just southeast of the canyon head (see also Fig. D7c). The crest of the segment south of the breach shifted west to lead into the new sediment sink - the head of Pegasus Canyon.

The segment north of the breach (and with it, Okains Canyon) was cut off from further supplies of littoral sediment. The trough landward of the former spit again became a lagoon opening northwards into the canyon. Another shallow breach is thought to have occurred in the coast further south (between 43°45'S and 43°50'S, Fig. D4) creating a washover channel between the open sea and the southern end of the lagoon. The coastline 17,000 yr ago is therefore considered to have resembled a modern barrier coastline, in which a long spit, or chain of low barrier islands, was separated from land by a large lagoon.

Sand and gravel transported along the seaward shore of the barrier would have been carried into the head of Pegasus Canyon - probably via the present canyon-head channels. The small portion of the present canyon head (3 in Fig. D3) that projects south of the terrace (Fig. D4) is thought to have been cut at this time.

The volume of littoral drift along the shores of the lagoon would have been minimal and erosion at the junction of the lagoon with the canyon should likewise have been minimal. There is, not surprisingly, a lack of significant tributaries on the southwest side of the canyon. Only two canyon-head channels (one partly buried) (Fig. D4) and two small gullies (4 and 5, Fig. D3) occur where the lagoon would have entered.

The distinct ridge and trough enclosed by the present 76 m isobath (Fig. D4) have been interpreted as a former barrier and lagoon, formed during a sea level stillstand about 15,000 yr ago (Chapter B). The ridge and trough disappear northwards but the northward projection of the ridge, along the strike of the shelf, trends into the small westernmost tributary of Pegasus Canyon. The head of this tributary is visible in Profile C (Fig. D6) on the western side of the canyon where it is seen to be cut into the fill of the buried western arm. The small tributary 6 is thus young and is considered to have been cut 15,000 yr ago by sediment carried along the seaward shoreline of this barrier.

The age and evolution of the only tributary on the north side of the canyon (7, Fig. D3) cannot be resolved with the available data.

During a renewed rise of sea level, which led to submergence of the 15,000 yr shore, headward erosion of the canyon did not keep pace with the rate of shoreline retreat and the canyon was left stranded on the continental shelf.

The canyon is thought to be largely dormant at present (Chapter C) and is assumed to have been similarly dormant during periods of high sea level in the past. It has been suggested, however, that some palimpsest sand is presently spilling over the southwestern rim of the canyon from the continental shelf (Chapter B). Sand spillover during past periods of high sea level may thus have contributed slightly to southward canyon erosion.

STRUCTURAL CONTROL OF THE MAIN ARM

The northwest-southeast trend of the main arm is anomalous and cuts obliquely across the north-south trends of the Pleistocene shorelines. Faulting is not responsible for the trend. The trend is parallel to the strike of the shelf edge and to the coastline of Banks Peninsula, and is thus parallel to the assumed strike of gently seaward dipping beds underlying the shelf. Since the shelf is a progradational structure, the average age of beds underlying the outer shelf will be younger than the average age of beds underlying the inner shelf. The landward penetration of the canyon through the sediments of the shelf would have thus required the erosion of increasingly older and more indurated strata. The anomalous trend of the main arm may thus reflect the strike of a particularly resistant horizon, through which the canyon could not be easily cut. Hard sandstone was dredged from only 260 m to 360 m below sea level on the southwest wall of the canyon (between tributaries 5 and 6).

The magnetic data, which indicates that the Banks Peninsula volcanics extend across the shelf to the canyon (Fig. D5), suggests that the resistant horizon could be a bed of hard volcanic rock. However, the sloping seismic reflector from the Banks Peninsula volcanics flattens out at about 450 m below sea level. Since the floor of the main arm of the canyon is only 400 m to 500 m below sea level, the volcanic beds are probably too deep to have influenced the course of the canyon.

SUMMARY AND CONCLUSIONS

The course of Pegasus Canyon on the continental shelf is not fault controlled. Its southward trend and its many south-trending arms have developed by shore-parallel erosion towards a littoral-drifted supply of sediment from the south during Pleistocene sea level stillstands. The trend of the main arm, obliquely across the southerly trend, is thought to be controlled by the strike of a resistent bed in the underlying strata.

No major tributaries have ever existed on the northwestern side of Pegasus Canyon.

A buried former arm of Pegasus Canyon lies west of the canyon's present most western point and is infilled with sediments assumed to be of Penultimate Glacial age. The canyon therefore reached its maximum landward penetration during or before the Penultimate Glacial.

Of the three south-trending arms, the eastern one may have formed 28,000 yr ago, the middle one is thought to have formed and been partly infilled during the Penultimate Glacial, the western and largest one is of unknown age but is older than 18,000 yr.

Canyon erosion during the last 18,000 yr was concentrated around the main arm. Shallow canyon-head channels, preserved in the bathymetry around the arm, are thought to have been feeders that funnelled sediment from Pleistocene shorelines into the canyon. Renewed headward erosion of the main arm took place about 17,000 yr ago but probably amounted to no more than a few kilometres. The small westernmost tributary is thought to have been cut 15,000 yr ago into the fill of the buried western arm of the canyon.

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APPENDIX 1

Significant minimum velocities of drift cards and sea-bed drifters.

SIGNIFICANT MINIMUM VELOCITIES OF DRIFT CARDS RELEASED OFFSHORE

Card	Station	Release Point Latitude S	Release Point Longitude E	Recovery Point N.Z. Yard Grid	Distance Travelled (naut miles)	Travelling Time (Days)	Minimum n.mi/da.	Velocity cm/sec.
N1680	H326	43° 49.3'	173° 14.0'	S65-3836	11	16	0.688	1.5
N1725	H341	44° 07.4'	173° 09.1'	N21-2729	187	57	3.28	7.0
N1727	H341	"	"	N31-7795	250	68	3.68	7.9
N1803	H367	44° 07.1'	172° 38.8'	N21-3845	210	48	4.38	9.4
N1807	H367	"	"	N31-5346	235	79	2.98	6.4
N1877	H381	44° 17.3'	172° 33.1'	S78-5238	220	62	3.55	7.6
N1950	H385	44° 03.7'	172° 13.7'	N21-2729	214	56	3.82	8.2
I1060	J400	43° 12.3'	172° 56.8'	N32-8505	223	87	2.57	5.5
I1088	J401	43° 17.3'	172° 57.9'	S78-3313	127	78	1.63	3.4
I1168	J403	43° 26.9'	173° 02.1'	S65-0765	13.4	19	0.69	1.5
I1214	J404	43° 31.8'	173° 04'	S77-5272	120	25	4.80	10.3
U1055	J407	43° 45'	173° 10'	S77-4673	132	107	1.30	2.8
U1104	J408	43° 50'	173° 11'	S77-5172	127	186	0.68	1.5
U1287	J413	44° 00.3'	173° 08.8'	N31-7183	233	83	2.81	6.0
U1343	J414	44° 00'	172° 59'	S77-4374	152	28	5.43	11.6
U1359	J415	44° 00.5'	172° 48.9'	S77-4673	157	67	2.34	5.0
U1393	J416	44° 00.5'	172° 45.0'	" "	160.5	24	6.70	14.4
U1608	J421	44° 30.2'	172° 45.6'	N32-8505	287	96	2.99	6.4

SIGNIFICANT MINIMUM VELOCITIES OF DRIFT CARDS RELEASED OFFSHORE (cont'd)

Card	Release Point Station	Release Point Latitude S	Release Point Longitude E	Recovery Point N.Z. Yard Grid	Distance Travelled (naut. miles)	Travelling Time (Days)	Minimum Velocity n.mi/da.	Minimum Velocity cm/sec.
U1638	J422	44° 31.2'	172° 32.4'	S77-5272	184	52	3.54	7.6
U1683	J423	44° 29'	172° 27'	N31-6669	274	74	3.70	7.9
U1726	J424	44° 26.6'	172° 20'	S77-4673	184	106	1.74	3.7
U1842	J427	44° 20.5'	172° 01'	S65-4130	60	10	6.00	12.9
U1859	J427	"	"	S65-0768	90	121	0.74	1.6
U1926	J429	44° 16.7'	171° 48.5'	S65-1317	48	14	3.43	7.4
U1957	J430	44° 15.0'	171° 42.0'	S55-6313	30	6	5.0	10.7
U1962	J430	"	"	S65-0720	50	17	2.94	6.3
U1990	J430	"	"	S55-7516	37	9	4.12	8.7
U1994	J431	44° 13'	171° 35.5'	S55-6112	33	8	4.12	8.7
X1006	J431	"	"	S55-6513	32.5	7	4.64	9.9
X1018	J431	"	"	S65-0520	51	13	3.92	8.4
X1049	J432	44° 00.0'	172° 3.5'	S65-1616	33	11	3.00	6.4
X1079	J434	44° 00.0'	172° 10'	S65-0772	74	19	3.90	8.4
X1099	J434	"	"	S65-0863	71	17	4.18	9.0
X1168	J438	44° 00.0'	172° 24.3'	S65-1055	60	35	1.72	3.7
X1241	J440	44° 00.0'	172° 35'	S77-5272	162	19	8.53	18.3
X1281	J454	43° 37.4'	172° 55.2'	S65-0858	10	3	3.33	7.1

MINIMUM VELOCITIES OF SEA-BED DRIFTERS RELEASED ON THE CONTINENTAL SHELF

Drifter	Release Point			Depth (m)	Recovery Point N.Z. Yard Grid or Lat.,Long.	Distance Travelled (naut. miles)	Travelling Time (Days)	Minimum Velocity	
	Station	Latitude S	Longitude E					n.mi/da.	cm/sec.
C1336	J406	43° 40'	173° 07.0'	20	S65-3836	3.5	4	0.875	1.9
C1181	J415	44° 00.5'	172° 48.9'	60	173° 16'E 43° 49'S	23	26	0.884	1.9
C1427	J419	44° 10.0'	172° 43.7'	75	173° 07'E 43° 59'S	19.5	16.75	1.162	2.5
C1409	J424	44° 26.6'	172° 20'	90	173° 39'E 43° 39'S	73	297	0.243	0.5
Y1550	J426	44° 21.4'	172° 05.0'	70	172° 21'E 44° 20'S	11.5	174	0.066	0.1
C1322	J429	44° 16.7'	171° 48.5'	40	171° 37'E 44° 23'S	10.5	25	0.420	0.9
C1102	J430	44° 15.0'	171° 42.0'	30	S44-9873	10.5	99	0.105	0.2
C1110	J430	"	"	"	S54-2693	12	77	0.156	0.3
C1207	J430	"	"	"	S54-3095	14	122	0.115	0.2
Y1682	J431	44° 13'	171° 35.5'	20	S54-3297	17	18.5	0.92	2.0
Y1765	J432	44° 00.0'	172° 3.5'	15	S55-6513	10	9	1.111	2.4
Y1944	J434	44° 00.0'	172° 10'	25	S55-6212	6.5	21	0.31	0.7
Y1629	J438	44° 00.0'	172° 24.3'	30	172° 58'E 44° 10'S	26	66	0.445	1.0
C1282	J439	43° 51'	172° 31.2'	10	S65-0720	8.5	21	0.404	0.9

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            GRAIN SIZE ANALYSES. FOLK-AFTER FOLK AND WARD(1957). INMAN-AFTER INMAN (1952).
              PERCENTILES DETERMINED BY INTERPOLATION OF NORMAL PROBABILITY CURVE       VERSION  2.3

CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

B548
                 DATA     0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.17 0.76 2.26 2.39 4.24 4.19 1.82 1.6616.07
  FREQUENCY PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  2.2  6.7  7.1 12.6 12.5  5.4  5.0 47.9
 CUMULATIVE PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.5  2.8  9.5 16.6 29.2 41.7 47.2 52.1100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 52.1% SILT = 47.9% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.34  2.61  2.96  3.17  3.89  5.25  5.89  7.20  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   4.23  STDEV  1.20  SKEW -0.09  KURT  1.23
GRAPHIC (FOLK)  MEAN   4.26  STDEV  1.42  SKEW  0.41  KURT  0.91 INMAN SD 1.46 SK  0.37***  INSUFFICIENT  DATA  ***

E43
                 DATA     0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.82 2.31 4.29 4.00 6.90 4.51 1.69 1.6822.76
  FREQUENCY PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.7  4.7  8.8  8.2 14.1  9.2  3.5  3.4 46.5
 CUMULATIVE PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.7  6.4 15.1 23.3 37.4 46.6 50.1 53.5100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 53.5% SILT = 46.5% CLAY =   0.0%

PERCENTILES (1,5,15,25,50,75,84,95)    2.17  2.45  2.78  3.03  3.74  5.70  6.62  8.51  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   4.18  STDEV  1.27  SKEW -0.04  KURT  1.22
GRAPHIC (FOLK)  MEAN   4.38  STDEV  1.88  SKEW  0.54  KURT  0.93 INMAN SD 1.92 SK  0.50***  INSUFFICIENT  DATA  ***

E45
                 DATA     0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.22 0.31 1.48 4.5316.6013.73 4.33 3.34 7.22
  FREQUENCY PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.4  0.6  2.9  8.7 32.1 26.5  8.4  6.5 14.0
 CUMULATIVE PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.4  1.0  3.9 12.6 44.7 71.2 79.6 86.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 86.0% SILT = 14.0% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.49  2.80  3.04  3.12  3.30  3.61  3.91  4.55
MOMENT MEASURES MEAN   3.57  STDEV  0.63  SKEW  1.59  KURT  4.33
GRAPHIC (FOLK)  MEAN   3.42  STDEV  0.43  SKEW  0.42  KURT  1.46 INMAN SD 0.44 SK  0.40

E46
                 DATA     0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.19 0.32 1.17 2.53 9.93 8.03 2.64 1.86 3.43
  FREQUENCY PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.6  1.1  3.9  8.4 33.0 26.7  8.8  6.2 11.4
 CUMULATIVE PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.6  1.7  5.6 14.0 47.0 73.7 82.4 88.6100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 88.6% SILT = 11.4% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.36  2.72  3.02  3.10  3.28  3.53  3.81  4.40
MOMENT MEASURES MEAN   3.50  STDEV  0.78  SKEW  1.75  KURT  5.24
GRAPHIC (FOLK)  MEAN   3.37  STDEV  0.45  SKEW  0.35  KURT  1.58 INMAN SD 0.39 SK  0.35

E47
                 DATA     0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.39 1.10 2.24 1.67 2.29 1.87 0.84 0.82 9.47
  FREQUENCY PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.9  5.3 10.8  8.1 11.1  9.0  4.1  3.9 45.8
 CUMULATIVE PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  1.9  7.2 18.0 26.1 37.2 46.2 50.2 54.2100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 54.2% SILT = 45.8% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.15  2.43  2.71  2.97  3.74  5.44  6.24  7.88  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   4.15  STDEV  1.28  SKEW -0.03  KURT  1.22                        ***  SAMPLE      BIMODAL  ***
GRAPHIC (FOLK)  MEAN   4.23  STDEV  1.71  SKEW  0.47  KURT  0.91 INMAN SD 1.76 SK  0.42***  INSUFFICIENT  DATA  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

E48
                    DATA   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 1.45 5.87 7.40 2.12 1.10 0.33 0.11 0.08 5.13
   FREQUENCY PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  6.2 24.9 31.4  9.0  4.7  1.4  0.4  0.4 21.7
  CUMULATIVE PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  6.2 31.0 62.4 71.4 76.1 77.5 77.9 78.3100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 78.3% SILT = 21.7% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.06   2.23   2.38   2.46   2.65   3.19   8.49 22.14   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   3.22   STDEV   1.23   SKEW   1.23   KURT   2.69
GRAPHIC (FOLK)  MEAN   4.51   STDEV   4.54   SKEW   0.93   KURT 11.12 INMAN SD 3.05 SK  0.91

E50
                    DATA   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.01 0.20 1.30 2.13 4.2812.94
   FREQUENCY PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  1.0  6.2 10.2 20.5 62.0
  CUMULATIVE PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  1.0  7.2 17.5 38.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 38.0% SILT = 62.0% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    3.25   3.45   3.72   3.85   4.12   4.39   4.52   4.77
MOMENT MEASURES MEAN   4.02   STDEV   0.38   SKEW -0.57   KURT   1.43
GRAPHIC (FOLK)  MEAN   4.12   STDEV   0.40   SKEW -0.01   KURT   1.02 INMAN SD 0.40 SK -0.01***  INSUFFICIENT  DATA  ***

E56
                    DATA   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.15 0.43 2.09 3.68 6.24 3.65 1.08 0.74 6.09
   FREQUENCY PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.6  1.8  8.7 15.2 25.8 15.1  4.5  3.1 25.2
  CUMULATIVE PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.6  2.4 11.1 26.3 52.1 67.2 71.7 74.8100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 74.8% SILT = 25.2% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.33   2.61   2.85   2.98   3.23   4.02   4.87   6.61
MOMENT MEASURES MEAN   3.71   STDEV   1.08   SKEW   0.90   KURT   2.14
GRAPHIC (FOLK)  MEAN   3.65   STDEV   1.11   SKEW   0.66   KURT   1.58 INMAN SD 1.01 SK  0.62

E57
                    DATA   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.16 0.37 1.58 2.52 4.12 3.49 1.41 1.17 4.20
   FREQUENCY PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.8  1.9  8.3 13.2 21.6 18.4  7.4  6.2 22.1
  CUMULATIVE PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.8  2.8 11.1 24.3 46.0 64.3 71.7 77.9100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 77.9% SILT = 22.1% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.28   2.60   2.86   3.01   3.30   3.88   4.29   5.13
MOMENT MEASURES MEAN   3.68   STDEV   1.02   SKEW   0.97   KURT   2.45
GRAPHIC (FOLK)  MEAN   3.48   STDEV   0.74   SKEW   0.41   KURT   1.19 INMAN SD 0.72 SK  0.38

F565
                    DATA   1.53 0.10 0.04 0.04 0.05 0.03 0.03 0.03 0.09 0.38 1.05 1.80 1.05 0.75 0.38 0.16 0.14 6.17
   FREQUENCY PERCENT  11.0  0.7  0.3  0.3  0.4  0.2  0.2  0.2  0.7  2.7  7.6 13.0  7.6  5.4  2.8  1.1  1.0 44.7
  CUMULATIVE PERCENT  11.0 11.7 12.0 12.3 12.7 12.9 13.1 13.4 14.0 16.7 24.4 37.4 45.0 50.4 53.2 54.3 55.3100.0
PROPORTIONS: GRAVEL = 11.0% SAND = 44.3% SILT = 44.7% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95) -15.98  -6.72   2.19   2.51   3.23   9.20 12.29 18.56   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   3.34   STDEV   2.51   SKEW -1.17   KURT   3.57
GRAPHIC (FOLK)  MEAN   5.90   STDEV   6.36   SKEW   0.50   KURT   1.55 INMAN SD 5.05 SK  0.79***  INSUFFICIENT  DATA  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

F566
                DATA    0.00 0.00 0.00 0.02 0.05 0.03 0.02 0.02 0.03 0.09 0.19 0.54 1.32 3.23 2.24 0.43 0.24 0.50
  FREQUENCY PERCENT     0.0  0.0  0.0  0.2  0.5  0.3  0.2  0.2  0.3  1.0  2.2  6.1 14.8 36.1 25.0  4.8  2.6  5.6
 CUMULATIVE PERCENT     0.0  0.0  0.0  0.2  0.8  1.1  1.3  1.5  1.8  2.8  5.0 11.0 25.8 61.9 87.0 91.8 94.4100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 94.4% SILT =  5.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.20  2.50  2.85  2.99  3.17  3.36  3.46  4.07
MOMENT MEASURES MEAN  3.23  STDEV  0.69  SKEW  1.25  KURT  9.19
GRAPHIC (FOLK)  MEAN  3.16  STDEV  0.39  SKEW  0.05  KURT  1.72 INMAN SD 0.31 SK -0.05

F567
                DATA    4.43 0.22 0.19 0.20 0.17 0.10 0.12 0.15 0.39 1.13 1.33 1.74 1.37 1.83 1.44 0.64 0.50 5.68
  FREQUENCY PERCENT    20.5  1.0  0.9  0.9  0.8  0.5  0.5  0.7  1.8  5.2  6.1  8.1  6.3  8.4  6.6  2.9  2.3 26.3
 CUMULATIVE PERCENT    20.5 21.5 22.4 23.3 24.1 24.6 25.1 25.8 27.6 32.8 39.0 47.0 53.4 61.8 68.5 71.4 73.7100.0
PROPORTIONS: GRAVEL = 20.5% SAND = 53.2% SILT = 26.3% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95) -21.99-12.47 -3.38  1.44  2.87  4.14  5.29  7.61   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  2.32  STDEV  2.61  SKEW -0.67  KURT  2.23                        ***  SAMPLE      BIMODAL  ***
GRAPHIC (FOLK)  MEAN  1.59  STDEV  5.21  SKEW -0.48  KURT  3.04 INMAN SD 4.33 SK -0.44

F568
                DATA    0.00 0.01 0.01 0.02 0.02 0.02 0.03 0.05 0.20 0.88 1.85 1.77 0.91 1.05 0.76 0.31 0.28 5.17
  FREQUENCY PERCENT     0.0  0.0  0.1  0.1  0.1  0.1  0.2  0.3  1.5  6.6 13.9 13.3  6.8  7.9  5.7  2.3  2.1 38.8
 CUMULATIVE PERCENT     0.0  0.0  0.1  0.3  0.4  0.6  0.8  1.1  2.7  9.2 23.1 36.4 43.3 51.2 56.8 59.2 61.2100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 61.2% SILT = 38.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.66  2.12  2.39  2.54  3.21  5.81  7.29 10.31   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  3.79  STDEV  1.42  SKEW  0.19  KURT  1.44                        ***  SAMPLE      BIMODAL  ***
GRAPHIC (FOLK)  MEAN  4.30  STDEV  2.47  SKEW  0.70  KURT  1.03 INMAN SD 2.45 SK  0.66

F569
                DATA    0.01 0.01 0.03 0.03 0.02 0.03 0.03 0.04 0.14 0.93 2.16 3.90 2.49 2.74 2.03 0.98 0.9513.57
  FREQUENCY PERCENT     0.0  0.0  0.1  0.1  0.1  0.1  0.1  0.1  0.5  3.1  7.2 13.0  8.3  9.1  6.7  3.2  3.1 45.1
 CUMULATIVE PERCENT     0.0  0.1  0.1  0.2  0.3  0.3  0.4  0.5  0.6  1.1  4.2 11.4 24.4 32.6 41.7 48.5 51.7 54.9100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 54.8% SILT = 45.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.95  2.29  2.50  2.77  3.62  5.74  6.75  8.80   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  4.06  STDEV  1.37  SKEW -0.10  KURT  1.61                        ***  SAMPLE      BIMODAL  ***
GRAPHIC (FOLK)  MEAN  4.32  STDEV  2.02  SKEW  0.55  KURT  0.90 INMAN SD 2.07 SK  0.51***  INSUFFICIENT  DATA  ***

F570
                DATA    0.00 0.00 0.01 0.00 0.01 0.01 0.01 0.01 0.10 1.29 3.04 3.55 0.96 0.30 0.06 0.01 0.01 0.50
  FREQUENCY PERCENT     0.0  0.0  0.1  0.0  0.1  0.1  0.1  0.1  1.0 13.1 30.9 36.0  9.7  3.1  0.6  0.1  0.1  5.1
 CUMULATIVE PERCENT     0.0  0.0  0.1  0.1  0.2  0.2  0.3  0.4  1.4 14.4 45.3 81.4 91.1 94.2 94.8 94.9 94.9100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 94.9% SILT =  5.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.94  2.12  2.27  2.35  2.53  2.70  2.81  4.32
MOMENT MEASURES MEAN  2.66  STDEV  0.71  SKEW  3.05  KURT 13.18
GRAPHIC (FOLK)  MEAN  2.53  STDEV  0.47  SKEW  0.33  KURT  2.61 INMAN SD 0.27 SK  0.03
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CLASS MIDPOINTS-PHI  -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI   -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

F571
                   DATA   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.02 0.03 0.16 0.28 0.25 0.12 0.11 0.09 0.04 0.05 0.01
  FREQUENCY PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  2.0  2.1 13.0 24.3 21.8  9.9  9.3  8.1  3.8  4.0  0.9
 CUMULATIVE PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.0  2.0  4.1 18.0 42.3 64.1 73.9 83.2 91.3 95.1 99.1100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 99.1% SILT =  0.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    1.54  2.03  2.23  2.33  2.59  3.03  3.27  3.74
MOMENT MEASURES MEAN   2.71  SIDEV  0.57  SKEW  1.37  KURT  7.00
GRAPHIC (FOLK)  MEAN   2.69  SIDEV  0.52  SKEW  0.33  KURT  1.02 INMAN SD 0.52 SK  0.31

H314
                   DATA   3.81 2.59 1.93 1.80 2.49 3.44 8.60 7.2510.9522.9322.1512.19 3.13 1.11 0.60 0.16 0.1913.32
  FREQUENCY PERCENT       3.2  2.2  1.6  1.5  2.1  2.9  7.3  6.1  9.2 19.3 18.7 10.3  2.6  0.9  0.5  0.1  0.2 11.2
 CUMULATIVE PERCENT       3.2  5.4  7.0  8.5 10.6 13.5 20.8 26.9 36.1 55.5 74.1 84.4 87.0 88.0 88.5 88.6 88.8100.0
PROPORTIONS: GRAVEL =   3.2% SAND = 85.6% SILT = 11.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   -1.98 -0.58  1.34  1.68  2.18  2.52  2.74 16.75  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   2.20  SIDEV  1.58  SKEW -0.08  KURT  5.09                        ***  SAMPLE    BIMODAL  ***
GRAPHIC (FOLK)  MEAN   2.09  SIDEV  2.97  SKEW  0.24  KURT  8.42 INMAN SD 0.70 SK -0.20

H315
                   DATA   0.95 1.52 1.35 1.38 3.31 6.8016.2019.5129.2137.8510.52 1.77 0.33 0.07 0.03 0.01 0.01 1.21
  FREQUENCY PERCENT       0.7  1.1  1.0  1.0  2.5  5.1 12.3 14.8 22.1 28.7  8.0  1.3  0.2  0.1  0.0  0.0  0.0  0.9
 CUMULATIVE PERCENT       0.7  1.9  2.9  4.0  6.5 11.6 23.9 38.7 60.8 89.4 97.4 98.7 99.0 99.0 99.1 99.1 99.1100.0
PROPORTIONS: GRAVEL =   0.7% SAND = 98.3% SILT =  0.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   -0.85  0.73  1.35  1.52  1.88  2.10  2.18  2.39
MOMENT MEASURES MEAN   1.77  SIDEV  0.74  SKEW -0.98  KURT 15.28
GRAPHIC (FOLK)  MEAN   1.81  SIDEV  0.46  SKEW -0.32  KURT  1.17 INMAN SD 0.42 SK -0.26

H316
                   DATA  22.72 6.16 3.11 2.20 2.52 2.37 6.21 6.5311.2629.7424.7911.41 2.56 1.15 0.64 0.12 0.10 5.90
  FREQUENCY PERCENT      16.3  4.4  2.2  1.6  1.8  1.7  4.5  4.7  8.1 21.3 17.8  8.2  1.8  0.8  0.5  0.1  0.1  4.2
 CUMULATIVE PERCENT      16.3 20.7 22.9 24.5 26.3 28.0 32.5 37.2 45.2 66.5 84.3 92.5 94.3 95.1 95.6 95.7 95.8100.0
PROPORTIONS: GRAVEL =  16.3% SAND = 79.5% SILT =  4.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   -5.05 -2.99 -1.04  0.64  2.05  2.36  2.49  3.20  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   1.30  SIDEV  2.00  SKEW -0.70  KURT  3.08
GRAPHIC (FOLK)  MEAN   1.17  SIDEV  1.82  SKEW -0.69  KURT  1.48 INMAN SD 1.76 SK -0.75

H317
                   DATA  36.9610.23 7.13 6.82 8.76 9.6413.44 9.0911.0117.1411.22 9.21 5.56 3.45 1.66 0.36 0.3722.21
  FREQUENCY PERCENT      20.1  5.6  3.9  3.7  4.8  5.2  7.3  4.9  6.0  9.3  6.1  5.0  3.0  1.9  0.9  0.2  0.2 12.1
 CUMULATIVE PERCENT      20.1 25.6 29.5 33.2 37.9 43.2 50.5 55.4 61.4 70.7 76.8 81.8 84.8 86.6 87.6 87.7 87.9100.0
PROPORTIONS: GRAVEL =  20.1% SAND = 67.9% SILT = 12.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   -5.04 -3.19 -1.42 -0.55  1.48  2.42  2.93 15.97  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   1.17  SIDEV  2.42  SKEW  0.01  KURT  2.38                        ***  SAMPLE    BIMODAL  ***
GRAPHIC (FOLK)  MEAN   1.00  SIDEV  3.99  SKEW  0.09  KURT  2.64 INMAN SD 2.18 SK -0.33
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CLASS MIDPOINTS-PHI  -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI   -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H318                 103.3
                DATA  ***** 0.06 0.67 0.75 0.97 0.81 0.78 0.53 1.05 2.86 6.5214.6317.8510.16 4.01 0.56 0.35 9.58
   FREQUENCY PERCENT  58.7  0.4  0.4  0.4  0.6  0.3  0.4  0.3  0.6  1.6  3.7  8.3 10.2  5.8  2.3  0.3  0.2  5.4
  CUMULATIVE PERCENT  58.7 59.1 59.5 59.9 60.5 60.8 61.3 61.6 62.2 63.8 67.5 75.8 86.0 91.8 94.0 94.4 94.6100.0
PROPORTIONS: GRAVEL = 58.7% SAND = 35.8% SILT =  5.4% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95) ******-97.08-63.59-47.11-12.38  2.72  2.94  4.60  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN -0.23  STDEV  2.81  SKEW  0.58  KURT  1.67
GRAPHIC (FOLK)  MEAN-24.34  STDEV 32.04  SKEW -0.60  KURT  0.84 INMAN SD **** SK -0.54

H319
                DATA  0.12 0.12 0.14 0.29 0.69 0.36 0.33 0.24 0.48 0.98 1.87 2.4912.4027.5228.39 5.73 3.14 6.39
   FREQUENCY PERCENT  0.1  0.1  0.1  0.3  0.8  0.4  0.4  0.3  0.5  1.1  2.0  2.7 13.5 30.0 31.0  6.2  3.4  7.0
  CUMULATIVE PERCENT  0.1  0.3  0.4  0.7  1.5  1.9  2.2  2.5  3.0  4.1  6.1  8.9 22.4 52.4 83.4 89.6 93.0100.0
PROPORTIONS: GRAVEL =  0.1% SAND = 92.9% SILT =  7.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.72  2.37  2.90  3.03  3.23  3.42  3.52  4.19
MOMENT MEASURES MEAN  3.28  STDEV  0.81  SKEW  0.02  KURT 10.81
GRAPHIC (FOLK)  MEAN  3.22  STDEV  0.43  SKEW -0.01  KURT  1.90 INMAN SD 0.31 SK -0.07

H320                                                                                      136.7
                DATA  0.00 0.08 0.07 0.10 0.23 0.31 0.78 0.68 1.03 1.48 1.23 1.36 1.87 2.65 5.86 5.39 9.41*****
   FREQUENCY PERCENT  0.0  0.0  0.0  0.1  0.1  0.2  0.5  0.4  0.6  0.9  0.7  0.8  1.1  1.6  3.5  3.2  5.6 80.8
  CUMULATIVE PERCENT  0.0  0.0  0.1  0.1  0.3  0.5  0.9  1.3  1.9  2.8  3.5  4.3  5.4  7.0 10.5 13.7 19.2100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 19.2% SILT = 80.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.55  2.90  3.86  4.22  4.96  5.71  6.06  6.78  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  5.06  STDEV  0.98  SKEW -2.16  KURT  7.10
GRAPHIC (FOLK)  MEAN  4.96  STDEV  1.14  SKEW -0.03  KURT  1.06 INMAN SD 1.10 SK  0.00***  INSUFFICIENT  DATA  ***

H321
                DATA  0.00 0.17 0.19 0.27 0.40 0.17 0.18 0.14 0.25 0.56 1.04 1.7110.7229.1734.85 8.21 4.67 6.87
   FREQUENCY PERCENT  0.0  0.2  0.2  0.3  0.4  0.2  0.2  0.1  0.3  0.6  1.0  1.7 10.8 29.3 35.0  8.2  4.7  6.9
  CUMULATIVE PERCENT  0.0  0.2  0.4  0.6  1.0  1.2  1.4  1.5  1.8  2.3  3.4  5.1 15.9 45.2 80.2 88.4 93.1100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 93.1% SILT =  6.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.97  2.74  3.00  3.09  3.28  3.46  3.61  4.14
MOMENT MEASURES MEAN  3.36  STDEV  0.73  SKEW  0.58  KURT  9.83
GRAPHIC (FOLK)  MEAN  3.30  STDEV  0.36  SKEW  0.15  KURT  1.58 INMAN SD 0.30 SK  0.07

H326
                DATA  0.29 1.04 0.56 0.54 0.77 2.22 8.0711.2321.9129.9715.28 4.61 0.74 0.38 0.15 0.03 0.02 1.08
   FREQUENCY PERCENT  0.3  1.1  0.6  0.5  0.8  2.2  8.2 11.4 22.2 30.3 15.5  4.7  0.7  0.4  0.1  0.0  0.0  1.1
  CUMULATIVE PERCENT  0.3  1.3  1.9  2.5  3.2  5.5 13.6 25.0 47.2 77.5 92.9 97.6 98.3 98.7 98.9 98.9 98.9100.0
PROPORTIONS: GRAVEL =  0.3% SAND = 98.6% SILT =  1.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.60  1.20  1.56  1.75  2.02  2.23  2.33  2.59
MOMENT MEASURES MEAN  1.96  STDEV  0.68  SKEW -0.24  KURT 17.70
GRAPHIC (FOLK)  MEAN  1.97  STDEV  0.40  SKEW -0.19  KURT  1.19 INMAN SD 0.39 SK -0.19
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H327
                DATA    0.29 0.70 0.46 0.56 0.83 1.02 1.81 1.97 2.50 3.39 1.61 0.79 0.43 0.52 0.83 0.92 1.5314.10
   FREQUENCY PERCENT    0.8  2.1  1.4  1.6  2.4  3.0  5.3  5.7  7.3  9.9  4.7  2.3  1.3  1.5  2.4  2.7  4.5 41.2
  CUMULATIVE PERCENT    0.8  2.9  4.2  5.9  8.3 11.3 16.6 22.3 29.6 39.5 44.2 46.5 47.7 49.2 51.7 54.3 58.8100.0
PROPORTIONS: GRAVEL =  0.8% SAND = 58.0% SILT = 41.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.93  0.25  1.48  1.85  3.33  4.99  5.70  7.12  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  3.40  STDEV  1.98  SKEW -0.34  KURT  2.10
GRAPHIC (FOLK)  MEAN  3.50  STDEV  2.10  SKEW  0.11  KURT  0.90 INMAN SD 2.11 SK  0.12***  INSUFFICIENT  DATA  ***

H328
                DATA   28.14 1.99 1.22 0.91 1.22 1.19 1.32 1.11 1.49 1.72 0.64 0.33 0.15 0.15 0.12 0.06 0.05 3.98
   FREQUENCY PERCENT   61.5  4.3  2.7  2.0  2.7  2.6  2.9  2.4  3.3  3.8  1.4  0.7  0.3  0.3  0.3  0.1  0.1  8.7
  CUMULATIVE PERCENT   61.5 65.8 68.5 70.5 73.2 75.8 78.7 81.1 84.3 88.1 89.5 90.2 90.5 90.8 91.1 91.2 91.3100.0
PROPORTIONS: GRAVEL = 61.5% SAND = 29.8% SILT =  8.7% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95) -12.31 -9.36 -6.56 -5.17 -2.26  1.18  1.97 14.78  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN -0.74  STDEV  2.58  SKEW  1.25  KURT  3.35
GRAPHIC (FOLK)  MEAN -2.28  STDEV  5.79  SKEW  0.20  KURT  1.56 INMAN SD 4.27 SK -0.01

H329
                DATA    5.25 1.35 0.58 0.39 0.67 1.32 3.21 3.96 5.71 5.54 1.88 1.33 0.97 0.65 0.12 0.02 0.01 1.77
   FREQUENCY PERCENT   15.1  3.9  1.7  1.1  1.9  3.8  9.3 11.4 16.5 15.9  5.4  3.8  2.8  1.9  0.4  0.0  0.0  5.1
  CUMULATIVE PERCENT   15.1 19.0 20.7 21.8 23.8 27.6 36.8 48.2 64.7 80.6 86.0 89.8 92.6 94.5 94.8 94.9 94.9100.0
PROPORTIONS: GRAVEL = 15.1% SAND = 79.8% SILT =  5.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -5.21 -3.00 -0.88  1.08  1.78  2.15  2.40  4.73  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  1.27  STDEV  1.94  SKEW -0.56  KURT  3.42
GRAPHIC (FOLK)  MEAN  1.10  STDEV  1.99  SKEW -0.43  KURT  2.96 INMAN SD 1.64 SK -0.02

H330
                DATA   13.75 4.10 2.32 1.44 1.39 1.62 2.60 2.35 2.78 3.72 1.87 1.04 0.55 0.72 0.47 0.14 0.13 6.77
   FREQUENCY PERCENT   28.8  8.6  4.9  3.0  2.9  3.4  5.4  4.9  5.8  7.8  3.9  2.2  1.2  1.5  1.0  0.3  0.3 14.2
  CUMULATIVE PERCENT   28.8 37.4 42.3 45.3 48.2 51.6 57.0 61.9 67.7 75.5 79.4 81.6 82.8 84.3 85.2 85.5 85.8100.0
PROPORTIONS: GRAVEL = 28.8% SAND = 57.0% SILT = 14.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -4.72 -3.28 -1.92 -1.24  1.13  2.23  3.20 15.98  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  0.75  STDEV  2.69  SKEW  0.31  KURT  2.06
GRAPHIC (FOLK)  MEAN  0.81  STDEV  4.20  SKEW  0.17  KURT  2.27 INMAN SD 2.56 SK -0.19

H331
                DATA    0.00 0.10 0.11 0.11 0.15 0.09 0.09 0.06 0.08 0.15 0.20 0.62 2.23 6.83 2.64 0.33 0.17 2.42
   FREQUENCY PERCENT    0.0  0.6  0.7  0.6  0.9  0.5  0.5  0.3  0.5  0.9  1.2  3.8 13.6 41.7 16.1  2.0  1.0 14.8
  CUMULATIVE PERCENT    0.0  0.6  1.3  2.0  2.9  3.4  3.9  4.3  4.8  5.7  6.9 10.7 24.3 66.0 82.2 84.2 85.2100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 85.2% SILT = 14.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.19  2.06  2.86  3.00  3.16  3.38  3.72  7.51  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  3.34  STDEV  1.03  SKEW  0.15  KURT  5.41
GRAPHIC (FOLK)  MEAN  3.25  STDEV  1.04  SKEW  0.46  KURT  5.98 INMAN SD 0.43 SK  0.32
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H338
                 DATA    0.00 0.01 0.01 0.01 0.01 0.01 0.01 0.00 0.01 0.01 0.02 0.10 0.45 3.75 5.69 1.95 1.14 1.64
  FREQUENCY PERCENT      0.0  0.1  0.1  0.1  0.1  0.0  0.0  0.0  0.1  0.1  0.1  0.7  3.1 25.3 38.4 13.1  7.7 11.1
 CUMULATIVE PERCENT      0.0  0.1  0.2  0.2  0.3  0.3  0.4  0.4  0.4  0.5  0.6  1.3  4.3 29.7 68.1 81.2 88.9100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 88.9% SILT = 11.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  2.66  3.01  3.15  3.22  3.38  3.62  3.83  4.31
MOMENT MEASURES MEAN  3.58  STDEV  0.74  SKEW  1.38  KURT  6.96
GRAPHIC (FOLK)  MEAN  3.46  STDEV  0.37  SKEW  0.38  KURT  1.32 INMAN SD 0.34 SK  0.32

H339
                 DATA    0.22 0.04 0.06 0.06 0.16 0.47 1.30 1.25 1.29 2.23 3.40 5.26 3.11 2.69 0.99 0.20 0.16 5.77
  FREQUENCY PERCENT      0.8  0.1  0.2  0.2  0.5  1.7  4.5  4.4  4.5  7.6 11.9 18.4 10.8  9.4  3.5  0.7  0.6 20.1
 CUMULATIVE PERCENT      0.8  0.9  1.1  1.3  1.9  3.5  8.0 12.4 16.9 24.7 36.6 54.9 65.8 75.2 78.6 79.3 79.9100.0
PROPORTIONS: GRAVEL =   0.8% SAND = 79.1% SILT = 20.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95) -0.25  1.35  1.95  2.26  2.68  3.25  5.99 14.24  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  3.03  STDEV  1.43  SKEW  0.31  KURT  3.94
GRAPHIC (FOLK)  MEAN  3.54  STDEV  2.96  SKEW  0.72  KURT  5.34 INMAN SD 2.02 SK  0.64

H340
                 DATA    1.68 0.58 0.47 0.30 0.33 0.31 0.59 0.76 1.52 3.57 4.92 5.74 2.87 1.71 0.43 0.08 0.05 1.79
  FREQUENCY PERCENT      6.1  2.1  1.7  1.1  1.2  1.1  2.1  2.7  5.5 12.9 17.8 20.7 10.4  6.2  1.6  0.3  0.2  6.5
 CUMULATIVE PERCENT      6.1  8.1  9.8 10.9 12.1 13.2 15.3 18.1 23.6 36.5 54.2 75.0 85.3 91.5 93.1 93.4 93.5100.0
PROPORTIONS: GRAVEL =   6.1% SAND = 87.5% SILT =  6.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95) -3.51 -1.31  1.56  2.03  2.44  2.75  2.96  6.26
MOMENT MEASURES MEAN  2.19  STDEV  1.61  SKEW -1.10  KURT  5.81
GRAPHIC (FOLK)  MEAN  2.32  STDEV  1.50  SKEW -0.12  KURT  4.30 INMAN SD 0.70 SK -0.25

H341
                 DATA    0.05 0.09 0.15 0.12 0.12 0.15 0.31 0.36 0.65 1.47 2.09 5.37 4.95 2.89 0.46 0.06 0.04 3.01
  FREQUENCY PERCENT      0.2  0.4  0.7  0.5  0.5  0.7  1.4  1.6  2.9  6.6  9.4 24.0 22.2 13.0  2.1  0.3  0.2 13.5
 CUMULATIVE PERCENT      0.2  0.6  1.3  1.8  2.4  3.0  4.4  6.0  9.0 15.5 24.9 48.9 71.1 84.0 86.1 86.4 86.5100.0
PROPORTIONS: GRAVEL =   0.2% SAND = 86.3% SILT = 13.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95) -0.20  1.60  2.26  2.50  2.76  3.07  3.25 20.83  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  2.96  STDEV  1.17  SKEW  0.01  KURT  5.31
GRAPHIC (FOLK)  MEAN  2.76  STDEV  3.16  SKEW  0.43  KURT 13.92 INMAN SD 0.49 SK -0.01

H342
                 DATA    0.00 0.05 0.04 0.05 0.11 0.22 0.52 0.66 1.23 2.86 2.47 1.70 1.30 2.43 1.01 0.19 0.12 3.30
  FREQUENCY PERCENT      0.0  0.2  0.2  0.3  0.6  1.2  2.8  3.6  6.7 15.7 13.5  9.3  7.1 13.3  5.5  1.0  0.7 18.1
 CUMULATIVE PERCENT      0.0  0.2  0.5  0.7  1.3  2.5  5.4  9.0 15.8 31.4 44.9 54.2 61.4 74.7 80.2 81.3 81.9100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 81.9% SILT = 18.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  0.75  1.47  2.00  2.16  2.64  3.26  4.82 11.36  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  3.00  STDEV  1.31  SKEW  0.86  KURT  2.98                      ***  SAMPLE    BIMODAL  ***
GRAPHIC (FOLK)  MEAN  3.16  STDEV  2.20  SKEW  0.66  KURT  3.67 INMAN SD 1.41 SK  0.55
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H343
                 DATA  0.00 0.04 0.04 0.06 0.12 0.08 0.06 0.04 0.07 0.14 0.23 0.63 1.44 5.04 2.83 0.45 0.20 1.28
   FREQUENCY PERCENT   0.0  0.3  0.3  0.5  1.0  0.6  0.5  0.3  0.5  1.1  1.8  4.9 11.3 39.6 22.2  3.5  1.6 10.0
  CUMULATIVE PERCENT   0.0  0.3  0.6  1.1  2.1  2.7  3.1  3.5  4.0  5.1  6.9 11.8 23.1 62.7 84.9 88.4 90.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 90.0% SILT = 10.0% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95)    0.39  2.23  2.86  3.01  3.17  3.37  3.49  5.08
MOMENT MEASURES MEAN   3.28  STDEV  0.92  SKEW  0.37  KURT  6.79
GRAPHIC (FOLK)  MEAN   3.17  STDEV  0.59  SKEW  0.17  KURT  3.25 INMAN SD 0.32 SK -0.01
H350
                 DATA  0.00 0.18 0.17 0.14 0.37 0.27 0.26 0.15 0.29 0.48 0.70 1.40 4.15 9.1713.91 4.56 2.3714.09
   FREQUENCY PERCENT   0.0  0.3  0.3  0.3  0.7  0.5  0.5  0.3  0.6  0.9  1.3  2.7  7.9 17.4 26.4  8.6  4.5 26.8
  CUMULATIVE PERCENT   0.0  0.3  0.7  0.9  1.6  2.1  2.6  2.9  3.5  4.4  5.7  8.4 16.3 33.7 60.1 68.7 73.2100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 73.2% SILT = 26.8% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95)    0.56  2.37  2.99  3.14  3.41  4.10  4.71  5.94
MOMENT MEASURES MEAN   3.77  STDEV  1.18  SKEW  0.04  KURT  3.38
GRAPHIC (FOLK)  MEAN   3.70  STDEV  0.97  SKEW  0.47  KURT  1.52 INMAN SD 0.86 SK  0.52
H351
                 DATA  0.01 0.08 0.06 0.04 0.08 0.07 0.08 0.06 0.11 0.44 2.11 7.12 3.34 1.41 0.22 0.03 0.02 1.91
   FREQUENCY PERCENT   0.1  0.4  0.3  0.3  0.5  0.4  0.4  0.3  0.6  2.6 12.3 41.4 19.4  8.2  1.3  0.2  0.1 11.1
  CUMULATIVE PERCENT   0.1  0.5  0.8  1.1  1.6  2.0  2.4  2.7  3.4  5.9 18.2 59.7 79.1 87.3 88.6 88.8 88.9100.0
PROPORTIONS: GRAVEL =   0.1% SAND = 88.8% SILT = 11.1% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95)    0.36  2.17  2.47  2.55  2.70  2.94  3.14 22.22  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   2.94  STDEV  1.01  SKEW  1.19  KURT  6.52
GRAPHIC (FOLK)  MEAN   2.77  STDEV  3.21  SKEW  0.63  KURT 21.08 INMAN SD 0.34 SK  0.31
H352
                 DATA  0.00 0.00 0.01 0.00 0.02 0.08 0.31 0.56 1.46 4.45 4.26 2.61 0.82 0.44 0.11 0.01 0.01 0.67
   FREQUENCY PERCENT   0.0  0.0  0.1  0.0  0.1  0.5  2.0  3.5  9.2 28.1 26.9 16.5  5.2  2.8  0.7  0.1  0.0  4.3
  CUMULATIVE PERCENT   0.0  0.0  0.1  0.1  0.2  0.7  2.7  6.3 15.5 43.6 70.5 87.0 92.2 94.9 95.6 95.7 95.7100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 95.7% SILT =  4.3% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95)    1.30  1.68  2.01  2.10  2.31  2.56  2.69  3.27
MOMENT MEASURES MEAN   2.43  STDEV  0.75  SKEW  2.76  KURT 12.57
GRAPHIC (FOLK)  MEAN   2.34  STDEV  0.41  SKEW  0.17  KURT  1.42 INMAN SD 0.34 SK  0.12
H353
                 DATA  0.00 0.08 0.11 0.09 0.09 0.12 0.23 0.28 0.57 1.52 2.29 3.43 2.60 2.86 1.08 0.21 0.13 1.97
   FREQUENCY PERCENT   0.0  0.5  0.6  0.5  0.5  0.7  1.3  1.6  3.3  8.6 12.9 19.4 14.7 16.2  6.1  1.2  0.7 11.2
  CUMULATIVE PERCENT   0.0  0.5  1.1  1.6  2.1  2.8  4.1  5.6  8.9 17.5 30.5 49.9 64.6 80.8 86.9 88.1 88.8100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 88.8% SILT = 11.2% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95)   -0.04  1.66  2.21  2.40  2.75  3.15  3.37  6.84
MOMENT MEASURES MEAN   2.93  STDEV  1.09  SKEW  0.84  KURT  4.99
GRAPHIC (FOLK)  MEAN   2.78  STDEV  1.08  SKEW  0.33  KURT  2.84 INMAN SD 0.58 SK  0.07*** SAMPLE     BIMODAL  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H354
                DATA    0.00 0.07 0.12 0.08 0.09 0.09 0.17 0.24 0.53 1.40 2.03 2.86 2.12 1.82 0.66 0.12 0.07 1.26
  FREQUENCY PERCENT     0.0  0.5  0.9  0.6  0.7  0.6  1.2  1.7  3.9 10.2 14.8 20.9 15.5 13.3  4.8  0.8  0.5  9.2
 CUMULATIVE PERCENT     0.0  0.5  1.4  2.0  2.6  3.3  4.5  6.2 10.1 20.4 35.1 56.0 71.4 84.7 89.5 90.3 90.8100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 90.8% SILT =  9.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.17  1.58  2.16  2.34  2.68  3.06  3.23  6.79
MOMENT MEASURES MEAN  2.82  STDEV  1.05  SKEW  0.85  KURT  5.72
GRAPHIC (FOLK)  MEAN  2.69  STDEV  1.06  SKEW  0.30  KURT  2.96 INMAN SD 0.54 SK  0.03

H355
                DATA    0.00 0.00 0.00 0.00 0.00 0.01 0.01 0.00 0.01 0.01 0.02 0.04 0.07 0.66 4.09 2.73 2.19 3.44
  FREQUENCY PERCENT     0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.3  0.5  5.0 30.9 20.6 16.5 25.9
 CUMULATIVE PERCENT     0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.2  0.2  0.3  0.4  0.7  1.2  6.2 37.0 57.6 74.1100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 74.1% SILT = 25.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.91  3.21  3.36  3.43  3.66  4.02  4.19  4.55
MOMENT MEASURES MEAN  4.04  STDEV  0.90  SKEW  0.82  KURT  2.31
GRAPHIC (FOLK)  MEAN  3.74  STDEV  0.41  SKEW  0.31  KURT  0.93 INMAN SD 0.41 SK  0.29

H356
                DATA    0.00 0.01 0.00 0.00 0.01 0.00 0.00 0.00 0.00 0.01 0.01 0.14 1.00 6.3922.66 9.67 4.72 2.16
  FREQUENCY PERCENT     0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.3  3.4 13.5 47.8 20.4 10.0  4.6
 CUMULATIVE PERCENT     0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.4  3.8 17.2 65.1 85.5 95.4100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 95.4% SILT =  4.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.85  3.04  3.24  3.30  3.43  3.61  3.73  3.98
MOMENT MEASURES MEAN  3.52  STDEV  0.50  SKEW  2.64  KURT 12.77
GRAPHIC (FOLK)  MEAN  3.46  STDEV  0.27  SKEW  0.20  KURT  1.28 INMAN SD 0.25 SK  0.22

H362
                DATA    0.00 0.20 0.30 0.37 0.78 0.42 0.47 0.29 0.43 0.78 1.21 3.9710.3410.83 8.74 1.91 1.18 2.80
  FREQUENCY PERCENT     0.0  0.4  0.7  0.8  1.7  0.9  1.0  0.7  1.0  1.7  2.7  8.8 23.0 24.0 19.4  4.2  2.6  6.2
 CUMULATIVE PERCENT     0.0  0.4  1.1  1.9  3.7  4.6  5.7  6.3  7.3  9.0 11.7 20.5 43.5 67.5 86.9 91.2 93.8100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 93.8% SILT =  6.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.06  1.35  2.63  2.81  3.07  3.33  3.45  4.14
MOMENT MEASURES MEAN  3.06  STDEV  0.93  SKEW -0.16  KURT  7.09
GRAPHIC (FOLK)  MEAN  3.05  STDEV  0.63  SKEW -0.14  KURT  2.18 INMAN SD 0.41 SK -0.06

H371
                DATA    0.00 0.02 0.03 0.03 0.12 0.44 1.22 1.49 2.37 3.80 1.85 0.62 0.21 0.11 0.08 0.11 0.23 0.79
  FREQUENCY PERCENT     0.0  0.1  0.2  0.2  0.9  3.3  9.0 11.0 17.6 28.2 13.7  4.6  1.5  0.8  0.6  0.8  1.7  5.8
 CUMULATIVE PERCENT     0.0  0.1  0.3  0.5  1.4  4.7 13.7 24.7 42.2 70.4 84.1 88.7 90.3 91.0 91.6 92.5 94.2100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 94.2% SILT =  5.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.83  1.26  1.56  1.76  2.07  2.32  2.50  4.14
MOMENT MEASURES MEAN  2.23  STDEV  0.97  SKEW  2.13  KURT  8.24
GRAPHIC (FOLK)  MEAN  2.04  STDEV  0.67  SKEW  0.18  KURT  2.07 INMAN SD 0.47 SK -0.08
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H372
                DATA    0.00 0.06 0.07 0.06 0.11 0.27 0.64 0.74 1.33 3.01 2.94 2.81 1.75 2.13 0.79 0.22 0.24 3.91
   FREQUENCY PERCENT    0.0  0.3  0.3  0.3  0.5  1.3  3.0  3.5  6.3 14.3 13.9 13.4  8.3 10.1  3.8  1.0  1.1 18.5
  CUMULATIVE PERCENT    0.0  0.3  0.6  0.9  1.2  2.7  5.7  9.2 15.5 29.8 43.8 57.1 65.4 75.5 79.3 80.3 81.5100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 81.5% SILT = 18.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    0.61   1.45   2.01   2.17   2.62   3.24   4.59   8.46   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   3.00   STDEV   1.33   SKEW   0.65   KURT   2.98                           ***  SAMPLE      BIMODAL   ***
GRAPHIC (FOLK)  MEAN   3.07   STDEV   1.71   SKEW   0.00   KURT   2.71 INMAN SD 1.29 SK  0.53
H373
                DATA    0.00 0.16 0.09 0.07 0.45 1.38 2.40 2.17 2.28 2.30 0.96 0.48 0.21 0.26 0.13 0.03 0.02 0.38
   FREQUENCY PERCENT    0.0  1.2  0.6  0.5  3.2 10.0 17.4 15.8 16.5 16.7  7.0  3.5  1.5  1.9  1.0  0.2  0.2  2.7
  CUMULATIVE PERCENT    0.0  1.2  1.8  2.3  5.6 15.6 33.0 48.8 65.3 82.1 89.1 92.5 94.0 95.9 96.9 97.1 97.3100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 97.3% SILT =  2.7% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   -0.67   0.93   1.26   1.40   1.77   2.13   2.31   3.12
MOMENT MEASURES MEAN   1.85   STDEV   0.67   SKEW   1.06   KURT  10.11                          ***  SAMPLE      BIMODAL   ***
GRAPHIC (FOLK)  MEAN   1.76   STDEV   0.59   SKEW   0.13   KURT   1.22 INMAN SD 0.53 SK  0.03
H374
                DATA    0.10 0.21 0.14 0.16 0.41 0.66 1.09 1.09 1.75 3.70 3.41 2.07 0.65 0.67 0.48 0.14 0.06 1.68
   FREQUENCY PERCENT    0.5  1.1  0.8  0.8  2.2  3.5  5.9  5.9  9.5 20.0 18.5 11.2  3.5  3.6  2.6  0.7  0.3  9.1
  CUMULATIVE PERCENT    0.5  1.6  2.4  3.2  5.5  9.0 15.0 20.9 30.4 50.4 68.9 80.1 83.6 87.2 89.8 90.6 90.9100.0
PROPORTIONS: GRAVEL =   0.5% SAND = 90.4% SILT =  9.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   -0.73   0.91   1.55   1.86   2.25   2.63   3.02   7.90   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   2.39   STDEV   1.24   SKEW   0.70   KURT   5.75
GRAPHIC (FOLK)  MEAN   2.27   STDEV   1.43   SKEW   0.34   KURT   3.75 INMAN SD 0.74 SK  0.06
H376
                DATA    2.55 0.39 0.16 0.10 0.09 0.06 0.06 0.05 0.16 0.35 0.96 1.97 1.46 1.71 0.48 0.07 0.05 2.65
   FREQUENCY PERCENT   19.2  2.9  1.2  0.7  0.7  0.5  0.5  0.4  1.2  2.6  7.2 14.8 10.9 12.8  3.6  0.5  0.4 19.9
  CUMULATIVE PERCENT   19.2 22.1 23.3 24.0 24.7 25.2 25.7 26.0 27.2 29.8 37.1 51.8 62.6 75.6 79.2 79.8 80.1100.0
PROPORTIONS: GRAVEL =  19.2% SAND = 60.9% SILT = 19.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   -8.10  -4.77  -1.60   1.16   2.72   3.24   6.96  19.89   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   2.12   STDEV   2.65   SKEW  -0.64   KURT   2.35                           ***  SAMPLE      BIMODAL   ***
GRAPHIC (FOLK)  MEAN   2.69   STDEV   5.08   SKEW   0.19   KURT   4.87 INMAN SD 4.28 SK -0.01
H377
                DATA    0.00 0.01 0.04 0.03 0.07 0.05 0.06 0.03 0.06 0.18 0.67 1.88 2.02 2.70 1.26 0.25 0.16 3.82
   FREQUENCY PERCENT    0.0  0.1  0.3  0.2  0.5  0.4  0.4  0.3  0.5  1.3  5.0 14.2 15.2 20.3  9.5  1.8  1.2 28.8
  CUMULATIVE PERCENT    0.0  0.1  0.4  0.6  1.1  1.5  1.9  2.2  2.6  4.0  9.0 23.2 38.4 58.7 68.2 70.1 71.2100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 71.2% SILT = 28.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    0.94   2.32   2.64   2.78   3.14   4.84   7.20  11.99   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   3.63   STDEV   1.26   SKEW   0.44   KURT   2.29
GRAPHIC (FOLK)  MEAN   4.33   STDEV   2.00   SKEW   0.80   KURT   1.93 INMAN SD 2.28 SK  0.78
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H378
               DATA    0.23 0.37 0.42 0.50 0.86 0.50 0.35 0.21 0.25 0.40 0.45 0.62 0.62 1.34 1.52 0.57 0.51 6.91
  FREQUENCY PERCENT    1.6  3.4  2.5  2.9  5.1  3.0  2.1  1.3  1.5  2.4  2.6  3.7  3.7  7.9  9.0  3.4  3.0 41.0
 CUMULATIVE PERCENT    1.6  5.0  7.5 10.4 15.5 18.5 20.6 21.9 23.3 25.7 28.4 32.0 35.7 43.6 52.6 56.0 59.0100.0
PROPORTIONS: GRAVEL =   1.6% SAND = 57.4% SILT = 41.0% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -1.19 -0.50  1.04  2.18  3.43  5.45  6.49  8.61  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   3.44  STDEV  2.09  SKEW -0.70  KURT  2.63
GRAPHIC (FOLK)  MEAN   3.65  STDEV  2.74  SKEW  0.13  KURT  1.14 INMAN SD 2.72 SK  0.12***  INSUFFICIENT  DATA  ***

H379
               DATA    0.00 0.06 0.05 0.04 0.10 0.07 0.05 0.04 0.05 0.10 0.12 0.24 0.67 2.01 1.39 0.29 0.22 4.47
  FREQUENCY PERCENT    0.0  0.6  0.5  0.4  1.0  0.7  0.5  0.4  0.5  1.0  1.2  2.4  6.7 20.2 14.0  2.9  2.2 44.9
 CUMULATIVE PERCENT    0.0  0.6  1.1  1.5  2.4  3.1  3.6  4.0  4.5  5.4  6.6  9.1 15.8 36.0 50.0 52.9 55.1100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 55.1% SILT = 44.9% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.05  2.14  3.00  3.13  3.50  6.51  7.98 10.97  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   4.10  STDEV  1.39  SKEW -0.53  KURT  2.86
GRAPHIC (FOLK)  MEAN   4.83  STDEV  2.58  SKEW  0.75  KURT  1.07 INMAN SD 2.49 SK  0.60***  INSUFFICIENT  DATA  ***

H380
               DATA    0.00 0.05 0.04 0.05 0.08 0.06 0.05 0.04 0.07 0.13 0.20 0.59 1.29 3.13 1.33 0.22 0.14 4.78
  FREQUENCY PERCENT    0.0  0.4  0.3  0.4  0.6  0.5  0.4  0.3  0.5  1.0  1.6  4.8 10.5 25.6 10.8  1.8  1.1 39.1
 CUMULATIVE PERCENT    0.0  0.4  0.7  1.1  1.8  2.2  2.6  3.0  3.5  4.5  6.2 11.0 21.5 47.1 57.9 59.8 60.9100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 60.9% SILT = 39.1% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.39  2.33  2.86  3.04  3.32  7.48 10.27 15.95  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   3.95  STDEV  1.34  SKEW -0.15  KURT  2.43
GRAPHIC (FOLK)  MEAN   5.49  STDEV  3.91  SKEW  0.87  KURT  1.26 INMAN SD 3.70 SK  0.88

H381
               DATA    0.03 0.04 0.04 0.04 0.25 0.75 1.17 1.03 1.64 4.21 4.10 2.80 1.29 1.35 0.54 0.08 0.03 0.56
  FREQUENCY PERCENT    0.2  0.2  0.2  0.2  1.3  3.8  5.9  5.2  8.2 21.1 20.6 14.1  6.5  6.8  2.7  0.4  0.1  2.8
 CUMULATIVE PERCENT    0.2  0.4  0.6  0.8  2.1  5.8 11.7 16.8 25.1 46.2 66.7 80.8 87.2 94.0 96.7 97.1 97.2100.0
PROPORTIONS: GRAVEL =   0.2% SAND = 97.0% SILT =  2.8% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.62  1.21  1.71  2.00  2.30  2.64  2.87  3.33
MOMENT MEASURES MEAN   2.33  STDEV  0.62  SKEW -0.89  KURT  9.78
GRAPHIC (FOLK)  MEAN   2.29  STDEV  0.61  SKEW -0.02  KURT  1.36 INMAN SD 0.58 SK -0.01

H382
               DATA    0.00 0.25 0.28 0.41 0.77 0.87 1.47 1.50 1.91 2.41 1.15 0.63 0.37 0.92 0.51 0.10 0.03 0.84
  FREQUENCY PERCENT    0.0  1.7  2.0  2.9  5.3  6.0 10.2 10.4 13.2 16.7  8.0  4.3  2.6  6.4  3.5  0.7  0.2  5.8
 CUMULATIVE PERCENT    0.0  1.7  3.7  6.6 11.9 17.9 28.1 38.5 51.7 68.4 76.4 80.8 83.3 89.7 93.2 94.0 94.2100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 94.2% SILT =  5.8% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.83  0.25  1.18  1.43  1.97  2.45  3.02  5.07
MOMENT MEASURES MEAN   2.06  STDEV  1.20  SKEW  0.92  KURT  5.12                    ***  SAMPLE     BIMODAL  ***
GRAPHIC (FOLK)  MEAN   2.06  STDEV  1.19  SKEW  0.22  KURT  1.93 INMAN SD 0.92 SK  0.14
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CLASS MIDPOINTS-PHI  -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI   -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H383
                 DATA   0.15 0.19 0.16 0.19 0.59 0.10 0.03 0.84 2.37 2.56 0.96 0.29 0.17 0.33 0.16 0.03 0.02 0.31
  FREQUENCY PERCENT     1.5  2.0  1.7  2.0  6.3  1.1  0.3  8.9 25.1 27.1 10.2  3.1  1.8  3.5  1.7  0.3  0.2  3.2
  CUMULATIVE PERCENT    1.5  3.5  5.2  7.2 13.4 14.5 14.9 23.8 48.9 76.0 86.1 89.2 91.0 94.6 96.2 96.6 96.8100.0
PROPORTIONS: GRAVEL =   1.5% SAND = 95.2% SILT =   3.2% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -1.24 -0.04  1.54  1.76  2.01  2.24  2.44  3.31
MOMENT MEASURES MEAN   1.94  STDEV  1.12  SKEW -0.35  KURT  8.27                        *** SAMPLE  POLYMODAL  ***
GRAPHIC (FOLK)  MEAN   2.00  STDEV  0.73  SKEW -0.14  KURT  2.89 INMAN SD 0.45 SK -0.05

H384
                 DATA   1.23 0.55 0.56 0.59 1.46 2.38 3.93 3.76 4.37 3.97 1.39 0.67 0.25 0.24 0.09 0.03 0.02 0.46
  FREQUENCY PERCENT     4.7  2.1  2.1  2.3  5.6  9.2 15.1 14.5 16.8 15.3  5.4  2.6  1.0  0.9  0.4  0.1  0.1  1.8
  CUMULATIVE PERCENT    4.7  6.9  9.0 11.3 16.9 26.1 41.2 55.7 72.6 87.9 93.2 95.8 96.8 97.7 98.0 98.1 98.2100.0
PROPORTIONS: GRAVEL =   4.7% SAND = 93.5% SILT =   1.8% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -2.77 -0.93  0.93  1.22  1.65  2.03  2.17  2.66
MOMENT MEASURES MEAN   1.46  STDEV  1.23  SKEW -1.03  KURT  7.57
GRAPHIC (FOLK)  MEAN   1.58  STDEV  0.86  SKEW -0.30  KURT  1.82 INMAN SD 0.62 SK -0.16

H385
                 DATA  60.62 1.39 0.77 0.69 0.84 0.43 0.29 0.15 0.14 0.21 0.11 0.09 0.09 0.12 0.16 0.19 0.52 2.78
  FREQUENCY PERCENT    87.1  2.0  1.1  1.0  1.2  0.6  0.4  0.2  0.2  0.3  0.2  0.1  0.1  0.2  0.2  0.3  0.7  4.0
  CUMULATIVE PERCENT   87.1 89.1 90.2 91.2 92.4 93.0 93.5 93.7 93.9 94.2 94.3 94.5 94.6 94.8 95.0 95.3 96.0100.0
PROPORTIONS: GRAVEL =  87.1% SAND =  8.9% SILT =   4.0% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95) -18.15-14.77-11.54 -9.96 -6.61 -3.27 -1.68  3.51  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  -1.88  STDEV  1.65  SKEW  3.12  KURT 11.72
GRAPHIC (FOLK)  MEAN  -6.61  STDEV  5.24  SKEW  0.05  KURT  1.12 INMAN SD 4.93 SK -0.00

H386
                 DATA  52.72 1.44 1.22 1.23 1.77 1.55 1.94 1.66 1.58 2.03 1.27 0.99 0.44 0.29 0.38 0.36 0.41 3.40
  FREQUENCY PERCENT    70.6  1.9  1.6  1.6  2.4  2.1  2.6  2.2  2.1  2.7  1.7  1.3  0.6  0.4  0.5  0.5  0.6  4.5
  CUMULATIVE PERCENT   70.6 72.5 74.1 75.8 78.2 80.2 82.8 85.1 87.2 89.9 91.6 92.9 93.5 93.9 94.4 94.9 95.5100.0
PROPORTIONS: GRAVEL =  70.6% SAND = 24.9% SILT =   4.5% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95) -26.29-20.28-14.54-11.72 -5.76  0.26  1.63  3.79  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  -1.16  STDEV  2.30  SKEW -1.52  KURT  4.17
GRAPHIC (FOLK)  MEAN  -6.23  STDEV  7.69  SKEW -0.14  KURT  0.82 INMAN SD 8.09 SK -0.08

H392
                 DATA   0.00 0.01 0.02 0.02 0.05 0.10 0.21 0.18 0.23 0.44 0.67 0.66 0.37 0.36 0.32 0.35 0.7315.51
  FREQUENCY PERCENT     0.0  0.1  0.1  0.1  0.2  0.5  1.0  0.9  1.1  2.2  3.3  3.3  1.8  1.8  1.6  1.7  3.6 76.7
  CUMULATIVE PERCENT    0.0  0.1  0.2  0.3  0.5  1.0  2.0  2.9  4.0  6.2  9.5 12.8 14.6 16.3 17.9 19.7 23.3100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 23.3% SILT =  76.7% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.25  2.12  3.20  4.11  5.47  6.83  7.48  8.79  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   4.85  STDEV  1.25  SKEW -1.65  KURT  4.38
GRAPHIC (FOLK)  MEAN   5.39  STDEV  2.08  SKEW -0.03  KURT  1.00 INMAN SD 2.14 SK -0.06***  INSUFFICIENT  DATA  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H395
                 DATA   3.21 1.72 1.15 0.74 0.79 1.00 2.21 3.54 6.01 8.33 3.54 1.50 0.50 0.27 0.09 0.02 0.01 2.03
  FREQUENCY PERCENT     8.7  4.7  3.1  2.0  2.2  2.7  6.0  9.6 16.4 22.7  9.7  4.1  1.4  0.7  0.2  0.1  0.0  5.5
 CUMULATIVE PERCENT     8.7 13.5 16.6 18.6 20.7 23.5 29.5 39.1 55.5 78.3 87.9 92.0 93.4 94.1 94.4 94.4 94.5100.0
PROPORTIONS: GRAVEL =  8.7% SAND = 85.7% SILT =  5.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -2.93 -1.57 -0.09  1.32  1.92  2.21  2.39  7.68  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   1.54   STDEV  1.72  SKEW -0.56  KURT  4.42
GRAPHIC (FOLK)  MEAN   1.41   STDEV  2.02  SKEW -0.19  KURT  4.25 INMAN SD 1.24 SK -0.62

H402
                 DATA   0.12 0.15 0.15 0.16 0.23 0.47 1.42 2.08 3.74 4.15 1.43 0.54 0.23 0.14 0.06 0.05 0.03 5.59
  FREQUENCY PERCENT     0.6  0.7  0.7  0.8  1.1  2.3  6.8 10.0 18.0 20.0  6.9  2.6  1.1  0.7  0.3  0.2  0.2 26.9
 CUMULATIVE PERCENT     0.6  1.3  2.0  2.8  3.9  6.2 13.0 23.1 41.1 61.1 68.0 70.6 71.7 72.4 72.7 72.9 73.1100.0
PROPORTIONS: GRAVEL =  0.6% SAND = 72.5% SILT = 26.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.68  1.13  1.58  1.78  2.11  7.19 24.34 59.19  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   2.82   STDEV  1.73  SKEW  0.54  KURT  2.44
GRAPHIC (FOLK)  MEAN   9.34   STDEV 14.49  SKEW  0.96  KURT  4.40 INMAN SD **** SK  0.95

H405
                 DATA   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.02 0.04 0.03 0.09 0.56 1.30 2.7125.20
  FREQUENCY PERCENT     0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.3  1.9  4.4  9.0 84.1
 CUMULATIVE PERCENT     0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.2  0.3  0.6  2.5  6.8 15.9100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 15.9% SILT = 84.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   3.33  3.67  4.00  4.17  4.51  4.86  5.02  5.35
MOMENT MEASURES MEAN   5.22   STDEV  0.86  SKEW -1.97  KURT  5.16
GRAPHIC (FOLK)  MEAN   4.51   STDEV  0.51  SKEW -0.00  KURT  1.00 INMAN SD 0.51 SK  0.00***  INSUFFICIENT  DATA  ***

H407
                 DATA   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.04 0.06 0.08 0.05 0.04 0.04 0.10 0.67 1.19 1.9818.69
  FREQUENCY PERCENT     0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.2  0.2  0.3  0.2  0.2  0.2  0.4  2.9  5.2  8.6 81.6
 CUMULATIVE PERCENT     0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.2  0.4  0.7  1.0  1.1  1.3  1.7  4.6  9.8 18.4100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 18.4% SILT = 81.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.56  3.52  3.94  4.14  4.57  5.00  5.20  5.61
MOMENT MEASURES MEAN   5.15   STDEV  0.76  SKEW -1.94  KURT  5.68
GRAPHIC (FOLK)  MEAN   4.57   STDEV  0.63  SKEW -0.00  KURT  1.00 INMAN SD 0.63 SK  0.00***  INSUFFICIENT  DATA  ***

H414
                 DATA   0.07 0.30 0.24 0.16 0.14 0.17 0.45 0.65 1.14 1.30 0.34 0.11 0.05 0.19 0.84 0.95 0.93 8.31
  FREQUENCY PERCENT     0.4  1.8  1.5  1.0  0.9  1.1  2.7  4.0  7.0  7.9  2.1  0.6  0.3  1.1  5.2  5.8  5.7 50.9
 CUMULATIVE PERCENT     0.4  2.3  3.7  4.7  5.6  6.6  9.4 13.3 20.3 28.2 30.3 31.0 31.3 32.4 37.6 43.4 49.1100.0
PROPORTIONS: GRAVEL =  0.4% SAND = 48.7% SILT = 50.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.76  0.69  1.85  2.15  4.04  5.22  5.77  6.91
MOMENT MEASURES MEAN   3.91   STDEV  1.85  SKEW -0.80  KURT  2.66
GRAPHIC (FOLK)  MEAN   3.89   STDEV  1.92  SKEW -0.10  KURT  0.83 INMAN SD 1.96 SK -0.12***  INSUFFICIENT  DATA  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H415
                DATA    0.00 0.13 0.08 0.07 0.06 0.03 0.04 0.03 0.03 0.06 0.31 3.8013.7812.24 9.18 2.33 1.48 4.40
   FREQUENCY PERCENT    0.0  0.3  0.2  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.6  7.9 28.7 25.5 19.1  4.8  3.1  9.2
  CUMULATIVE PERCENT    0.0  0.3  0.4  0.6  0.7  0.8  0.9  0.9  1.0  1.1  1.8  9.7 38.3 63.8 82.9 87.8 90.8100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 90.8% SILT =  9.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.02  2.64  2.83  2.91  3.11  3.38  3.55  4.47
MOMENT MEASURES MEAN  3.29  STDEV  0.81  SKEW  1.14  KURT  7.83
GRAPHIC (FOLK)  MEAN  3.16  STDEV  0.46  SKEW  0.34  KURT  1.56 INMAN SD 0.36 SK  0.21

H416
                DATA    0.00 0.12 0.09 0.08 0.09 0.15 0.38 0.37 0.65 1.46 0.70 0.26 0.12 0.19 0.47 0.52 0.62 8.03
   FREQUENCY PERCENT    0.0  0.9  0.6  0.6  0.6  1.1  2.6  2.6  4.6 10.2  4.9  1.8  0.8  1.3  3.3  3.7  4.3 56.2
  CUMULATIVE PERCENT    0.0  0.9  1.5  2.1  2.7  3.7  6.4  9.0 13.5 23.7 28.6 30.5 31.3 32.6 35.9 39.5 43.8100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 43.8% SILT = 56.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.37  1.38  2.07  2.32  4.35  5.88  6.61  8.08  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  4.12  STDEV  1.70  SKEW -0.72  KURT  2.15
GRAPHIC (FOLK)  MEAN  4.34  STDEV  2.15  SKEW  0.05  KURT  0.77 INMAN SD 2.27 SK -0.01***  INSUFFICIENT  DATA  ***

H421
                DATA    0.37 0.43 0.22 0.15 0.23 0.39 0.99 1.19 2.26 5.45 4.52 2.25 0.50 0.24 0.08 0.02 0.01 0.94
   FREQUENCY PERCENT    1.8  2.1  1.1  0.8  1.1  1.9  4.9  5.9 11.2 27.0 22.3 11.1  2.5  1.2  0.4  0.1  0.0  4.6
  CUMULATIVE PERCENT    1.8  4.0  5.0  5.8  6.9  8.8 13.7 19.6 30.8 57.8 80.1 91.2 93.7 94.9 95.2 95.3 95.4100.0
PROPORTIONS: GRAVEL =   1.8% SAND = 93.5% SILT =  4.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -1.36 -0.02  1.60  1.88  2.18  2.43  2.57  3.34
MOMENT MEASURES MEAN  2.12  STDEV  1.16  SKEW -0.46  KURT  9.00
GRAPHIC (FOLK)  MEAN  2.12  STDEV  0.75  SKEW -0.25  KURT  2.47 INMAN SD 0.48 SK -0.19

H422
                DATA    0.68 0.34 0.38 0.33 0.45 0.36 0.64 0.86 1.73 3.77 2.45 0.89 0.25 0.25 0.11 0.03 0.02 1.13
   FREQUENCY PERCENT    4.6  2.3  2.6  2.3  3.1  2.5  4.4  5.9 11.8 25.7 16.7  6.1  1.7  1.7  0.7  0.2  0.1  7.7
  CUMULATIVE PERCENT    4.6  7.0  9.5 11.8 14.9 17.4 21.7 27.6 39.4 65.1 81.8 87.8 89.5 91.2 92.0 92.2 92.3100.0
PROPORTIONS: GRAVEL =   4.6% SAND = 87.6% SILT =  7.7% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -2.61 -0.91  1.12  1.64  2.10  2.39  2.58 10.95  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  1.96  STDEV  1.57  SKEW -0.39  KURT  5.40
GRAPHIC (FOLK)  MEAN  1.93  STDEV  2.16  SKEW  0.07  KURT  6.52 INMAN SD 0.73 SK -0.34

H423
                DATA    0.09 0.10 0.19 0.19 0.36 0.60 1.48 2.28 3.53 4.08 1.33 0.51 0.20 0.16 0.06 0.01 0.01 0.50
   FREQUENCY PERCENT    0.6  0.7  1.2  1.2  2.3  3.8  9.5 14.6 22.5 26.0  8.5  3.2  1.3  1.0  0.4  0.1  0.0  3.2
  CUMULATIVE PERCENT    0.6  1.2  2.4  3.6  5.9  9.7 19.2 33.8 56.3 82.3 90.9 94.1 95.3 96.3 96.7 96.8 96.8100.0
PROPORTIONS: GRAVEL =   0.6% SAND = 96.3% SILT =  3.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.63  0.82  1.43  1.61  1.93  2.17  2.29  2.93
MOMENT MEASURES MEAN  1.93  STDEV  0.91  SKEW  0.85  KURT 11.77
GRAPHIC (FOLK)  MEAN  1.88  STDEV  0.54  SKEW -0.11  KURT  1.54 INMAN SD 0.43 SK -0.17
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H424
                   DATA    2.01 0.77 0.75 0.77 0.85 0.68 0.37 0.82 0.99 1.14 0.52 0.43 0.54 1.22 0.59 0.13 0.08 2.50
  FREQUENCY PERCENT  12.8  4.9  4.8  4.9  5.6  4.3  5.6  5.2  6.3  7.3  3.3  2.8  3.4  7.8  3.8  0.8  0.5 16.0
 CUMULATIVE PERCENT  12.8 17.8 22.6 27.4 33.0 37.4 42.9 48.1 54.4 61.7 65.0 67.7 71.2 78.9 82.7 83.5 84.0100.0
PROPORTIONS: GRAVEL =  12.8% SAND = 71.2% SILT = 16.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -3.85 -2.22 -0.67  0.26  1.82  3.12  3.99 11.53  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  1.71  STDEV  2.38  SKEW -0.12  KURT  2.42
GRAPHIC (FOLK)  MEAN  1.72  STDEV  3.25  SKEW  0.17  KURT  1.97 INMAN SD 2.33 SK -0.07

H425
                   DATA    0.03 0.14 0.18 0.20 0.30 0.22 0.22 0.19 0.44 1.54 2.24 2.87 1.88 2.51 1.01 0.16 0.07 0.49
  FREQUENCY PERCENT   0.2  0.9  1.2  1.4  2.1  1.5  1.5  1.3  3.0 10.5 15.3 19.5 12.8 17.1  6.8  1.1  0.5  3.3
 CUMULATIVE PERCENT   0.2  1.1  2.4  3.7  5.8  7.3  8.8 10.1 13.0 23.5 38.8 58.3 71.2 88.3 95.1 96.2 96.7100.0
PROPORTIONS: GRAVEL =   0.2% SAND = 96.5% SILT =  3.3% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.54  0.83  2.08  2.28  2.64  3.05  3.17  3.49
MOMENT MEASURES MEAN  2.59  STDEV  0.95  SKEW -0.45  KURT  7.76              *** SAMPLE     BIMODAL  ***
GRAPHIC (FOLK)  MEAN  2.63  STDEV  0.63  SKEW -0.20  KURT  1.42 INMAN SD 0.55 SK -0.03

H427
                   DATA    0.00 0.02 0.06 0.06 0.12 0.07 0.07 0.05 0.09 0.15 0.18 0.43 0.95 2.64 2.17 0.64 0.45 1.51
  FREQUENCY PERCENT   0.0  0.2  0.6  0.7  1.2  0.8  0.7  0.5  0.9  1.5  1.9  4.5  9.8 27.3 22.4  6.6  4.7 15.6
 CUMULATIVE PERCENT   0.0  0.2  0.8  1.5  2.7  3.5  4.2  4.7  5.6  7.2  9.0 13.5 23.4 50.6 73.1 79.7 84.4100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 84.4% SILT = 15.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.16  1.83  2.82  3.02  3.24  3.57  3.98  4.89
MOMENT MEASURES MEAN  3.42  STDEV  1.10  SKEW  0.14  KURT  4.54
GRAPHIC (FOLK)  MEAN  3.35  STDEV  0.75  SKEW  0.17  KURT  2.28 INMAN SD 0.58 SK  0.27

H428
                   DATA    0.30 0.20 0.19 0.30 0.45 0.42 0.93 1.40 2.56 3.68 1.38 0.43 0.38 0.64 0.40 0.08 0.05 0.74
  FREQUENCY PERCENT   2.0  1.4  1.3  2.0  3.1  2.9  6.4  9.6 17.6 25.3  9.5  2.9  2.6  4.4  2.7  0.6  0.4  5.1
 CUMULATIVE PERCENT   2.0  3.4  4.8  6.8  9.9 12.8 19.2 28.8 46.4 71.6 81.3 84.2 86.8 91.3 94.0 94.6 94.9100.0
PROPORTIONS: GRAVEL =   2.0% SAND = 92.9% SILT =  5.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -1.63  0.07  1.30  1.66  2.03  2.33  2.73  4.06
MOMENT MEASURES MEAN  2.03  STDEV  1.25  SKEW -0.14  KURT  7.24
GRAPHIC (FOLK)  MEAN  2.05  STDEV  0.94  SKEW  0.03  KURT  2.43 INMAN SD 0.67 SK  0.04

H429
                   DATA    0.19 0.19 0.28 0.18 0.22 0.17 0.79 1.63 3.29 6.04 2.30 0.62 0.19 0.13 0.04 0.01 0.00 0.39
  FREQUENCY PERCENT   1.2  1.1  1.6  1.1  1.3  1.0  4.7  9.8 19.6 36.1 14.1  3.7  1.2  0.8  0.3  0.0  0.0  2.4
 CUMULATIVE PERCENT   1.2  2.3  3.9  5.0  6.3  7.3 12.1 21.8 41.5 77.6 91.7 95.4 96.5 97.3 97.6 97.6 97.6100.0
PROPORTIONS: GRAVEL =   1.2% SAND = 96.5% SILT =  2.4% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -1.10  0.50  1.61  1.80  2.06  2.23  2.34  2.72
MOMENT MEASURES MEAN  1.97  STDEV  0.92  SKEW -0.57  KURT 13.08
GRAPHIC (FOLK)  MEAN  2.00  STDEV  0.52  SKEW -0.31  KURT  2.10 INMAN SD 0.37 SK -0.21
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H430
                DATA   0.53 0.29 0.40 0.31 0.30 0.23 0.47 0.79 1.70 4.37 3.16 1.06 0.27 0.14 0.04 0.01 0.00 0.48
  FREQUENCY PERCENT    3.6  2.0  2.8  2.1  2.1  1.6  3.2  5.4 11.6 30.0 21.8  7.3  1.8  0.9  0.3  0.1  0.0  3.3
 CUMULATIVE PERCENT    3.6  5.6  8.4 10.5 12.6 14.2 17.4 22.8 34.5 64.5 86.3 93.6 95.4 96.3 96.6 96.7 96.7100.0
PROPORTIONS: GRAVEL =  3.6% SAND = 93.0% SILT =  3.3% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -2.27 -0.64  1.39  1.80  2.13  2.36  2.47  2.94
MOMENT MEASURES MEAN  1.90  STDEV  1.29  SKEW -1.05  KURT  7.71
GRAPHIC (FOLK)  MEAN  2.00  STDEV  0.61  SKEW -0.46  KURT  2.65 INMAN SD 0.54 SK -0.37

H431
                DATA   1.42 0.75 0.54 0.41 0.32 0.23 0.57 1.03 1.96 3.25 2.32 1.19 0.25 0.08 0.02 0.00 0.00 0.73
  FREQUENCY PERCENT    9.4  5.0  3.6  2.7  2.2  1.5  3.8  6.8 13.0 21.6 15.4  7.9  1.7  0.5  0.1  0.0  0.0  4.8
 CUMULATIVE PERCENT    9.4 14.4 18.0 20.7 22.8 24.3 28.2 35.0 48.0 69.5 84.9 92.8 94.5 95.0 95.1 95.2 95.2100.0
PROPORTIONS: GRAVEL =  9.4% SAND = 85.8% SILT =  4.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -3.01 -1.65 -0.26  1.29  2.02  2.33  2.48  3.23
MOMENT MEASURES MEAN  1.53  STDEV  1.75  SKEW -0.69  KURT  4.14
GRAPHIC (FOLK)  MEAN  1.41  STDEV  1.43  SKEW -0.59  KURT  1.94 INMAN SD 1.37 SK -0.67

H432
                DATA   0.14 0.06 0.04 0.03 0.03 0.03 0.09 0.14 0.33 1.09 1.34 0.68 0.12 0.04 0.01 0.00 0.00 0.13
  FREQUENCY PERCENT    3.2  1.5  0.9  0.8  0.7  0.7  2.0  3.2  7.6 25.4 31.2 15.9  2.8  1.0  0.2  0.0  0.0  2.9
 CUMULATIVE PERCENT    3.2  4.6  5.5  6.3  7.0  7.7  9.7 12.9 20.5 45.9 77.2 93.0 95.8 96.8 97.0 97.1 97.1100.0
PROPORTIONS: GRAVEL =  3.2% SAND = 93.9% SILT =  2.9% CLAY =  0.0%
                                                                              ***  ZERO CLASS PRESENT  ***
PERCENTILES (1,5,16,25,50,75,84,95)  -2.35 -0.29  1.86  2.05  2.28  2.48  2.59  2.91
MOMENT MEASURES MEAN  2.12  STDEV  1.16  SKEW -1.62  KURT 10.95
GRAPHIC (FOLK)  MEAN  2.24  STDEV  0.67  SKEW -0.38  KURT  3.07 INMAN SD 0.36 SK -0.16

H433
                DATA   0.01 0.27 0.23 0.14 0.15 0.28 1.38 2.61 4.22 4.65 2.15 0.86 0.23 0.09 0.02 0.01 0.00 0.76
  FREQUENCY PERCENT    0.1  1.5  1.2  0.8  0.8  1.5  7.5 14.3 23.1 26.6 11.8  4.7  1.3  0.5  0.1  0.0  0.0  4.2
 CUMULATIVE PERCENT    0.1  1.6  2.8  3.6  4.4  5.9 13.5 27.8 50.9 77.5 89.3 94.0 95.2 95.7 95.8 95.8 95.8100.0
PROPORTIONS: GRAVEL =  0.1% SAND = 95.8% SILT =  4.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.59  1.10  1.55  1.71  1.99  2.22  2.37  2.95
MOMENT MEASURES MEAN  2.03  STDEV  0.93  SKEW -1.41  KURT 10.48
GRAPHIC (FOLK)  MEAN  1.97  STDEV  0.48  SKEW -0.01  KURT  1.47 INMAN SD 0.41 SK -0.07

H434
                DATA   0.01 0.06 0.07 0.03 0.03 0.02 0.04 0.09 0.29 1.10 0.90 0.44 0.16 0.20 0.24 0.21 0.33 8.54
  FREQUENCY PERCENT    0.1  0.5  0.6  0.2  0.2  0.2  0.3  0.7  2.3  8.6  7.1  3.5  1.3  1.6  1.9  1.7  2.6 66.9
 CUMULATIVE PERCENT    0.1  0.6  1.1  1.3  1.6  1.7  2.1  2.7  5.0 13.6 20.7 24.2 25.5 27.0 28.9 30.6 33.1100.0
PROPORTIONS: GRAVEL =  0.1% SAND = 33.1% SILT = 66.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.09  2.00  2.34  2.91  5.52  7.86  8.97 11.23  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  4.48  STDEV  1.53  SKEW -1.12  KURT  3.04
GRAPHIC (FOLK)  MEAN  5.61  STDEV  3.06  SKEW  0.14  KURT  0.76 INMAN SD 3.31 SK  0.04***  INSUFFICIENT  DATA  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H435
                DATA    0.00 0.03 0.02 0.01 0.01 0.01 0.01 0.00 0.01 0.01 0.02 0.03 0.05 0.45 1.47 1.14 1.10 6.73
  FREQUENCY PERCENT     0.0  0.2  0.1  0.1  0.1  0.1  0.0  0.0  0.1  0.1  0.2  0.3  0.5  4.0 13.2 10.3  9.9 60.7
 CUMULATIVE PERCENT     0.0  0.2  0.4  0.5  0.6  0.7  0.7  0.7  0.8  0.9  1.1  1.4  1.8  5.9 19.1 29.4 39.3100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 39.3% SILT = 60.7% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.41   3.21   3.46   3.65   4.25   4.87   5.17   5.76
MOMENT MEASURES MEAN   4.70   STDEV   1.06   SKEW -1.02   KURT   4.10
GRAPHIC (FOLK)  MEAN   4.29   STDEV   0.81   SKEW  0.13   KURT   0.86 INMAN SD 0.85 SK  0.07***  INSUFFICIENT  DATA  ***
H436
                DATA    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.04 0.21 1.19 1.80 0.68 0.49 0.41
  FREQUENCY PERCENT     0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.7  4.4 24.7 37.3 14.1 10.2  8.4
 CUMULATIVE PERCENT     0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.1  0.2  0.9  5.3 30.1 67.3 81.4 91.6100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 91.6% SILT =  8.4% CLAY =   0.0%
                                                                              ***  ZERO CLASS PRESENT  ***
PERCENTILES (1,5,16,25,50,75,84,95)    2.76   2.99   3.14   3.22   3.38   3.63   3.80   4.14
MOMENT MEASURES MEAN   3.55   STDEV   0.65   SKEW  2.05   KURT   7.50
GRAPHIC (FOLK)  MEAN   3.44   STDEV   0.34   SKEW  0.29   KURT   1.14 INMAN SD 0.33 SK  0.26
H437
                DATA    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.01 0.05 0.63 1.95 1.02 0.73 1.00
  FREQUENCY PERCENT     0.0  0.1  0.0  0.1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.2  0.9 11.6 36.1 18.9 13.5 18.5
 CUMULATIVE PERCENT     0.0  0.1  0.1  0.2  0.2  0.2  0.2  0.2  0.2  0.2  0.2  0.4  1.3 13.0 49.1 68.0 81.5100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 81.5% SILT = 18.5% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.94   3.13   3.28   3.35   3.51   3.87   4.06   4.44
MOMENT MEASURES MEAN   3.84   STDEV   0.84   SKEW  1.08   KURT   4.04
GRAPHIC (FOLK)  MEAN   3.62   STDEV   0.39   SKEW  0.41   KURT   1.03 INMAN SD 0.39 SK  0.40
H441
                DATA    0.00 0.01 0.01 0.01 0.01 0.00 0.00 0.00 0.01 0.01 0.01 0.02 0.01 0.05 0.32 0.88 2.22 8.44
  FREQUENCY PERCENT     0.0  0.1  0.1  0.0  0.1  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.1  0.4  2.7  7.4 18.5 70.3
 CUMULATIVE PERCENT     0.0  0.1  0.1  0.2  0.2  0.3  0.3  0.3  0.3  0.4  0.5  0.6  0.7  1.1  3.8 11.2 29.7100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 29.7% SILT = 70.3% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    3.19   3.56   3.83   3.95   4.20   4.44   4.56   4.80
MOMENT MEASURES MEAN   4.97   STDEV   0.65   SKEW -1.36   KURT   4.96
GRAPHIC (FOLK)  MEAN   4.20   STDEV   0.37   SKEW -0.01   KURT   1.03 INMAN SD 0.36 SK  0.00***  INSUFFICIENT  DATA  ***
H442
                DATA    0.00 0.02 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.02 0.05 0.09 0.99 3.10 1.83 1.35 6.49
  FREQUENCY PERCENT     0.0  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.3  0.6  7.1 22.1 13.1  9.7 46.3
 CUMULATIVE PERCENT     0.0  0.1  0.2  0.3  0.3  0.4  0.5  0.5  0.6  0.6  0.8  1.1  1.7  8.8 30.9 44.0 53.7100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 53.7% SILT = 46.3% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.68   3.15   3.35   3.45   3.90   4.60   4.93   5.60
MOMENT MEASURES MEAN   4.40   STDEV   1.07   SKEW -0.23   KURT   2.29
GRAPHIC (FOLK)  MEAN   4.06   STDEV   0.76   SKEW  0.34   KURT   0.87 INMAN SD 0.79 SK  0.30***  INSUFFICIENT  DATA  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H443
                DATA      0.00 0.01 0.00 0.00 0.00 0.00 0.01 0.01 0.02 0.12 0.50 0.80 0.41 0.34 0.27 0.17 0.23 8.77
  FREQUENCY PERCENT       0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  1.0  4.3  6.9  3.6  2.9  2.3  1.5  2.0 75.2
 CUMULATIVE PERCENT       0.0  0.0  0.1  0.1  0.1  0.1  0.2  0.2  0.4  1.4  5.7 12.5 16.1 19.0 21.3 22.8 24.8100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 24.8% SILT = 75.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.18  2.47  2.99  4.03  6.64  9.25 10.48 13.00  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  4.85  STDEV  1.17  SKEW -1.35  KURT  3.16
GRAPHIC (FOLK)  MEAN  6.70  STDEV  3.47  SKEW  0.12  KURT  0.83 INMAN SD 3.74 SK  0.03***  INSUFFICIENT  DATA  ***

H444
                DATA      0.00 0.08 0.09 0.08 0.08 0.09 0.24 0.60 2.02 6.01 5.02 2.08 0.36 0.14 0.04 0.01 0.01 0.35
  FREQUENCY PERCENT       0.0  0.5  0.5  0.4  0.5  0.5  1.4  3.5 11.7 34.8 29.0 12.0  2.1  0.8  0.2  0.1  0.0  2.0
 CUMULATIVE PERCENT       0.0  0.5  1.0  1.4  1.9  2.4  3.8  7.3 19.0 53.7 82.8 94.8 96.8 97.7 97.9 98.0 98.0100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 98.0% SILT =  2.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    0.01  1.60  1.95  2.05  2.23  2.42  2.52  2.77
MOMENT MEASURES MEAN  2.25  STDEV  0.64  SKEW  1.61  KURT 17.76
GRAPHIC (FOLK)  MEAN  2.23  STDEV  0.32  SKEW -0.02  KURT  1.31 INMAN SD 0.28 SK  0.03

H445
                DATA      0.00 0.04 0.01 0.04 0.09 0.05 0.05 0.04 0.06 0.12 0.27 0.83 1.67 3.41 2.28 0.51 0.30 0.93
  FREQUENCY PERCENT       0.0  0.3  0.1  0.4  0.8  0.4  0.5  0.3  0.5  1.1  2.5  7.8 15.6 31.9 21.4  4.8  2.8  8.7
 CUMULATIVE PERCENT       0.0  0.3  0.4  0.8  1.6  2.0  2.5  2.9  3.4  4.5  7.0 14.8 30.4 62.3 83.7 88.5 91.3100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 91.3% SILT =  8.7% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    0.64  2.31  2.77  2.92  3.15  3.38  3.52  4.44
MOMENT MEASURES MEAN  3.25  STDEV  0.67  SKEW  5.56  KURT  7.13
GRAPHIC (FOLK)  MEAN  3.15  STDEV  0.51  SKEW  0.09  KURT  1.90 INMAN SD 0.37 SK -0.03

H446
                DATA      0.00 0.07 0.07 0.15 0.26 0.13 0.13 0.16 0.39 1.09 1.67 2.55 3.05 4.47 1.92 0.35 0.20 1.02
  FREQUENCY PERCENT       0.0  0.4  0.4  0.8  1.5  0.7  0.7  0.9  2.2  6.1  9.5 14.4 17.3 25.3 10.8  2.0  1.1  5.8
 CUMULATIVE PERCENT       0.0  0.4  0.8  1.6  3.1  3.9  4.6  5.5  7.7 13.8 23.3 37.7 55.0 80.3 91.1 93.1 94.2100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 94.2% SILT =  5.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    0.15  1.63  2.32  2.53  2.93  3.19  3.32  4.19
MOMENT MEASURES MEAN  2.96  STDEV  0.71  SKEW  0.35  KURT  6.95
GRAPHIC (FOLK)  MEAN  2.86  STDEV  0.64  SKEW -0.12  KURT  1.60 INMAN SD 0.50 SK -0.22

H447
                DATA      0.00 0.05 0.02 0.06 0.10 0.05 0.06 0.05 0.20 1.07 2.03 3.01 2.18 2.43 0.93 0.21 0.12 0.59
  FREQUENCY PERCENT       0.0  0.4  0.2  0.4  0.7  0.4  0.4  0.4  1.5  8.1 15.4 22.8 16.5 18.5  7.1  1.6  0.9  4.5
 CUMULATIVE PERCENT       0.0  0.4  0.6  1.0  1.7  2.1  2.6  3.0  4.5 12.6 28.1 50.9 67.4 85.9 93.0 94.6 95.5100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 95.5% SILT =  4.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    0.50  2.02  2.32  2.46  2.74  3.09  3.22  3.85
MOMENT MEASURES MEAN  2.82  STDEV  0.79  SKEW  0.89  KURT  9.03                 ***  SAMPLE     BIMODAL  ***
GRAPHIC (FOLK)  MEAN  2.76  STDEV  0.50  SKEW  0.14  KURT  1.19 INMAN SD 0.45 SK  0.06
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H450
                 DATA    0.00 0.04 0.02 0.01 0.03 0.03 0.05 0.06 0.16 0.39 0.49 0.72 3.4612.6114.02 5.56 4.14 8.95
  FREQUENCY PERCENT      0.0  0.1  0.0  0.0  0.1  0.1  0.1  0.1  0.3  0.8  1.0  1.4  6.8 24.9 27.6 11.0  8.2 17.6
 CUMULATIVE PERCENT      0.0  0.1  0.1  0.1  0.2  0.3  0.3  0.5  0.8  1.5  2.5  3.9 10.8 35.6 63.2 74.2 82.4100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 82.4% SILT = 17.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.09  2.80  3.07  3.16  3.38  3.77  4.06  4.64
MOMENT MEASURES MEAN   3.68  STDEV  0.92  SKEW  0.99  KURT  3.80
GRAPHIC (FOLK)  MEAN   3.50  STDEV  0.52  SKEW  0.37  KURT  1.23 INMAN SD 0.49 SK  0.37

H452
                 DATA    0.00 0.00 0.01 0.01 0.02 0.03 0.01 0.01 0.02 0.11 0.52 3.65 5.21 4.97 1.81 0.42 0.29 3.49
  FREQUENCY PERCENT      0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.0  0.1  0.5  2.5 17.7 25.3 24.2  8.8  2.1  1.4 17.0
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.1  0.2  0.3  0.4  0.4  0.5  1.0  3.5 21.3 46.6 70.8 79.6 81.6 83.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 83.0% SILT = 17.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.24  2.54  2.70  2.79  3.03  3.36  4.18  7.18  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   3.38  STDEV  1.00  SKEW  1.37  KURT  3.64
GRAPHIC (FOLK)  MEAN   3.31  STDEV  1.07  SKEW  0.67  KURT  3.33 INMAN SD 0.74 SK  0.55

H453
                 DATA    0.00 0.02 0.02 0.02 0.02 0.02 0.02 0.01 0.03 0.09 0.51 2.98 3.63 2.96 0.74 0.15 0.12 4.75
  FREQUENCY PERCENT      0.0  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.2  0.6  3.2 18.6 22.6 18.4  4.6  0.9  0.7 29.5
 CUMULATIVE PERCENT      0.0  0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.9  1.5  4.7 23.2 45.8 64.2 68.8 69.7 70.5100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 70.5% SILT = 29.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.06  2.51  2.68  2.77  3.06  5.66  9.54 17.42  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   3.65  STDEV  1.24  SKEW  0.62  KURT  2.05
GRAPHIC (FOLK)  MEAN   5.09  STDEV  3.97  SKEW  0.91  KURT  2.12 INMAN SD 3.43 SK  0.69

H454
                 DATA    0.00 0.00 0.00 0.01 0.01 0.01 0.00 0.00 0.01 0.01 0.02 0.07 0.20 0.84 1.03 0.53 0.5510.74
  FREQUENCY PERCENT      0.0  0.0  0.0  0.0  0.1  0.0  0.0  0.0  0.0  0.1  0.1  0.5  1.4  6.0  7.4  3.8  3.9 76.6
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.0  0.1  0.2  0.2  0.2  0.3  0.4  0.5  1.0  2.4  8.4 15.7 19.5 23.4100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 23.4% SILT = 76.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.76  3.14  3.52  4.09  5.35  6.61  7.21  8.42  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   5.00  STDEV  0.93  SKEW -1.46  KURT  3.66
GRAPHIC (FOLK)  MEAN   5.36  STDEV  1.72  SKEW  0.08  KURT  0.86 INMAN SD 1.84 SK  0.01***  INSUFFICIENT  DATA  ***

H455
                 DATA    0.00 0.01 0.01 0.01 0.02 0.01 0.01 0.01 0.01 0.02 0.03 0.04 0.05 0.24 4.0213.7121.4251.30
  FREQUENCY PERCENT      0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.3  4.4 15.1 23.6 56.4
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.1  0.1  0.1  0.2  0.2  0.5  4.9 20.0 43.6100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 43.6% SILT = 56.4% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    3.32  3.50  3.70  3.81  4.06  4.31  4.43  4.66
MOMENT MEASURES MEAN   4.73  STDEV  0.89  SKEW -0.39  KURT  1.58
GRAPHIC (FOLK)  MEAN   4.06  STDEV  0.36  SKEW  0.03  KURT  0.96 INMAN SD 0.36 SK  0.01***  INSUFFICIENT  DATA  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H458
                   DATA    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.01 0.02 0.03 0.48 3.60 1.53 1.24 3.03
  FREQUENCY PERCENT        0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.2  0.3  4.9 36.2 15.4 12.4 30.5
 CUMULATIVE PERCENT        0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.3  0.6  5.4 41.7 57.0 69.5100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 69.5% SILT = 30.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    3.05  3.24  3.36  3.42  3.64  4.12  4.36  4.85
MOMENT MEASURES MEAN   4.11  STDEV  0.94  SKEW  0.72  KURT  1.69
GRAPHIC (FOLK)  MEAN   3.79  STDEV  0.50  SKEW  0.48  KURT  0.94 INMAN SD 0.50 SK  0.45
H460
                   DATA    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.01 0.10 0.61 4.05 5.49 2.31 1.65 2.03
  FREQUENCY PERCENT        0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.6  3.8 24.9 33.8 14.2 10.2 12.5
 CUMULATIVE PERCENT        0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.7  4.5 29.4 63.2 77.4 87.5100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 87.5% SILT = 12.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.79  3.01  3.15  3.22  3.40  3.70  3.90  4.31
MOMENT MEASURES MEAN   3.64  STDEV  0.75  SKEW  1.78  KURT  4.95
GRAPHIC (FOLK)  MEAN   3.49  STDEV  0.38  SKEW  0.36  KURT  1.10 INMAN SD 0.37 SK  0.33
H461
                   DATA    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.02 0.02 0.03 0.04 0.42 4.61 6.77 7.0825.06
  FREQUENCY PERCENT        0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.9 10.5 15.4 16.1 56.9
 CUMULATIVE PERCENT        0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.2  0.3  1.2 11.7 27.0 43.1100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 43.1% SILT = 56.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    3.22  3.39  3.56  3.72  4.10  4.48  4.67  5.04
MOMENT MEASURES MEAN   4.70  STDEV  0.93  SKEW -0.36  KURT  1.25
GRAPHIC (FOLK)  MEAN   4.12  STDEV  0.52  SKEW  0.10  KURT  0.89 INMAN SD 0.54 SK  0.05*** INSUFFICIENT  DATA  ***
H462
                   DATA    0.00 0.00 0.00 0.00 0.01 0.01 0.02 0.02 0.02 0.01 0.01 0.04 0.15 2.00 6.03 2.48 1.72 2.02
  FREQUENCY PERCENT        0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.3  1.0 13.7 41.5 17.0 11.8 13.9
 CUMULATIVE PERCENT        0.0  0.0  0.0  0.1  0.1  0.2  0.3  0.5  0.6  0.7  0.8  1.1  2.1 15.8 57.3 74.3 86.1100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 86.1% SILT = 13.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    2.70  3.09  3.25  3.32  3.46  3.76  3.95  4.32
MOMENT MEASURES MEAN   3.72  STDEV  0.77  SKEW  1.36  KURT  4.99
GRAPHIC (FOLK)  MEAN   3.55  STDEV  0.36  SKEW  0.40  KURT  1.14 INMAN SD 0.35 SK  0.40
H463
                   DATA    0.00 0.01 0.02 0.04 0.05 0.03 0.08 0.13 0.31 1.04 1.03 0.74 0.32 0.29 0.23 0.11 0.10 4.78
  FREQUENCY PERCENT        0.0  0.1  0.2  0.4  0.5  0.3  0.8  1.4  3.3 11.2 11.1  8.0  3.4  3.1  2.4  1.2  1.0 51.6
 CUMULATIVE PERCENT        0.0  0.1  0.3  0.6  1.1  1.5  2.3  3.7  7.0 18.2 29.3 37.3 40.7 43.7 46.2 47.4 48.4100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 48.4% SILT = 51.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    0.88  1.86  2.21  2.41  4.38 10.87 13.95 20.21   *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN   4.01  STDEV  1.60  SKEW -0.29  KURT  1.43
GRAPHIC (FOLK)  MEAN   6.85  STDEV  5.71  SKEW  0.68  KURT  0.89 INMAN SD 5.87 SK  0.63*** INSUFFICIENT  DATA  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H466
               DATA   0.00 0.07 0.13 0.25 0.55 0.32 0.25 0.15 0.19 0.32 0.37 1.37 3.56 7.05 2.68 0.48 0.26 1.28
  FREQUENCY PERCENT   0.0  0.3  0.6  1.3  2.9  1.6  1.3  0.8  1.0  1.7  1.9  7.1 18.5 36.6 13.9  2.5  1.4  6.6
 CUMULATIVE PERCENT   0.0  0.3  1.0  2.3  5.1  6.8  8.1  8.9  9.8 11.5 13.4 20.5 39.0 75.6 89.5 92.0 93.4100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 93.4% SILT =  6.6% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95)    0.01  0.98  2.60  2.82  3.07  3.25  3.38  4.36
MOMENT MEASURES MEAN  3.01  STDEV  0.99  SKEW -0.18  KURT  6.18
GRAPHIC (FOLK)  MEAN  3.02  STDEV  0.71  SKEW -0.22  KURT  3.25 INMAN SD 0.39 SK -0.20

H467
               DATA   0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.03 0.07 0.12 0.55 0.86 0.49 0.5112.45
  FREQUENCY PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.2  0.5  0.8  3.6  5.7  3.3  3.4 82.6
 CUMULATIVE PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.2  0.7  1.5  5.1 10.8 14.0 17.4100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 17.4% SILT = 82.6% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95)    2.88  3.25  3.90  4.47  5.67  6.87  7.44  8.60  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  5.14  STDEV  0.60  SKEW -1.84  KURT  4.61
GRAPHIC (FOLK)  MEAN  5.67  STDEV  1.70  SKEW  0.05  KURT  0.91 INMAN SD 1.77 SK  0.00***  INSUFFICIENT  DATA  ***

H470
               DATA   7.60 1.03 0.53 0.42 0.43 0.26 0.23 0.19 0.32 0.70 0.46 0.31 0.17 0.12 0.04 0.02 0.02 8.69
  FREQUENCY PERCENT  35.3  4.8  2.4  2.0  2.0  1.2  1.0  0.9  1.5  3.3  2.1  1.5  0.8  0.6  0.2  0.1  0.1 40.3
 CUMULATIVE PERCENT  35.3 40.1 42.5 44.5 46.5 47.7 48.7 49.6 51.1 54.4 56.5 58.0 58.8 59.3 59.5 59.6 59.7100.0
PROPORTIONS: GRAVEL = 35.3% SAND = 24.4% SILT = 40.3% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95)   -8.71 -6.01 -3.44 -2.17  1.82 63.83108.34198.81  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  1.60  STDEV  3.54  SKEW -0.02  KURT  1.24
GRAPHIC (FOLK)  MEAN 35.57  STDEV 58.98  SKEW  0.91  KURT  1.27 INMAN SD **** SK  0.91***  INSUFFICIENT  DATA  ***

H472
               DATA   0.00 0.01 0.00 0.01 0.00 0.01 0.01 0.01 0.04 0.33 0.81 1.25 0.87 0.83 0.61 0.28 0.28 7.11
  FREQUENCY PERCENT   0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.0  0.3  2.7  6.5 10.0  7.0  6.6  4.9  2.3  2.3 57.1
 CUMULATIVE PERCENT   0.0  0.0  0.1  0.1  0.1  0.2  0.2  0.3  0.6  3.3  9.8 19.8 26.8 33.5 38.4 40.7 42.9100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 42.9% SILT = 57.1% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95)    2.06  2.34  2.67  2.94  4.77  7.68  9.05 11.86  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  4.37  STDEV  1.35  SKEW -0.47  KURT  1.50
GRAPHIC (FOLK)  MEAN  5.50  STDEV  3.04  SKEW  0.42  KURT  0.82 INMAN SD 3.19 SK  0.34***  INSUFFICIENT  DATA  ***

H782
               DATA  10.42 1.40 1.32 1.38 1.34 0.76 0.68 0.49 0.58 0.86 0.68 0.61 0.25 0.21 0.50 0.77 1.06 3.74
  FREQUENCY PERCENT  49.7  4.2  4.0  4.2  4.1  2.3  2.0  1.5  1.8  2.6  2.1  1.8  0.8  0.6  1.5  2.3  3.2 11.3
 CUMULATIVE PERCENT  49.7 53.9 57.9 62.1 66.2 68.5 70.5 72.0 73.7 76.3 78.4 80.2 81.0 81.6 83.1 85.5 88.7100.0
PROPORTIONS: GRAVEL = 49.7% SAND = 39.0% SILT = 11.3% CLAY =  0.0%
PERCENTILES (1,5,16,25,50,75,84,95) -11.87 -8.67 -5.63 -4.13 -0.96  2.12  3.59  4.71  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN -0.06  STDEV  2.86  SKEW  0.75  KURT  2.14
GRAPHIC (FOLK)  MEAN -1.00  STDEV  4.33  SKEW -0.08  KURT  0.88 INMAN SD 4.61 SK -0.01
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CLASS MIDPOINTS-PHI  -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI   -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H783
              DATA    0.00 0.05 0.07 0.10 0.30 0.48 0.58 0.42 0.46 0.61 1.03 2.26 3.22 6.57 2.57 0.28 0.12 1.16
  FREQUENCY PERCENT   0.0  0.3  0.3  0.5  1.5  2.4  2.9  2.0  2.3  3.9  5.0 11.0 15.7 32.1 12.5  1.4  0.6  5.7
 CUMULATIVE PERCENT   0.0  0.3  0.6  1.1  2.5  4.9  7.7  9.8 12.0 16.0 21.0 32.1 47.8 79.9 92.4 93.7 94.3100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 94.3% SILT =  5.7% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.45  1.26  2.25  2.60  3.02  3.20  3.32  4.31
MOMENT MEASURES MEAN  2.91  STDEV  0.92  SKEW  0.28  KURT  6.08
GRAPHIC (FOLK)  MEAN  2.86  STDEV  0.73  SKEW -0.29  KURT  2.06 INMAN SD 0.53 SK -0.44

H784
              DATA    0.00 0.10 0.15 0.14 0.19 0.14 0.15 0.12 0.15 0.23 0.27 0.94 2.01 4.39 2.38 0.52 0.25 2.82
  FREQUENCY PERCENT   0.0  0.6  1.0  1.0  1.2  0.9  1.0  0.8  1.0  1.5  1.8  6.3 13.5 29.4 15.9  3.5  1.7 18.9
 CUMULATIVE PERCENT   0.0  0.7  1.7  2.6  3.9  4.8  5.8  6.6  7.6  9.1 10.9 17.2 30.7 60.1 76.0 79.5 81.1100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 81.1% SILT = 18.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.28  1.31  2.71  2.90  3.17  3.48  4.46  7.17  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  3.37  STDEV  1.24  SKEW -0.00  KURT  4.08
GRAPHIC (FOLK)  MEAN  3.45  STDEV  1.33  SKEW  0.42  KURT  4.15 INMAN SD 0.88 SK  0.48

H785
              DATA    0.02 0.18 0.17 0.15 0.24 0.19 0.15 0.10 0.15 0.23 0.40 1.61 2.50 3.74 1.83 0.39 0.27 4.06
  FREQUENCY PERCENT   0.1  1.1  1.1  0.9  1.4  1.1  0.9  0.6  0.9  1.4  2.4  9.8 15.3 22.9 11.2  2.4  1.7 24.8
 CUMULATIVE PERCENT   0.1  1.2  2.3  3.2  4.6  5.8  6.6  7.3  8.2  9.6 12.0 21.8 37.1 60.0 71.2 73.5 75.2100.0
PROPORTIONS: GRAVEL =  0.1% SAND = 75.1% SILT = 24.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.54  1.09  2.61  2.81  3.14  3.97  5.51  8.65  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  3.44  STDEV  1.40  SKEW -0.15  KURT  3.54
GRAPHIC (FOLK)  MEAN  3.76  STDEV  1.67  SKEW  0.55  KURT  2.67 INMAN SD 1.45 SK  0.64

H786
              DATA    0.00 0.02 0.03 0.03 0.07 0.05 0.05 0.04 0.06 0.12 0.15 0.34 0.61 1.40 0.68 0.20 0.29 6.86
  FREQUENCY PERCENT   0.0  0.2  0.3  0.2  0.6  0.5  0.4  0.3  0.5  1.1  1.4  3.1  5.5 12.7  6.2  1.8  2.7 62.5
 CUMULATIVE PERCENT   0.0  0.2  0.4  0.7  1.3  1.8  2.2  2.5  3.1  4.1  5.5  8.6 14.1 26.8 33.0 34.8 37.5100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 37.5% SILT = 62.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.79  2.41  3.04  3.22  5.13  7.51  8.64 10.94  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  4.54  STDEV  1.32  SKEW -0.98  KURT  2.99                      *** SAMPLE       BIMODAL  ***
GRAPHIC (FOLK)  MEAN  5.60  STDEV  2.69  SKEW  0.31  KURT  0.81 INMAN SD 2.80 SK  0.26*** INSUFFICIENT DATA    ***

H787
              DATA    0.02 0.11 0.12 0.20 0.60 0.47 0.41 0.27 0.36 0.63 0.57 0.76 0.65 1.13 1.15 0.72 1.04 6.31
  FREQUENCY PERCENT   0.1  0.7  0.7  1.3  3.9  3.0  2.6  1.7  2.3  4.0  3.7  4.9  4.2  7.3  7.4  4.7  6.7 40.7
 CUMULATIVE PERCENT   0.1  0.8  1.5  2.9  6.7  9.7 12.4 14.1 16.4 20.5 24.2 29.0 33.2 40.5 47.9 52.6 59.3100.0
PROPORTIONS: GRAVEL =  0.1% SAND = 59.2% SILT = 40.7% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.34  0.82  1.90  2.55  3.61  4.64  5.11  6.07
MOMENT MEASURES MEAN  3.73  STDEV  1.70  SKEW -0.46  KURT  2.24                      *** SAMPLE       BIMODAL  ***
GRAPHIC (FOLK)  MEAN  3.56  STDEV  1.58  SKEW -0.06  KURT  1.03 INMAN SD 1.58 SK -0.05*** INSUFFICIENT DATA    ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST


H796
                   DATA   0.00 0.03 0.02 0.05 0.06 0.05 0.07 0.04 0.05 0.11 0.24 0.56 0.91 2.90 3.35 1.73 1.49 4.31
  FREQUENCY PERCENT       0.0  0.2  0.2  0.3  0.4  0.3  0.4  0.2  0.3  0.7  1.5  3.5  5.7 18.2 21.0 10.8  9.3 27.0
 CUMULATIVE PERCENT       0.0  0.2  0.4  0.6  1.0  1.3  1.7  2.0  2.3  3.0  4.5  8.0 13.7 31.9 52.8 63.7 73.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 73.0% SILT = 27.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.00  2.54  3.04  3.17  3.47  4.06  4.36  4.98
MOMENT MEASURES MEAN  3.84  STDEV  1.12  SKEW  0.16  KURT  3.12
GRAPHIC (FOLK)  MEAN  3.62  STDEV  0.70  SKEW  0.30  KURT  1.12 INMAN SD 0.66 SK  0.35

H798
                   DATA   0.00 0.00 0.01 0.01 0.02 0.02 0.01 0.01 0.04 0.02 0.03 0.06 0.19 2.25 6.62 4.42 3.65 4.46
  FREQUENCY PERCENT       0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.1  0.2  0.1  0.1  0.3  0.9 10.3 30.3 20.3 16.7 20.4
 CUMULATIVE PERCENT       0.0  0.0  0.0  0.1  0.2  0.2  0.3  0.3  0.5  0.6  0.8  1.0  1.9 12.2 42.6 62.8 79.6100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 79.6% SILT = 20.4% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.72  3.12  3.29  3.38  3.59  3.92  4.08  4.41
MOMENT MEASURES MEAN  3.90  STDEV  0.66  SKEW  0.94  KURT  3.29
GRAPHIC (FOLK)  MEAN  3.66  STDEV  0.39  SKEW  0.26  KURT  0.97 INMAN SD 0.40 SK  0.25

H799
                   DATA   0.00 0.00 0.01 0.01 0.01 0.02 0.02 0.01 0.01 0.02 0.02 0.03 0.04 0.13 1.12 2.85 4.71 5.99
  FREQUENCY PERCENT       0.0  0.0  0.0  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.1  0.2  0.3  0.8  7.5 19.0 31.4 40.0
 CUMULATIVE PERCENT       0.0  0.0  0.1  0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8  1.1  1.3  2.2  9.6 28.6 60.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 60.0% SILT = 40.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.69  3.38  3.60  3.71  3.92  4.13  4.23  4.42
MOMENT MEASURES MEAN  4.41  STDEV  0.93  SKEW -0.04  KURT  2.49
GRAPHIC (FOLK)  MEAN  3.92  STDEV  0.31  SKEW -0.03  KURT  1.03 INMAN SD 0.31 SK -0.02

H800
                   DATA   0.00 0.02 0.03 0.03 0.04 0.03 0.03 0.02 0.04 0.06 0.07 0.10 0.10 0.26 1.01 1.27 2.79 9.54
  FREQUENCY PERCENT       0.0  0.1  0.2  0.2  0.3  0.2  0.2  0.1  0.2  0.4  0.5  0.6  0.7  1.7  6.5  8.2 18.1 61.8
 CUMULATIVE PERCENT       0.0  0.1  0.3  0.5  0.8  0.9  1.1  1.3  1.5  1.9  2.3  3.0  3.6  5.3 11.9 20.1 38.2100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 38.2% SILT = 61.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.34  3.21  3.64  3.83  4.14  4.45  4.60  4.91
MOMENT MEASURES MEAN  4.74  STDEV  1.05  SKEW -1.25  KURT  4.77
GRAPHIC (FOLK)  MEAN  4.13  STDEV  0.50  SKEW -0.07  KURT  1.11 INMAN SD 0.48 SK -0.04***  INSUFFICIENT  DATA  ***

H801
                   DATA   0.00 0.01 0.01 0.02 0.03 0.02 0.02 0.02 0.03 0.07 0.10 0.15 0.31 1.52 1.65 0.60 1.04 7.59
  FREQUENCY PERCENT       0.0  0.1  0.1  0.1  0.3  0.2  0.2  0.1  0.3  0.5  0.7  1.1  2.3 11.6 12.5  4.6  7.9 57.6
 CUMULATIVE PERCENT       0.0  0.1  0.2  0.3  0.5  0.7  0.9  1.0  1.3  1.8  2.5  3.7  6.0 17.5 30.0 34.6 42.4100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 42.4% SILT = 57.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.72  2.91  3.23  3.41  4.23  5.05  5.44  6.23
MOMENT MEASURES MEAN  4.56  STDEV  1.16  SKEW -0.72  KURT  2.55                   ***  SAMPLE      BIMODAL  ***
GRAPHIC (FOLK)  MEAN  4.30  STDEV  1.06  SKEW  0.15  KURT  0.83 INMAN SD 1.11 SK  0.09***  INSUFFICIENT  DATA  ***
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H802
                  DATA  0.00 0.04 0.06 0.07 0.17 0.10 0.09 0.06 0.10 0.25 0.36 0.39 0.34 0.93 2.13 0.75 0.74 9.50
  FREQUENCY PERCENT     0.0  0.3  0.4  0.4  1.1  0.5  0.5  0.4  0.6  1.6  2.2  2.4  2.1  5.8 13.2  4.6  4.6 59.1
 CUMULATIVE PERCENT     0.0  0.3  0.7  1.1  2.2  2.8  3.3  3.7  4.4  5.9  8.2 10.6 12.7 18.5 31.7 36.3 40.9100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 40.9% SILT = 59.1% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    0.40  2.11  3.15  3.38  4.48  5.87  6.54  7.88  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  4.47  STDEV  1.36  SKEW -1.05  KURT  3.43
GRAPHIC (FOLK)  MEAN  4.72  STDEV  1.72  SKEW  0.20  KURT  0.95 INMAN SD 1.69 SK  0.22***  INSUFFICIENT  DATA  ***
H803
                  DATA  0.00 0.05 0.05 0.08 0.20 0.15 0.16 0.13 0.17 0.30 0.28 0.28 0.22 0.33 0.52 0.35 0.5310.74
  FREQUENCY PERCENT     0.0  0.4  0.3  0.6  1.4  1.0  1.1  0.9  1.2  2.0  1.9  1.9  1.5  2.2  3.5  2.4  3.7 74.0
 CUMULATIVE PERCENT     0.0  0.4  0.7  1.2  2.6  3.7  4.8  5.6  6.8  8.8 10.7 12.6 14.1 16.4 19.9 22.3 26.0100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 26.0% SILT = 74.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    0.31  1.57  3.21  3.93  5.36  6.79  7.47  8.85  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  4.74  STDEV  1.40  SKEW -1.70  KURT  4.86                         ***  SAMPLE       BIMODAL  ***
GRAPHIC (FOLK)  MEAN  5.35  STDEV  2.17  SKEW -0.03  KURT  1.04 INMAN SD 2.13 SK -0.01***  INSUFFICIENT  DATA  ***
H804
                  DATA  0.00 0.03 0.01 0.02 0.05 0.03 0.03 0.02 0.03 0.06 0.08 0.09 0.08 0.16 0.29 0.31 0.42 9.44
  FREQUENCY PERCENT     0.0  0.3  0.1  0.1  0.4  0.2  0.2  0.2  0.3  0.6  0.7  0.8  0.7  1.4  2.6  2.8  3.8 84.8
 CUMULATIVE PERCENT     0.0  0.3  0.4  0.5  0.9  1.1  1.4  1.5  1.8  2.4  3.1  3.9  4.5  6.0  8.6 11.4 15.2100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 15.2% SILT = 84.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    1.11  3.09  4.05  4.49  5.44  6.39  6.84  7.75  *** EXTRAPOLATED TOO FAR ***
MOMENT MEASURES MEAN  5.13  STDEV  0.96  SKEW -2.86  KURT 11.82
GRAPHIC (FOLK)  MEAN  5.44  STDEV  1.40  SKEW -0.00  KURT  1.01 INMAN SD 1.39 SK  0.00***  INSUFFICIENT  DATA  ***
H805
                  DATA  0.00 0.02 0.01 0.01 0.03 0.02 0.02 0.02 0.03 0.05 0.07 0.10 0.10 0.25 0.34 0.31 0.66 8.22
  FREQUENCY PERCENT     0.0  0.2  0.1  0.1  0.3  0.2  0.2  0.1  0.3  0.5  0.7  1.0  1.0  2.4  3.3  3.0  6.5 80.2
 CUMULATIVE PERCENT     0.0  0.2  0.3  0.4  0.7  0.9  1.1  1.3  1.5  2.0  2.7  3.7  4.6  7.1 10.4 13.4 19.8100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 19.8% SILT = 80.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)    1.35  3.04  3.86  4.16  4.81  5.45  5.76  6.38
MOMENT MEASURES MEAN  5.05  STDEV  0.98  SKEW -2.30  KURT  8.53
GRAPHIC (FOLK)  MEAN  4.81  STDEV  0.98  SKEW -0.03  KURT  1.06 INMAN SD 0.95 SK  0.00***  INSUFFICIENT  DATA  ***
H807
                  DATA  0.00 0.17 0.51 0.92 1.81 1.15 0.86 0.45 0.44 0.59 0.51 0.72 0.72 1.81 2.20 1.48 1.94 6.85
  FREQUENCY PERCENT     0.0  0.7  2.2  4.0  7.8  5.0  3.7  1.9  1.9  2.5  2.2  3.1  3.1  7.8  9.5  6.4  8.4 29.6
 CUMULATIVE PERCENT     0.0  0.7  2.9  6.9 14.7 19.7 23.4 25.3 27.3 29.8 32.0 35.2 38.3 46.1 55.6 62.0 70.4100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 70.4% SILT = 29.6% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   -0.40  0.30  1.07  1.71  3.35  4.15  4.50  5.20
MOMENT MEASURES MEAN  3.26  STDEV  1.01  SKEW -0.23  KURT  1.93                         ***  SAMPLE       BIMODAL  ***
GRAPHIC (FOLK)  MEAN  2.97  STDEV  1.60  SKEW -0.29  KURT  0.82 INMAN SD 1.71 SK -0.33
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

J433
                DATA    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.01 0.01 0.01 0.01 0.02 0.09 0.97 1.96 2.43 4.18
   FREQUENCY PERCENT    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.1  0.2  1.0 10.0 20.2 25.1 43.2
  CUMULATIVE PERCENT    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.2  0.3  0.5  1.5 11.4 31.7 56.8100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 56.8% SILT = 43.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   3.15  3.39  3.57  3.66  3.93  4.19  4.32  4.57
MOMENT MEASURES MEAN  4.46  STDEV  0.92  SKEW  0.16  KURT  1.23
GRAPHIC (FOLK)  MEAN  3.94  STDEV  0.37  SKEW  0.05  KURT  0.95 INMAN SD 0.37 SK  0.03*** INSUFFICIENT  DATA  ***

J439
                DATA    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.01 0.02 0.19 1.61 6.7013.8110.51 6.74 1.96 1.81 4.54
   FREQUENCY PERCENT    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.4  3.4 14.0 28.8 21.9 14.1  4.1  3.8  9.5
  CUMULATIVE PERCENT    0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.5  3.8 17.8 46.7 68.6 82.7 86.8 90.5100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 90.5% SILT =  9.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.33  2.54  2.73  2.82  3.04  3.35  3.58  4.42
MOMENT MEASURES MEAN  3.25  STDEV  0.80  SKEW  1.96  KURT  6.10
GRAPHIC (FOLK)  MEAN  3.11  STDEV  0.50  SKEW  0.37  KURT  1.46 INMAN SD 0.42 SK  0.27

J445
                DATA    0.00 0.00 0.00 0.01 0.03 0.04 0.10 0.10 0.34 0.44 0.48 1.9415.3926.2617.29 3.83 2.02 3.09
   FREQUENCY PERCENT    0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.5  0.6  0.7  2.7 21.6 36.8 24.2  5.4  2.8  4.3
  CUMULATIVE PERCENT    0.0  0.0  0.0  0.0  0.1  0.1  0.3  0.4  0.9  1.5  2.1  4.9 26.4 63.2 87.5 92.8 95.7100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 95.7% SILT =  4.3% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.07  2.75  2.91  2.99  3.16  3.35  3.45  3.93
MOMENT MEASURES MEAN  3.24  STDEV  0.57  SKEW  2.31  KURT 11.72
GRAPHIC (FOLK)  MEAN  3.16  STDEV  0.31  SKEW  0.19  KURT  1.32 INMAN SD 0.27 SK  0.07

J448
                DATA    1.38 3.17 2.29 2.17 3.16 4.9111.1713.5222.7330.3812.07 4.81 1.40 0.42 0.13 0.02 0.01 1.58
   FREQUENCY PERCENT    1.2  2.6  2.0  1.9  2.7  4.3  9.7 11.7 19.7 26.3 10.5  4.2  1.2  0.4  0.1  0.0  0.0  1.4
  CUMULATIVE PERCENT    1.2  3.9  5.9  7.8 10.6 14.8 24.5 36.2 55.9 82.3 92.7 96.9 98.1 98.5 98.6 98.6 98.6100.0
PROPORTIONS: GRAVEL =  1.2% SAND = 97.4% SILT =  1.4% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -1.07 -0.21  1.29  1.51  1.93  2.17  2.28  2.61
MOMENT MEASURES MEAN  1.76  STDEV  0.95  SKEW -0.94  KURT 10.15
GRAPHIC (FOLK)  MEAN  1.83  STDEV  0.68  SKEW -0.40  KURT  1.76 INMAN SD 0.50 SK -0.28

J451
                DATA    0.00 0.00 0.00 0.01 0.01 0.01 0.03 0.02 0.05 0.12 0.45 2.45 9.6813.1314.87 3.18 1.44 0.69
   FREQUENCY PERCENT    0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.0  0.1  0.3  1.0  5.3 21.0 28.5 32.2  6.9  3.1  1.5
  CUMULATIVE PERCENT    0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.2  0.3  0.5  1.5  6.8 27.8 56.3 88.5 95.4 98.5100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 98.5% SILT =  1.5% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.39  2.69  2.89  2.98  3.20  3.37  3.45  3.73
MOMENT MEASURES MEAN  3.21  STDEV  0.42  SKEW  1.99  KURT 15.88
GRAPHIC (FOLK)  MEAN  3.18  STDEV  0.30  SKEW -0.04  KURT  1.07 INMAN SD 0.28 SK -0.10
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

J456
                DATA     0.00 0.00 0.00 0.01 0.01 0.02 0.06 0.06 0.20 0.67 1.83 7.2016.8515.73 9.37 1.23 0.40 0.51
  FREQUENCY PERCENT      0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.4  1.2  3.4 13.3 31.1 29.0 17.3  2.3  0.7  0.9
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.0  0.0  0.1  0.2  0.3  0.7  1.9  5.3 18.6 49.7 78.7 96.0 98.3 99.1100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 99.1% SILT =  0.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.09  2.49  2.72  2.81  3.00  3.21  3.30  3.47
MOMENT MEASURES MEAN  3.02  SIDEV  0.40  SKEW  1.76  KURT 16.28
GRAPHIC (FOLK)  MEAN  3.01  SIDEV  0.30  SKEW -0.01  KURT  1.01 INMAN SD 0.29 SK  0.02

J459
                DATA     0.00 0.00 0.00 0.00 0.01 0.03 0.05 0.05 0.18 0.72 2.34 8.0020.1616.4510.31 1.75 1.12 1.53
  FREQUENCY PERCENT      0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.3  1.2  3.7 12.8 32.2 26.2 16.4  2.8  1.8  2.4
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.2  0.5  1.7  5.4 18.1 50.3 76.5 93.0 95.8 97.6100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 97.6% SILT =  2.4% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.14  2.48  2.72  2.81  3.00  3.23  3.34  3.67
MOMENT MEASURES MEAN  3.06  SIDEV  0.51  SKEW  2.46  KURT 14.11
GRAPHIC (FOLK)  MEAN  3.02  SIDEV  0.34  SKEW  0.12  KURT  1.16 INMAN SD 0.31 SK  0.10

J461
                DATA     0.00 0.00 0.00 0.01 0.02 0.03 0.06 0.06 0.14 0.25 0.38 1.60 8.9123.4735.38 9.28 5.3511.78
  FREQUENCY PERCENT      0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.1  0.3  0.4  1.7  9.2 24.3 36.6  9.6  5.5 12.2
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.2  0.3  0.6  1.0  2.6 11.8 36.1 72.7 82.3 87.8100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 87.8% SILT = 12.2% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.51  2.85  3.06  3.15  3.34  3.55  3.82  4.50
MOMENT MEASURES MEAN  3.55  SIDEV  0.78  SKEW  1.69  KURT  5.13
GRAPHIC (FOLK)  MEAN  3.41  SIDEV  0.44  SKEW  0.33  KURT  1.69 INMAN SD 0.38 SK  0.25

J463
                DATA     0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.01 0.02 0.11 0.48 5.02 6.38 0.81 0.20 0.26
  FREQUENCY PERCENT      0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.2  0.8  3.6 37.7 43.1  6.1  1.5  1.9
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.1  0.2  1.1  4.7 42.4 90.5 96.6 98.1100.0
PROPORTIONS: GRAVEL =  0.0% SAND = 98.1% SILT =  1.9% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.74  3.01  3.11  3.17  3.28  3.39  3.45  3.66
MOMENT MEASURES MEAN  3.32  SIDEV  0.36  SKEW  4.07  KURT 25.84
GRAPHIC (FOLK)  MEAN  3.28  SIDEV  0.18  SKEW  0.08  KURT  1.20 INMAN SD 0.17 SK -0.00

H599
                DATA     0.00 0.30 0.27 0.53 1.39 2.55 3.84 2.90 2.70 2.81 1.57 1.07 0.54 0.56 0.39 0.17 0.14 0.00
  FREQUENCY PERCENT      0.0  1.4  1.3  2.4  6.4 11.7 17.7 13.4 12.4 12.9  7.2  4.9  2.5  2.6  1.8  0.8  0.7  0.0
 CUMULATIVE PERCENT      0.0  1.4  2.6  5.1 11.4 23.2 40.9 54.2 66.6 79.5 86.8 91.7 94.2 96.8 98.5 99.3100.0100.0
PROPORTIONS: GRAVEL =  0.0% SAND =100.0% SILT =  0.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.74  0.49  1.11  1.28  1.67  2.15  2.40  3.07
MOMENT MEASURES MEAN  1.71  SIDEV  0.77  SKEW -0.16  KURT  4.10
GRAPHIC (FOLK)  MEAN  1.73  SIDEV  0.71  SKEW  0.11  KURT  1.21 INMAN SD 0.64 SK  0.13
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H601
                 DATA    0.00 0.00 0.00 0.00 0.00 0.01 0.01 0.03 0.11 0.36 0.50 0.99 0.98 1.88 1.67 0.72 0.69 0.00
  FREQUENCY PERCENT      0.0  0.0  0.0  0.0  0.0  0.1  0.1  0.4  1.4  4.6  6.3 12.4 12.3 23.6 21.0  9.1  8.7  0.0
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.0  0.1  0.1  0.3  0.6  2.0  6.6 12.8 25.3 37.6 61.2 82.2 91.3100.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND =100.0% SILT =   0.0% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.85  2.19  2.57  2.75  3.13  3.40  3.54  3.78
MOMENT MEASURES MEAN   3.07  STDEV  0.49  SKEW -0.54  KURT  3.32
GRAPHIC (FOLK)  MEAN   3.08  STDEV  0.48  SKEW -0.17  KURT  0.99 INMAN SD 0.48 SK -0.15

H604
                 DATA    0.00 0.00 0.01 0.03 0.07 0.09 0.18 0.22 0.53 1.30 1.74 2.40 1.81 2.70 2.26 1.09 0.94 0.00
  FREQUENCY PERCENT      0.0  0.0  0.0  0.2  0.4  0.6  1.2  1.4  3.5  8.5 11.3 15.6 11.8 17.6 14.7  7.1  6.1  0.0
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.2  0.7  1.2  2.4  3.8  7.3 15.8 27.1 42.7 54.5 72.1 86.8 93.9100.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND =100.0% SILT =   0.0% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   1.16  1.85  2.26  2.46  2.90  3.29  3.44  3.76         *** SAMPLE     BIMODAL  ***
MOMENT MEASURES MEAN   2.85  STDEV  0.61  SKEW -0.60  KURT  3.73
GRAPHIC (FOLK)  MEAN   2.87  STDEV  0.59  SKEW -0.10  KURT  0.94 INMAN SD 0.59 SK -0.09

H606
                 DATA    0.00 0.09 0.07 0.06 0.12 0.25 0.62 0.84 1.55 2.40 1.44 0.78 0.33 0.23 0.14 0.05 0.04 0.00
  FREQUENCY PERCENT      0.0  1.0  0.8  0.6  1.3  2.6  6.9  9.3 17.2 26.7 15.9  8.6  3.7  2.6  1.5  0.5  0.4  0.0
 CUMULATIVE PERCENT      0.0  1.0  1.7  2.4  3.7  6.4 13.4 22.7 40.0 66.6 82.6 91.2 94.9 97.5 99.1 99.6100.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND =100.0% SILT =   0.0% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.46  1.13  1.56  1.79  2.09  2.37  2.53  3.00
MOMENT MEASURES MEAN   2.05  STDEV  0.63  SKEW -1.09  KURT  7.40
GRAPHIC (FOLK)  MEAN   2.07  STDEV  0.52  SKEW -0.05  KURT  1.32 INMAN SD 0.48 SK -0.08

H607
                 DATA    0.00 0.99 0.73 0.52 0.52 0.35 0.36 0.33 0.64 1.73 2.23 2.83 1.79 2.37 1.80 0.82 0.73 0.00
  FREQUENCY PERCENT      0.0  5.3  3.9  2.8  2.7  1.9  1.9  1.7  3.4  9.2 11.9 15.1  9.6 12.7  9.6  4.4  3.9  0.0
 CUMULATIVE PERCENT      0.0  5.3  9.2 12.0 14.7 16.6 18.5 20.2 23.7 32.9 44.8 59.9 69.5 82.1 91.7 96.1100.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND =100.0% SILT =   0.0% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -1.73 -0.55  1.17  2.04  2.59  3.10  3.29  3.67         *** SAMPLE     BIMODAL  ***
MOMENT MEASURES MEAN   2.30  STDEV  1.19  SKEW -1.24  KURT  3.78
GRAPHIC (FOLK)  MEAN   2.35  STDEV  1.17  SKEW -0.41  KURT  1.63 INMAN SD 1.06 SK -0.33

H609
                 DATA    0.00 0.00 0.00 0.15 0.28 0.34 0.64 0.64 1.08 1.97 1.65 1.38 0.68 0.72 0.47 0.18 0.13 0.00
  FREQUENCY PERCENT      0.0  0.0  0.0  1.5  2.7  3.3  6.2  6.2 10.5 19.1 16.0 13.4  6.6  7.0  4.5  1.7  1.3  0.0
 CUMULATIVE PERCENT      0.0  0.0  0.0  1.5  4.2  7.5 13.6 19.8 30.3 49.4 65.4 78.9 85.4 92.5 97.0 98.7100.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND =100.0% SILT =   0.0% CLAY =   0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.33  1.08  1.60  1.88  2.26  2.67  2.94  3.37
MOMENT MEASURES MEAN   2.26  STDEV  0.69  SKEW -0.28  KURT  3.33
GRAPHIC (FOLK)  MEAN   2.27  STDEV  0.68  SKEW -0.01  KURT  1.19 INMAN SD 0.67 SK  0.02
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CLASS MIDPOINTS-PHI -2.50-0.75-0.25 0.25 0.75 1.13 1.38 1.63 1.88 2.13 2.38 2.63 2.88 3.13 3.38 3.63 3.88 5.50
CLASS LIMITS - PHI  -1.00-0.50 0.00 0.50 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00 REST

H610
                 DATA    0.00 0.58 0.52 0.31 0.24 0.18 0.24 0.25 0.51 1.24 1.60 2.23 1.72 2.70 2.45 1.26 1.14 0.00
  FREQUENCY PERCENT      0.0  3.4  3.0  1.8  1.4  1.0  1.4  1.5  3.0  7.2  9.3 13.0 10.0 15.7 14.2  7.3  6.6  0.0
 CUMULATIVE PERCENT      0.0  3.4  6.4  8.2  9.6 10.7 12.1 13.5 16.5 23.7 33.1 46.1 56.1 71.8 86.0 93.4100.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND =100.0% SILT =  0.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -1.32 -0.20  1.96  2.29  2.85  3.30  3.46  3.77
MOMENT MEASURES MEAN   2.59  STDEV  1.09  SKEW -1.58  KURT  5.19              *** SAMPLE     BIMODAL  ***
GRAPHIC (FOLK)  MEAN   2.75  STDEV  0.98  SKEW -0.36  KURT  1.61 INMAN SD 0.75 SK -0.19
H613
                 DATA    0.00 0.00 0.00 0.12 0.26 0.25 0.39 0.44 0.82 1.76 1.94 2.48 1.68 2.49 1.90 0.70 0.59 0.00
  FREQUENCY PERCENT      0.0  0.0  0.0  0.7  1.7  1.6  2.5  2.8  5.2 11.1 12.2 15.7 10.6 15.7 12.0  4.4  3.7  0.0
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.7  2.4  4.0  6.5  9.3 14.5 25.6 37.8 53.5 64.1 79.9 91.9 96.3100.0100.0
PROPORTIONS: GRAVEL =   0.0% SAND =100.0% SILT =  0.0% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   0.62  1.36  2.04  2.24  2.69  3.16  3.32  3.66
MOMENT MEASURES MEAN   2.65  STDEV  0.69  SKEW -0.68  KURT  3.61              *** SAMPLE     BIMODAL  ***
GRAPHIC (FOLK)  MEAN   2.69  STDEV  0.67  SKEW -0.09  KURT  1.02 INMAN SD 0.64 SK -0.02
H337
                 DATA    0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.08 0.09 0.08 0.17 0.46 0.86 1.4016.27
  FREQUENCY PERCENT      0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.4  0.5  0.4  0.9  2.3  4.4  7.2 83.8
 CUMULATIVE PERCENT      0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.4  0.9  1.3  2.2  4.5  9.0 16.2100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 16.2% SILT = 83.8% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)   2.82  3.53  3.99  4.22  4.69  5.17  5.39  5.85
MOMENT MEASURES MEAN   5.19  STDEV  0.72  SKEW -2.04  KURT  5.64
GRAPHIC (FOLK)  MEAN   4.69  STDEV  0.70  SKEW -0.00  KURT  1.00 INMAN SD 0.70 SK -0.00*** INSUFFICIENT  DATA  ***
H387/2
                 DATA    0.00 0.26 0.31 0.34 0.57 0.62 0.95 0.83 0.89 0.92 0.49 0.30 0.17 0.32 1.41 2.21 2.98 5.19
  FREQUENCY PERCENT      0.0  1.4  1.6  1.8  3.0  3.3  5.1  4.4  4.7  4.9  2.6  1.6  0.9  1.7  7.5 11.8 15.9 27.7
 CUMULATIVE PERCENT      0.0  1.4  3.0  4.8  7.9 11.2 16.3 20.7 25.4 30.4 33.0 34.6 35.5 37.2 44.7 56.5 72.3100.0
PROPORTIONS: GRAVEL =   0.0% SAND = 72.3% SILT = 27.7% CLAY =  0.0%

PERCENTILES (1,5,16,25,50,75,84,95)  -0.70  0.53  1.49  1.98  3.61  4.05  4.23  4.61
MOMENT MEASURES MEAN   3.38  STDEV  1.69  SKEW -0.33  KURT  2.22
GRAPHIC (FOLK)  MEAN   3.11  STDEV  1.30  SKEW -0.53  KURT  0.81 INMAN SD 1.37 SK -0.55
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	PERCENTILES								FOLK MEASURES				MOMENT MEASURES				
	1	5	16	25	50	75	84	95	MEAN	SDEV	SKEW	KURT	MEAN	SDEV	SKEW	KURT	WARNING
B548	2.34	2.61	2.93	3.17	3.89	5.25	5.89	7.20	4.26	1.42	0.41	0.91	4.28	1.20	-0.09	1.23	*
E43	2.17	2.45	2.78	3.03	3.74	5.70	6.62	8.51	4.38	1.85	0.54	0.93	4.18	1.27	-0.04	1.22	*
E45	2.49	2.80	3.04	3.12	3.30	3.61	3.91	4.55	3.42	0.48	0.42	1.46	3.57	0.83	1.59	4.33	
E46	2.36	2.72	3.02	3.10	3.28	3.53	3.81	4.40	3.37	0.45	0.35	1.58	3.50	0.78	1.75	5.24	
E47	2.15	2.43	2.71	2.97	3.74	5.44	6.24	7.88	4.23	1.71	0.47	0.91	4.15	1.28	-0.03	1.22	*
E48	2.06	2.23	2.30	2.46	2.65	3.19	8.49	22.14	4.51	4.54	0.93	11.12	3.22	1.23	1.23	2.69	*
E50	3.25	3.45	3.72	3.85	4.12	4.39	4.52	4.77	4.12	0.40	-0.01	1.02	4.82	0.88	-0.57	1.43	*
E56	2.33	2.61	2.85	2.98	3.23	4.02	4.67	6.61	3.65	1.11	0.66	1.58	3.71	1.08	0.90	2.14	
E57	2.28	2.50	2.86	3.01	3.30	3.85	4.29	5.13	3.48	0.74	0.41	1.19	3.68	1.02	0.97	2.45	
F565	-15.98	-6.72	2.19	2.51	3.23	9.20	12.29	18.56	5.90	6.36	0.50	1.55	3.34	2.51	-1.17	3.57	*
F566	1.20	2.50	2.85	2.99	3.17	3.36	3.46	4.07	3.16	0.39	0.05	1.72	3.23	0.69	1.25	9.19	
F567	-21.99	-12.47	-3.38	1.44	2.87	4.14	5.29	7.61	1.59	5.21	-0.48	3.04	2.32	2.81	-0.67	2.23	*
F568	1.66	2.12	2.39	2.54	3.21	5.81	7.29	10.31	4.30	2.47	0.70	1.03	3.79	1.42	0.19	1.44	*
F569	1.95	2.29	2.60	2.77	3.62	5.74	6.75	8.80	4.32	2.02	0.55	0.90	4.06	1.37	-0.10	1.61	*
F570	1.94	2.12	2.27	2.35	2.53	2.70	2.81	4.32	2.53	0.47	0.33	2.61	2.66	0.71	3.05	13.18	
F571	1.54	2.03	2.23	2.33	2.59	3.03	3.27	3.74	2.69	0.52	0.33	1.02	2.71	0.57	1.37	7.00	
H314	-1.98	-0.58	1.34	1.68	2.18	2.52	2.74	16.75	2.09	2.97	0.24	8.42	2.20	1.58	-0.08	5.09	*
H315	-0.85	0.73	1.35	1.52	1.88	2.10	2.18	2.39	1.81	0.46	-0.32	1.17	1.77	0.74	-0.98	16.28	
H316	-5.05	-2.99	-1.04	0.64	2.05	2.36	2.49	3.20	1.17	1.82	-0.69	1.48	1.30	2.00	-0.70	3.08	*
H317	-5.04	-3.19	-1.42	-0.55	1.48	2.42	2.93	15.97	1.00	3.99	0.09	2.64	1.17	2.42	0.01	2.36	*
H318	******	-97.08	-63.59	-47.11	*****	2.72	2.94	4.60	*****	32.04	-0.60	0.84	-0.23	2.81	-0.58	1.67	*
H319	0.72	2.37	2.90	3.03	3.23	3.42	3.52	4.19	3.22	0.43	-0.01	1.90	3.28	0.81	0.02	10.81	
H320	1.55	2.90	3.86	4.22	4.96	5.71	6.06	6.78	4.96	1.14	-0.03	1.06	5.06	0.98	-2.16	7.10	*
H321	0.97	2.74	3.00	3.09	3.28	3.46	3.61	4.14	3.30	0.36	0.15	1.58	3.36	0.73	0.58	9.83	
H326	-0.60	1.20	1.56	1.75	2.02	2.23	2.33	2.59	1.97	0.40	-0.19	1.19	1.96	0.68	-0.24	17.70	
H327	-0.93	0.25	1.48	1.85	3.33	4.99	5.70	7.12	3.50	2.10	0.11	0.90	3.40	1.98	-0.34	2.10	*
H328	-12.31	-9.36	-6.50	-5.17	-2.26	1.18	1.97	14.76	-2.28	5.79	0.20	1.56	-0.74	2.58	1.25	3.35	*
H329	-5.21	-3.00	-0.80	1.08	1.78	2.15	2.40	4.73	1.10	1.99	-0.43	2.56	1.27	1.94	-0.56	3.42	*
H330	-4.72	-3.20	-1.92	-1.24	1.13	2.23	3.20	15.98	0.81	4.20	0.17	2.27	0.76	2.69	0.31	2.06	*
H331	-0.19	2.06	2.86	3.00	3.10	3.36	3.72	7.51	3.25	1.04	0.46	5.98	3.34	1.08	0.15	5.41	*
H338	2.66	3.01	3.15	3.22	3.38	3.62	3.83	4.31	3.46	0.37	0.38	1.32	3.58	0.74	1.38	6.96	
H339	-0.25	1.35	1.95	2.26	2.68	3.25	5.99	14.24	3.54	2.96	0.72	5.34	3.03	1.43	0.31	3.94	*
H340	-3.51	-1.31	1.50	2.03	2.44	2.75	2.96	6.26	2.32	1.50	-0.12	4.30	2.19	1.01	-1.10	5.81	
H341	-0.20	1.60	2.26	2.50	2.76	3.07	3.25	20.83	2.76	3.16	0.43	13.92	2.96	1.17	0.61	5.31	*
H342	0.75	1.47	2.00	2.16	2.64	3.26	4.62	11.36	3.16	2.20	0.66	3.67	3.00	1.31	0.86	2.98	*
H343	0.39	2.23	2.86	3.01	3.17	3.37	3.49	5.08	3.17	0.59	0.17	3.25	3.28	0.92	0.37	6.79	
H350	0.56	2.37	2.99	3.14	3.41	4.10	4.71	5.94	3.70	0.97	0.47	1.52	3.77	1.18	0.04	3.38	
H351	0.30	2.17	2.47	2.55	2.70	2.94	3.14	22.22	2.77	3.21	0.63	21.08	2.94	1.01	1.19	6.52	*
H352	1.30	1.66	2.01	2.10	2.31	2.56	2.69	3.27	2.34	0.41	0.17	1.42	2.43	0.75	2.76	12.57	
H353	-0.04	1.66	2.21	2.40	2.75	3.15	3.37	6.84	2.78	1.08	0.33	2.84	2.93	1.09	0.84	4.99	*
H354	-0.17	1.58	2.10	2.34	2.68	3.00	3.23	6.79	2.69	1.06	0.30	2.96	2.82	1.05	0.35	5.72	
H355	2.91	3.21	3.30	3.43	3.66	4.02	4.19	4.55	3.74	0.41	0.31	0.93	4.04	0.90	0.82	2.31	
H356	2.85	3.04	3.24	3.30	3.43	3.61	3.73	3.98	3.46	0.27	0.20	1.26	3.52	0.50	2.04	12.77	
H362	-0.06	1.35	2.63	2.81	3.07	3.33	3.45	4.14	3.05	0.63	-0.14	2.18	3.06	0.93	-0.18	7.09	
H371	0.83	1.20	1.50	1.76	2.07	2.32	2.50	4.14	2.04	0.67	0.18	3.07	2.23	0.97	2.13	8.24	
H372	0.61	1.45	2.01	2.17	2.62	3.24	4.59	8.40	3.07	1.71	0.60	2.71	3.00	1.33	0.85	2.98	*
H373	-0.67	0.93	1.26	1.40	1.77	2.13	2.31	3.12	1.78	0.59	0.13	1.22	1.85	0.87	1.60	10.11	*
H374	-0.73	0.91	1.55	1.86	2.25	2.63	3.02	7.90	2.27	1.43	0.34	3.75	2.39	1.24	0.70	5.75	*
H376	-8.10	-4.77	-1.60	1.16	2.72	3.24	6.96	19.89	2.09	5.88	0.19	4.87	2.12	2.65	-0.64	2.35	*
H377	0.94	2.32	2.64	2.78	3.14	4.84	7.20	11.99	4.33	2.60	0.80	1.93	3.63	1.26	0.44	2.29	*
H378	-1.19	-0.50	1.04	2.18	3.43	5.45	6.49	8.61	3.65	2.74	0.13	1.14	3.44	2.09	-0.70	2.63	*

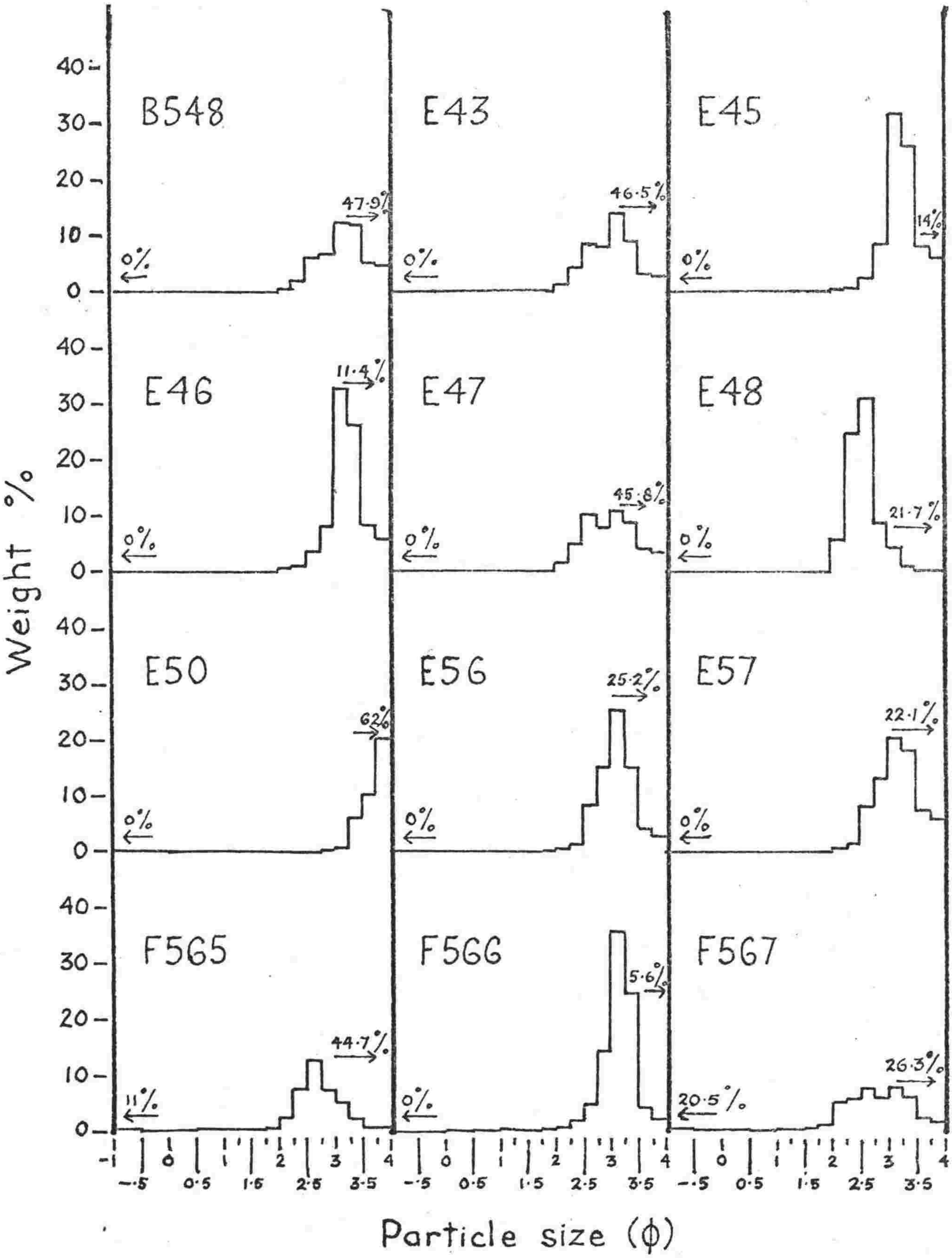
	PERCENTILES								FOLK MEASURES				MOMENT MEASURES				
	1	5	16	25	50	75	84	95	MEAN	SDEV	SKEW	KURT	MEAN	SDEV	SKEW	KURT	WARNING
H379	-0.05	2.14	3.00	3.13	3.50	6.51	7.98	10.97	4.83	2.58	0.75	1.07	4.10	1.39	-0.53	2.86	*
H380	0.39	2.33	2.86	3.04	3.32	7.48	10.27	15.95	5.49	3.91	0.87	1.26	3.95	1.34	-0.15	2.43	*
H381	0.62	1.21	1.71	2.00	2.30	2.64	2.87	3.33	2.29	0.61	-0.02	1.36	2.33	0.82	0.89	9.78	
H382	-0.83	0.25	1.18	1.43	1.97	2.45	3.02	5.07	2.06	1.19	0.22	1.93	2.06	1.20	0.92	5.12	*
H383	-1.24	-0.04	1.54	1.76	2.01	2.24	2.44	3.31	2.00	0.73	-0.14	2.89	1.94	1.12	-0.35	8.27	*
H384	-2.77	-0.93	0.93	1.22	1.65	2.03	2.17	2.66	1.58	0.86	-0.30	1.82	1.46	1.23	-1.03	7.57	
H385	-18.15	-14.77	-11.54	-9.96	-6.61	-3.27	-1.68	3.51	-6.61	5.24	0.05	1.12	-1.88	1.85	3.12	11.72	*
H386	-26.29	-20.28	-14.54	-11.72	-5.78	0.28	1.63	3.79	-6.23	7.69	-0.14	0.82	-1.16	2.30	1.52	4.17	*
H392	1.25	2.12	3.20	4.11	5.47	6.83	7.48	8.79	5.39	2.08	-0.03	1.00	4.85	1.25	-1.65	4.38	*
H395	-2.93	-1.57	-0.09	1.32	1.92	2.21	2.39	7.68	1.41	2.02	-0.19	4.25	1.54	1.72	-0.56	4.42	*
H402	-0.66	1.13	1.56	1.78	2.11	7.19	24.34	59.19	9.34	14.49	0.96	4.40	2.82	1.73	0.54	2.44	*
H405	3.33	3.67	4.00	4.17	4.51	4.86	5.02	5.35	4.51	0.51	-0.00	1.00	5.22	0.66	-1.97	5.16	*
H407	2.56	3.52	3.94	4.14	4.57	5.00	5.20	5.61	4.57	0.63	-0.00	1.00	5.15	0.76	-1.94	5.68	*
H414	-0.76	0.69	1.85	2.15	4.04	5.22	5.77	6.91	3.89	1.92	-0.10	0.83	3.91	1.65	-0.60	2.66	*
H415	2.02	2.64	2.83	2.91	3.11	3.30	3.55	4.47	3.16	0.46	0.34	1.56	3.29	0.81	1.14	7.83	
H416	-0.37	1.36	2.07	2.32	4.35	5.86	6.01	8.08	4.34	2.15	0.05	0.77	4.12	1.70	-0.72	2.15	*
H421	-1.36	-0.02	1.60	1.88	2.18	2.43	2.57	3.34	2.12	0.75	-0.25	2.47	2.12	1.16	-0.46	9.00	
H422	-2.61	-0.91	1.12	1.64	2.10	2.39	2.58	10.95	1.93	2.16	0.07	6.52	1.96	1.57	-0.39	5.40	*
H423	-0.63	0.82	1.43	1.61	1.93	2.17	2.29	2.93	1.88	0.54	-0.11	1.54	1.93	0.91	0.65	11.77	
H424	-3.85	-2.22	-0.67	0.26	1.82	3.12	3.99	11.53	1.72	3.25	0.17	1.97	1.71	2.38	-0.12	2.42	*
H425	-0.54	0.83	2.08	2.28	2.64	3.05	3.17	3.49	2.63	0.68	-0.20	1.42	2.59	0.95	-0.45	7.76	*
H427	0.16	1.83	2.82	3.02	3.24	3.57	3.98	4.89	3.35	0.75	0.17	2.28	3.42	1.10	0.14	4.54	
H428	-1.63	0.07	1.36	1.66	2.03	2.33	2.73	4.06	2.05	0.94	0.03	2.43	2.03	1.25	-0.14	7.24	
H429	-1.10	0.50	1.61	1.80	2.06	2.23	2.34	2.72	2.00	0.52	-0.31	2.10	1.97	0.92	-0.57	13.08	
H430	-2.27	-0.64	1.39	1.80	2.13	2.36	2.47	2.94	2.00	0.61	-0.46	2.65	1.90	1.29	-1.05	7.71	
H431	-3.01	-1.65	-0.26	1.29	2.02	2.33	2.48	3.23	1.41	1.43	-0.59	1.94	1.53	1.75	-0.69	4.14	
H432	-2.35	-0.29	1.86	2.05	2.28	2.46	2.59	2.91	2.24	0.67	-0.38	3.07	2.12	1.16	-1.62	10.95	*
H433	-0.59	1.10	1.55	1.71	1.99	2.22	2.37	2.95	1.97	0.48	-0.01	1.47	2.03	0.93	1.41	10.48	
H434	-0.09	2.06	2.34	2.91	5.52	7.80	8.97	11.23	5.61	3.06	-0.14	0.76	4.48	1.53	-1.12	3.04	*
H435	2.41	3.21	3.46	3.65	4.25	4.87	5.17	5.76	4.29	0.81	0.13	0.86	4.70	1.06	-1.02	4.10	*
H436	2.76	2.99	3.14	3.33	3.38	3.63	3.80	4.14	3.44	0.34	0.29	1.14	3.55	0.65	2.05	7.50	*
H437	2.94	3.13	3.23	3.35	3.51	3.87	4.06	4.44	3.62	0.39	0.41	1.03	3.84	0.64	1.08	4.04	
H441	3.19	3.56	3.63	3.95	4.20	4.44	4.56	4.80	4.20	0.37	-0.01	1.03	4.97	0.85	-1.36	4.96	*
H442	2.65	3.15	3.35	3.45	3.90	4.60	4.93	5.60	4.06	0.76	0.34	0.87	4.40	1.07	-0.23	2.29	*
H443	2.18	2.47	2.99	4.03	6.64	9.25	10.48	13.00	6.70	3.47	0.12	0.83	4.85	1.17	-1.35	3.16	*
H444	0.01	1.60	1.95	2.05	2.23	2.42	2.52	2.77	2.23	0.32	-0.02	1.31	2.25	0.64	1.01	17.76	
H445	0.04	2.31	2.77	2.92	3.15	3.36	3.52	4.44	3.15	0.51	-0.09	1.90	3.25	0.87	0.56	7.13	
H446	0.15	1.53	2.32	2.53	2.93	3.19	3.32	4.19	2.86	0.64	-0.12	1.60	2.90	0.91	0.35	6.95	
H447	0.50	2.02	2.32	2.46	2.74	3.09	3.22	3.85	2.76	0.50	0.14	1.19	2.82	0.79	0.89	9.03	*
H450	2.09	2.80	3.07	3.16	3.38	3.77	4.06	4.64	3.50	0.52	0.37	1.23	3.68	0.92	0.99	3.80	
H452	2.24	2.54	2.70	2.79	3.03	3.36	4.18	7.18	3.31	1.07	0.67	3.33	3.38	1.00	1.37	3.64	*
H453	2.06	2.51	2.63	2.77	3.06	5.60	9.54	17.42	5.09	3.97	0.91	2.12	3.65	1.24	0.62	2.05	*
H454	2.76	3.14	3.52	4.09	5.35	6.61	7.21	8.42	5.36	1.72	0.08	0.86	5.00	0.93	-1.46	3.66	*
H455	3.32	3.50	3.70	3.81	4.06	4.31	4.43	4.66	4.06	0.36	0.03	0.96	4.73	0.89	-0.39	1.58	*
H458	3.05	3.24	3.36	3.42	3.64	4.12	4.36	4.85	3.79	0.50	0.48	0.94	4.11	0.94	-0.72	1.69	
H460	2.79	3.01	3.15	3.22	3.40	3.70	3.90	4.31	3.49	0.38	0.36	1.10	3.64	0.75	1.78	4.95	
H461	3.22	3.39	3.56	3.72	4.10	4.46	4.67	5.04	4.12	0.52	0.10	0.89	4.70	0.93	-0.36	1.25	*
H462	2.70	3.09	3.25	3.32	3.46	3.76	3.95	4.32	3.55	0.36	0.40	1.14	3.72	0.77	1.36	4.99	
H463	0.86	1.86	2.21	2.41	4.38	10.87	13.95	20.21	6.65	5.71	0.68	0.89	4.01	1.60	-0.29	1.43	*
H466	0.01	0.98	2.60	2.82	3.07	3.25	3.38	4.36	3.02	0.71	-0.22	3.25	3.01	0.99	-0.18	6.18	
H467	2.88	3.25	3.90	4.47	5.67	6.87	7.44	8.60	5.67	1.70	0.05	0.91	5.14	0.80	-1.84	4.61	*

	PERCENTILES 1	5	16	25	50	75	84	95	FOLK MEASURES MEAN	SDEV	SKEW	KURT	MOMENT MEASURES MEAN	SDEV	SKEW	KURT	WARNING
H470	-8.71	-6.01	-3.44	-2.17	1.82	63.83	*****	*****	35.57	58.95	0.91	1.27	1.60	3.54	-0.02	1.24	*
H472	2.06	2.34	2.67	2.94	4.77	7.60	9.05	11.86	5.50	3.04	0.42	0.82	4.37	1.35	-0.47	1.50	*
H782	-11.87	-8.67	-5.63	-4.13	-0.96	2.12	3.59	4.71	-1.00	4.33	-0.08	0.88	-0.06	2.86	0.75	2.14	*
H783	0.45	1.20	2.25	2.60	3.02	3.20	3.32	4.31	2.86	0.73	-0.29	2.06	2.91	0.92	0.28	6.08	
H784	-0.20	1.31	2.71	2.90	3.17	3.40	4.46	7.17	3.45	1.33	0.42	4.15	3.37	1.24	-0.00	4.08	*
H785	-0.54	1.09	2.61	2.81	3.14	3.97	5.51	8.65	3.76	1.87	0.55	2.67	3.44	1.40	-0.15	3.54	*
H786	0.79	2.41	3.04	3.22	5.13	7.51	8.64	10.94	5.60	2.69	0.31	0.81	4.54	1.32	-0.96	2.99	*
H787	-0.34	0.82	1.96	2.55	3.61	4.64	5.11	6.07	3.56	1.58	-0.06	1.03	3.73	1.70	-0.46	2.24	*
H791	-0.37	1.45	2.66	2.94	3.13	3.30	3.41	5.00	3.07	0.73	-0.10	4.07	3.10	1.00	-0.26	6.93	
H792	-0.78	1.07	2.64	2.86	3.21	5.09	7.03	10.99	4.29	2.60	0.66	1.82	3.61	1.47	-0.30	3.17	*
H793	-0.75	0.52	2.43	2.68	3.12	4.56	7.25	12.69	4.27	3.05	0.64	2.62	3.40	1.53	-0.22	2.98	*
H794	-0.24	1.79	2.63	2.86	3.41	6.02	7.38	10.16	4.47	2.46	0.64	1.09	3.92	1.49	-0.37	2.47	*
H795	-0.63	0.54	1.06	1.21	1.54	1.97	2.14	2.63	1.58	0.59	0.07	1.13	1.63	0.89	1.83	10.98	
H796	1.00	2.54	3.04	3.17	3.47	4.06	4.36	4.98	3.62	0.70	0.30	1.12	3.84	1.12	0.16	3.12	
H798	2.72	3.12	3.29	3.38	3.59	3.92	4.08	4.41	3.66	0.39	0.26	0.97	3.90	0.86	0.94	3.29	
H799	2.69	3.36	3.60	3.71	3.92	4.13	4.23	4.42	3.92	0.31	-0.03	1.03	4.41	0.93	-0.04	2.49	
H800	1.34	3.21	3.64	3.83	4.14	4.45	4.60	4.91	4.13	0.50	-0.07	1.11	4.74	1.05	-1.25	4.77	*
H801	1.72	2.91	3.23	3.41	4.23	5.05	5.44	6.23	4.30	1.06	0.15	0.83	4.56	1.16	-0.72	2.55	*
H802	0.40	2.11	3.15	3.38	4.48	5.87	6.54	7.86	4.72	1.72	0.20	0.95	4.47	1.36	-1.05	3.43	*
H803	0.31	1.57	3.21	3.93	5.36	6.79	7.47	8.85	5.35	2.17	-0.03	1.04	4.74	1.40	-1.70	4.86	*
H804	1.11	3.59	4.05	4.49	5.44	6.39	6.84	7.73	5.44	1.40	-0.00	1.01	5.13	0.96	-2.86	11.82	*
H805	1.35	3.04	3.85	4.16	4.31	5.45	5.76	6.38	4.61	0.98	-0.03	1.06	5.05	0.98	-2.30	8.53	*
H807	-0.40	0.30	1.07	1.71	3.35	4.15	4.50	5.20	2.97	1.60	-0.29	0.82	3.26	1.61	-0.23	1.93	*
J433	3.15	3.39	3.57	3.66	3.93	4.19	4.32	4.57	3.94	0.37	0.05	0.95	4.46	0.92	0.16	1.23	*
J439	2.33	2.54	2.73	2.82	3.04	3.35	3.58	4.42	3.11	0.50	0.37	1.46	3.26	0.60	1.96	6.10	
J445	2.07	2.75	2.91	2.99	3.16	3.35	3.45	3.93	3.18	0.31	0.19	1.32	3.24	0.57	2.31	11.72	
J448	-1.07	-0.21	1.29	1.51	1.93	2.17	2.28	2.61	1.83	0.68	-0.40	1.76	1.76	0.95	-0.94	10.15	
J451	2.39	2.69	2.89	2.98	3.20	3.37	3.45	3.73	3.18	0.30	-0.04	1.07	3.21	0.42	1.99	15.88	
J456	2.09	2.49	2.72	2.81	3.00	3.21	3.30	3.47	3.01	0.30	-0.01	1.01	3.02	0.40	1.76	16.28	
J459	2.14	2.40	2.72	2.81	3.00	3.23	3.34	3.67	3.02	0.34	0.12	1.16	3.06	0.51	2.46	14.11	
J461	2.51	2.85	3.06	3.15	3.34	3.55	3.62	4.50	3.41	0.44	0.33	1.69	3.55	0.78	1.69	5.13	
J463	2.74	3.01	3.11	3.17	3.28	3.39	3.45	3.66	3.28	0.16	0.08	1.20	3.32	0.36	4.07	25.84	
H599	-0.74	0.49	1.11	1.28	1.67	2.15	2.40	3.07	1.73	0.71	0.11	1.21	1.71	0.77	-0.16	4.10	
H601	1.85	2.19	2.57	2.75	3.13	3.40	3.54	3.78	3.08	0.48	-0.17	0.99	3.07	0.49	-0.54	3.32	
H604	1.16	1.85	2.26	2.46	2.90	3.29	3.44	3.76	2.87	0.59	-0.10	0.94	2.85	0.61	-0.60	3.73	*
H606	-0.46	1.13	1.56	1.79	2.09	2.37	2.53	3.00	2.07	0.52	-0.05	1.32	2.05	0.63	-1.09	7.40	
H607	-1.73	-0.55	1.17	2.04	2.59	3.10	3.29	3.67	2.35	1.17	-0.41	1.63	2.30	1.19	-1.24	3.78	*
H609	0.33	1.08	1.60	1.88	2.26	2.67	2.94	3.37	2.27	0.68	-0.01	1.19	2.26	0.69	-0.28	3.33	
H610	-1.32	-0.20	1.96	2.29	2.85	3.30	3.46	3.77	2.75	0.98	-0.36	1.61	2.59	1.09	-1.58	5.19	*
H613	0.62	1.36	2.04	2.24	2.69	3.16	3.32	3.66	2.69	0.67	-0.09	1.02	2.65	0.69	-0.68	3.61	*
H337	2.82	3.53	3.99	4.22	4.69	5.17	5.39	5.85	4.69	0.70	-0.00	1.00	5.19	0.72	-2.04	5.64	*
H387/2	-0.70	0.53	1.49	1.98	3.61	4.05	4.23	4.61	3.11	1.30	-0.53	0.81	3.38	1.09	-0.33	2.22	

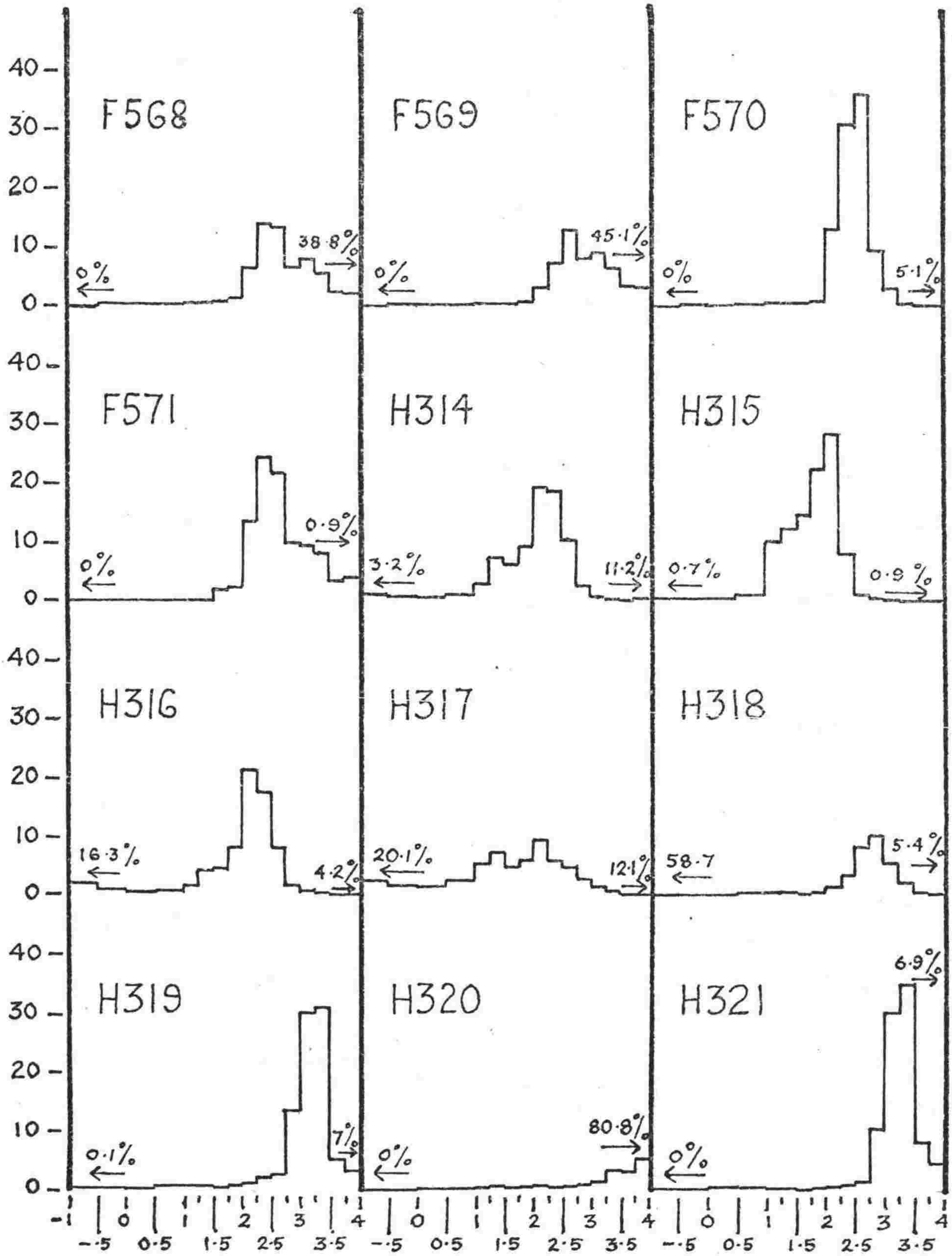
APPENDIX 3

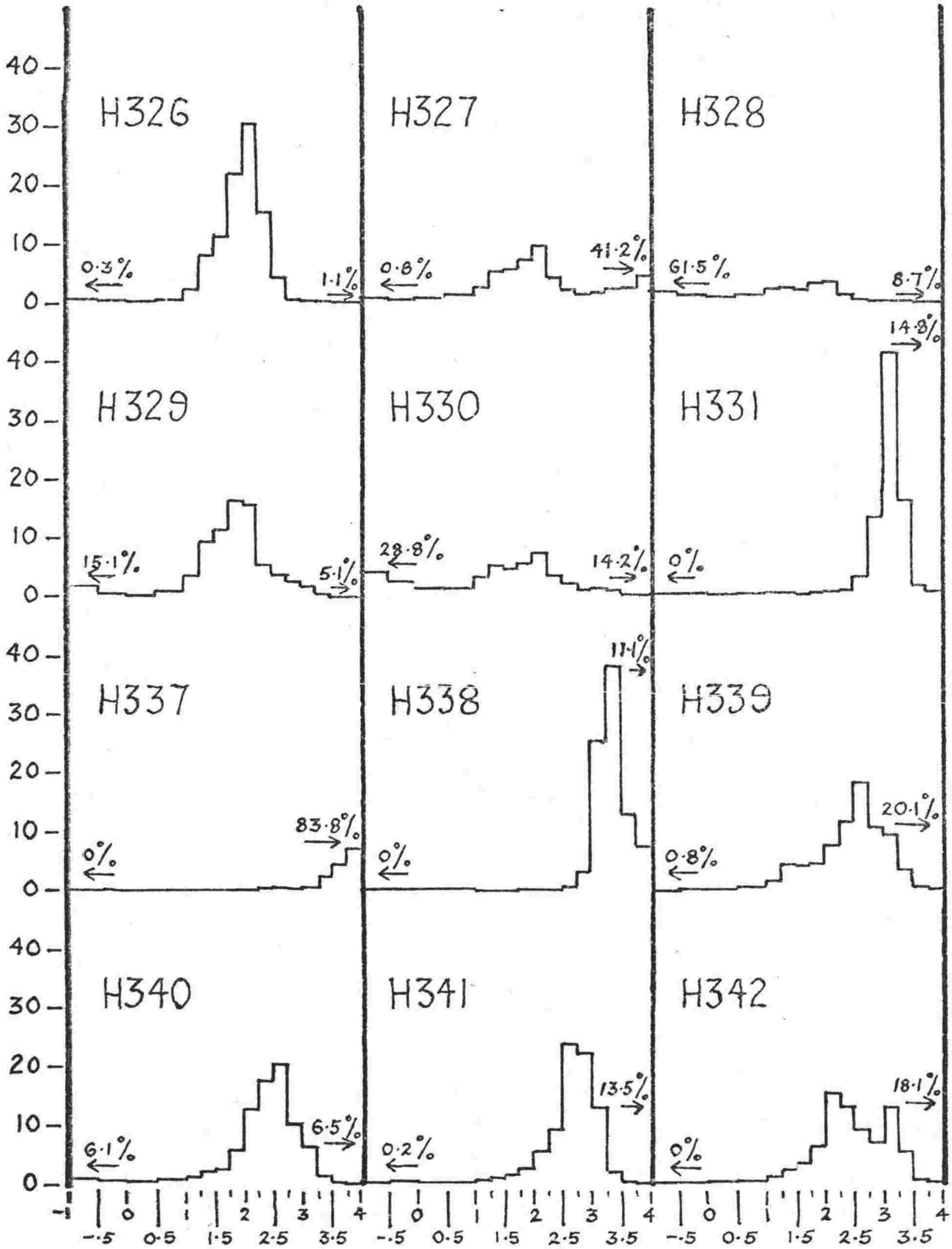
Histograms of grain-size distribution
in the sand range.

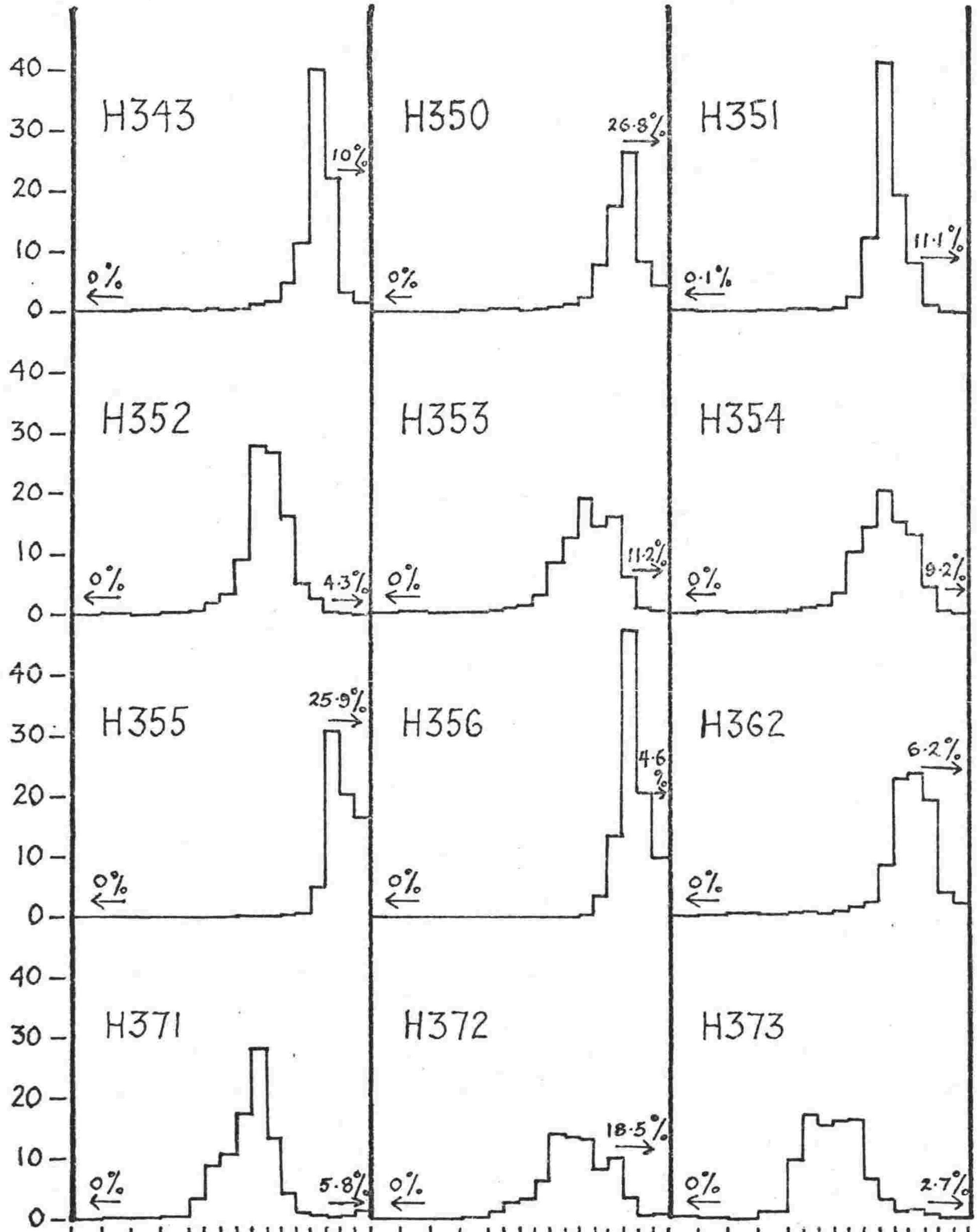
- The gravel content and mud content are noted on the left and right hand sides of each histogram.



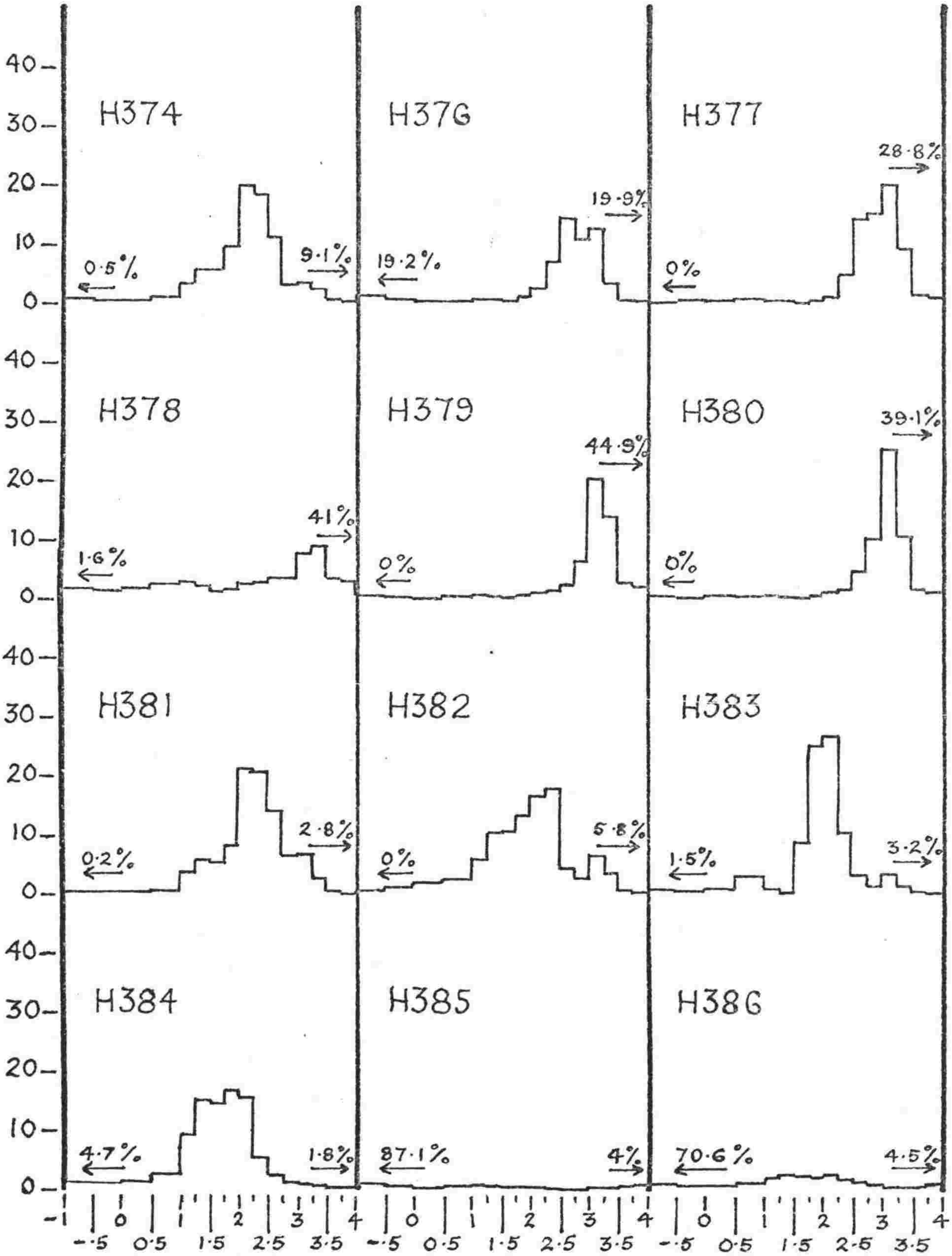
B548
E43
E45
E46
E47
E48
E50
E56
E57
F565
F566
F567
47·9%
46·5%
14%
11·4%
45·8%
21·7%
62%
25·2%
22·1%
44·7%
5·6%
26·3%
0%
11%
20·5%
Weight %
Particle size (ϕ)


F568
F569
F570
F571
H314
H315
H316
H317
H318
H319
H320
H321
0%
38.8%
0%
45.1%
0%
5.1%
0%
0.9%
3.2%
11.2%
0.7%
0.9%
16.3%
4.2%
20.1%
12.1%
58.7
5.4%
0.1%
7%
0%
80.8%
0%
6.9%
40
30
20
10
0
-1
0
1
2
3
4
-.5
0.5
1.5
2.5
3.5

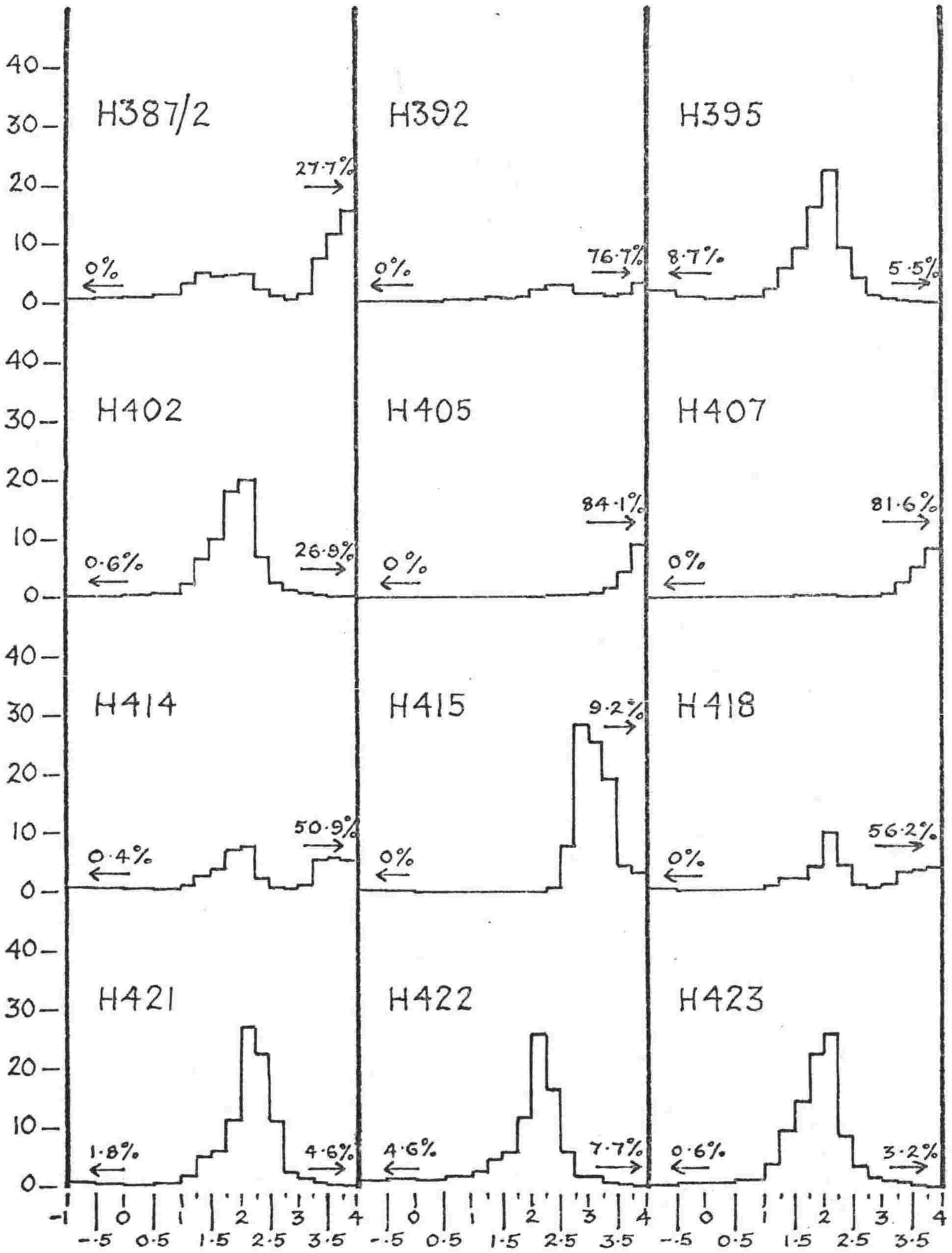

H326
0.3%
1.1%
H327
0.8%
41.2%
H328
61.5%
8.7%
H329
15.1%
5.1%
H330
28.8%
14.2%
H331
0%
14.8%
H337
0%
83.8%
H338
0%
11.1%
H339
0.8%
20.1%
H340
6.1%
6.5%
H341
0.2%
13.5%
H342
0%
18.1%
0
10
20
30
40
-1
-.5
0
0.5
1
1.5
2
2.5
3
3.5
4



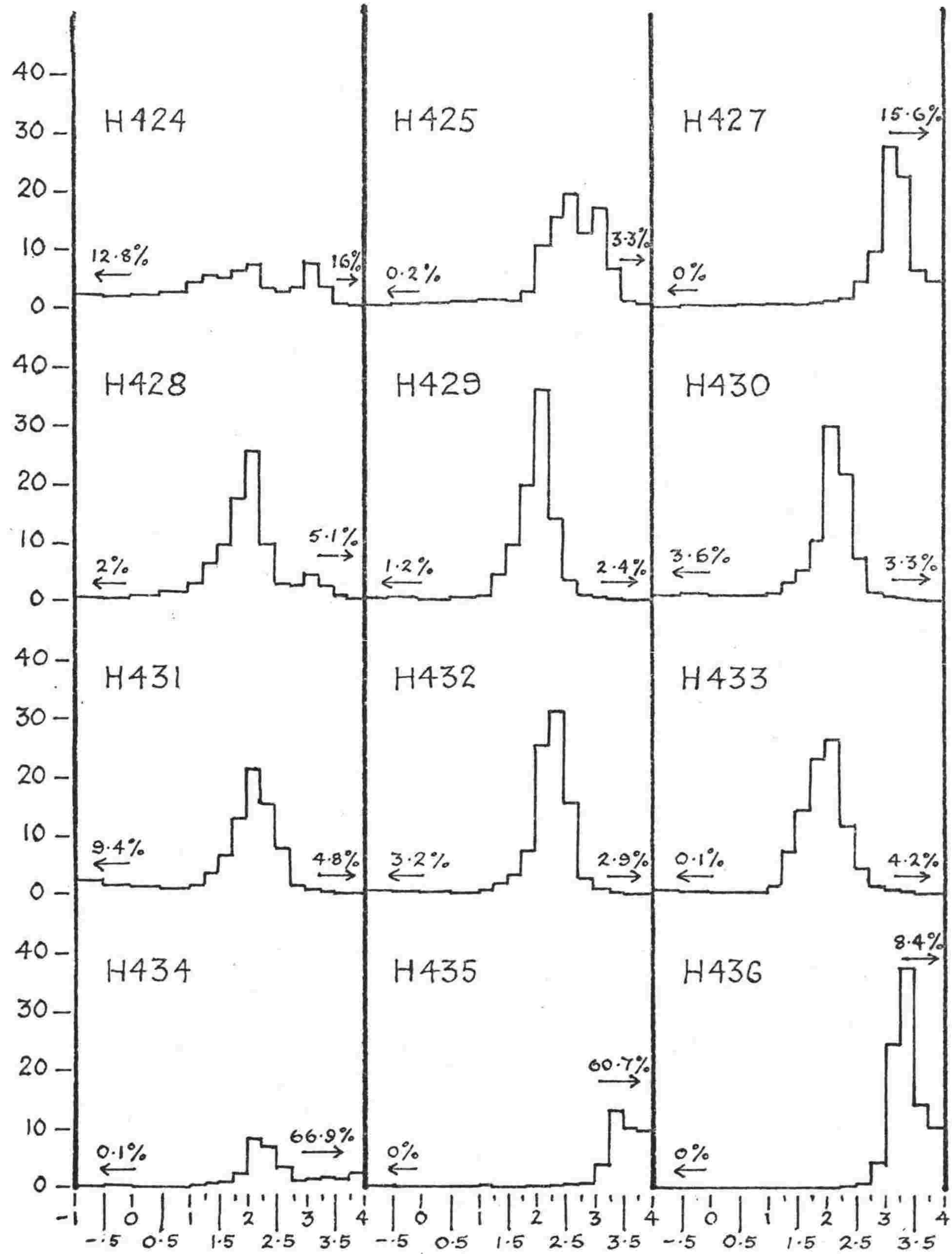
H343
H350
H351
H352
H353
H354
H355
H356
H362
H371
H372
H373
10%
26·8%
11·1%
0·1%
4·3%
11·2%
9·2%
25·9%
4·6%
6·2%
5·8%
18·5%
2·7%
0%
40
30
20
10
0
-1
0
1
2
3
4
-·5
0·5
1·5
2·5
3·5

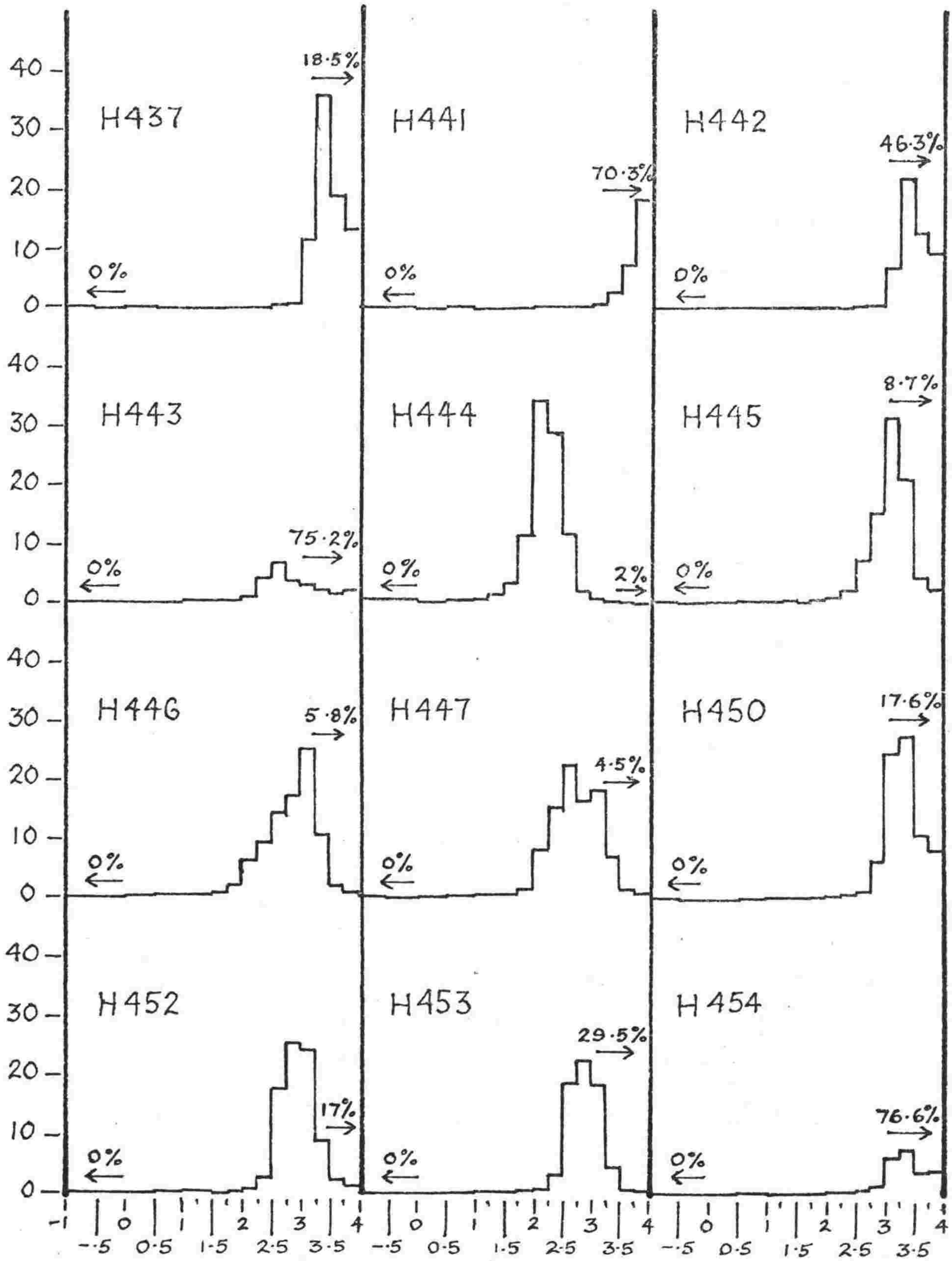


H374
0·5%
9·1%
H376
19·2%
19·9%
H377
0%
28·8%
H378
1·6%
41%
H379
0%
44·9%
H380
0%
39·1%
H381
0·2%
2·8%
H382
0%
5·8%
H383
1·5%
3·2%
H384
4·7%
1·8%
H385
87·1%
4%
H386
70·6%
4·5%
0
10
20
30
40
-1
0
1
2
3
4
-·5
0·5
1·5
2·5
3·5

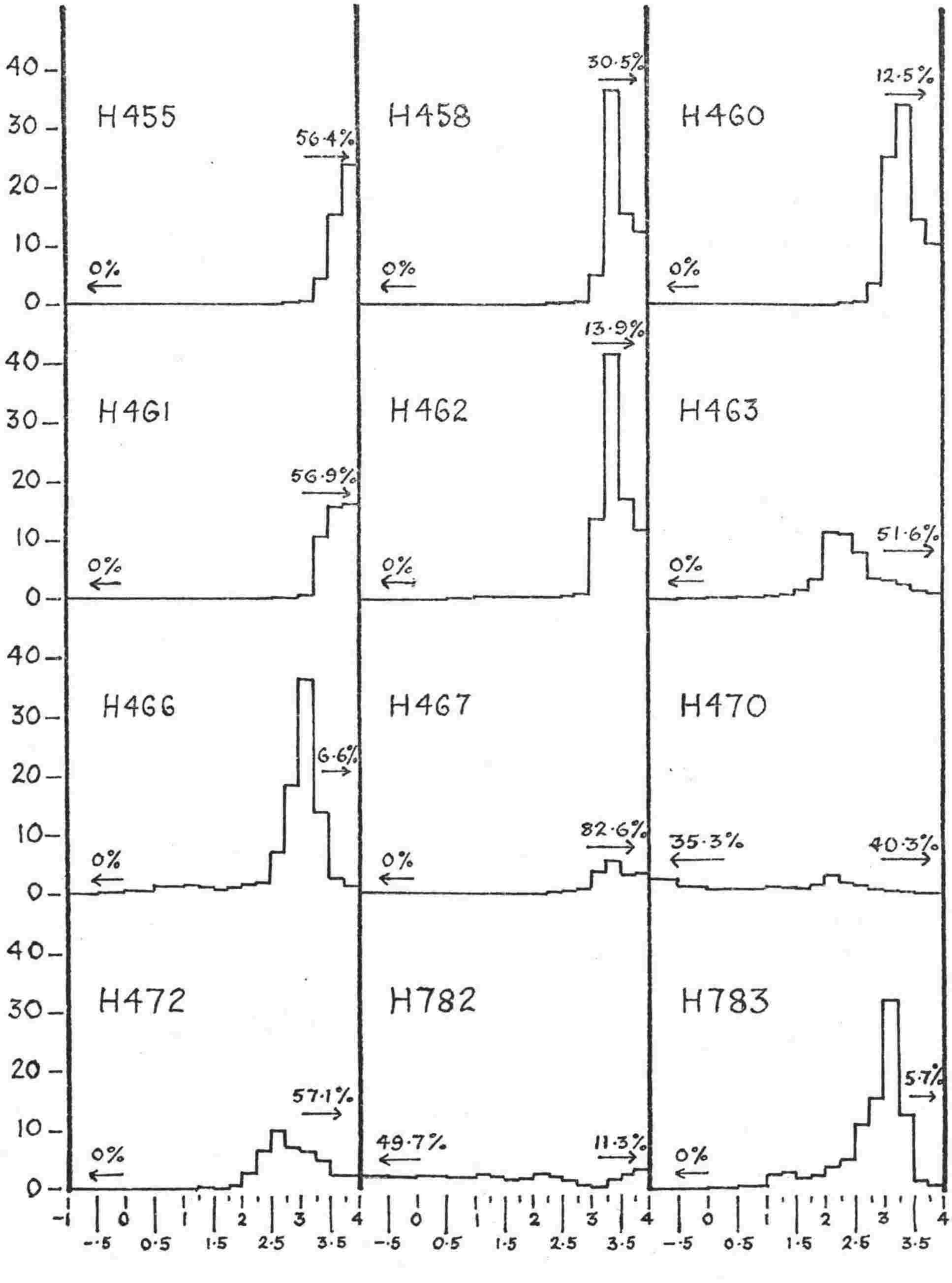


H387/2
27·7%
0%
H392
0%
76·7%
H395
8·7%
5·5%
H402
0·6%
26·9%
H405
84·1%
0%
H407
81·6%
0%
H414
0·4%
50·9%
H415
9·2%
0%
H418
0%
56·2%
H421
1·8%
4·6%
H422
4·6%
7·7%
H423
0·6%
3·2%
40
30
20
10
0
-1
0
1
2
3
4
-·5
0·5
1·5
2·5
3·5

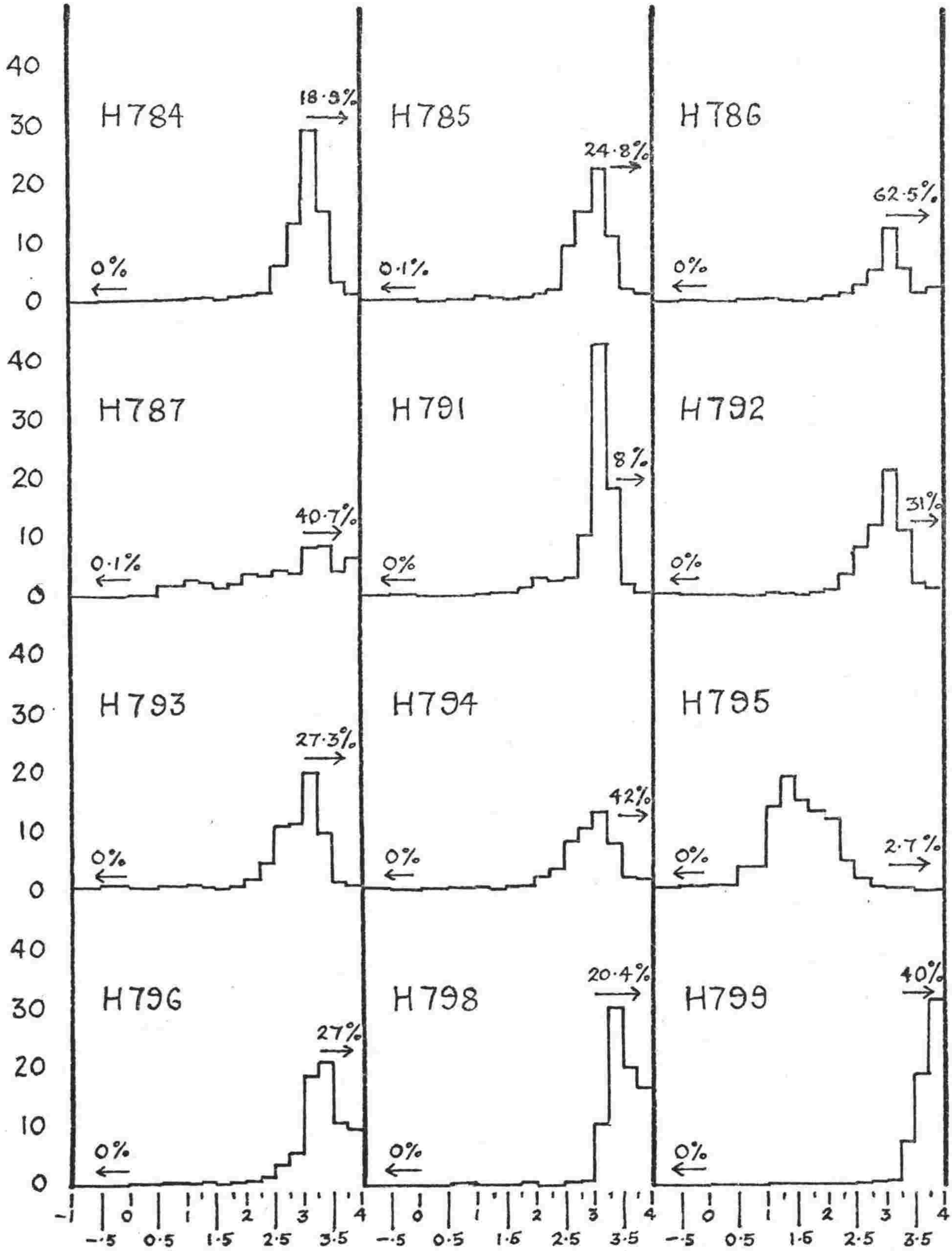

H424
H425
H427
H428
H429
H430
H431
H432
H433
H434
H435
H436
12·8%
16%
0·2%
3·3%
0%
15·6%
2%
5·1%
1·2%
2·4%
3·6%
3·3%
9·4%
4·8%
3·2%
2·9%
0·1%
4·2%
0·1%
66·9%
0%
60·7%
0%
8·4%
0
10
20
30
40
-1
0
1
2
3
4
-·5
0·5
1·5
2·5
3·5



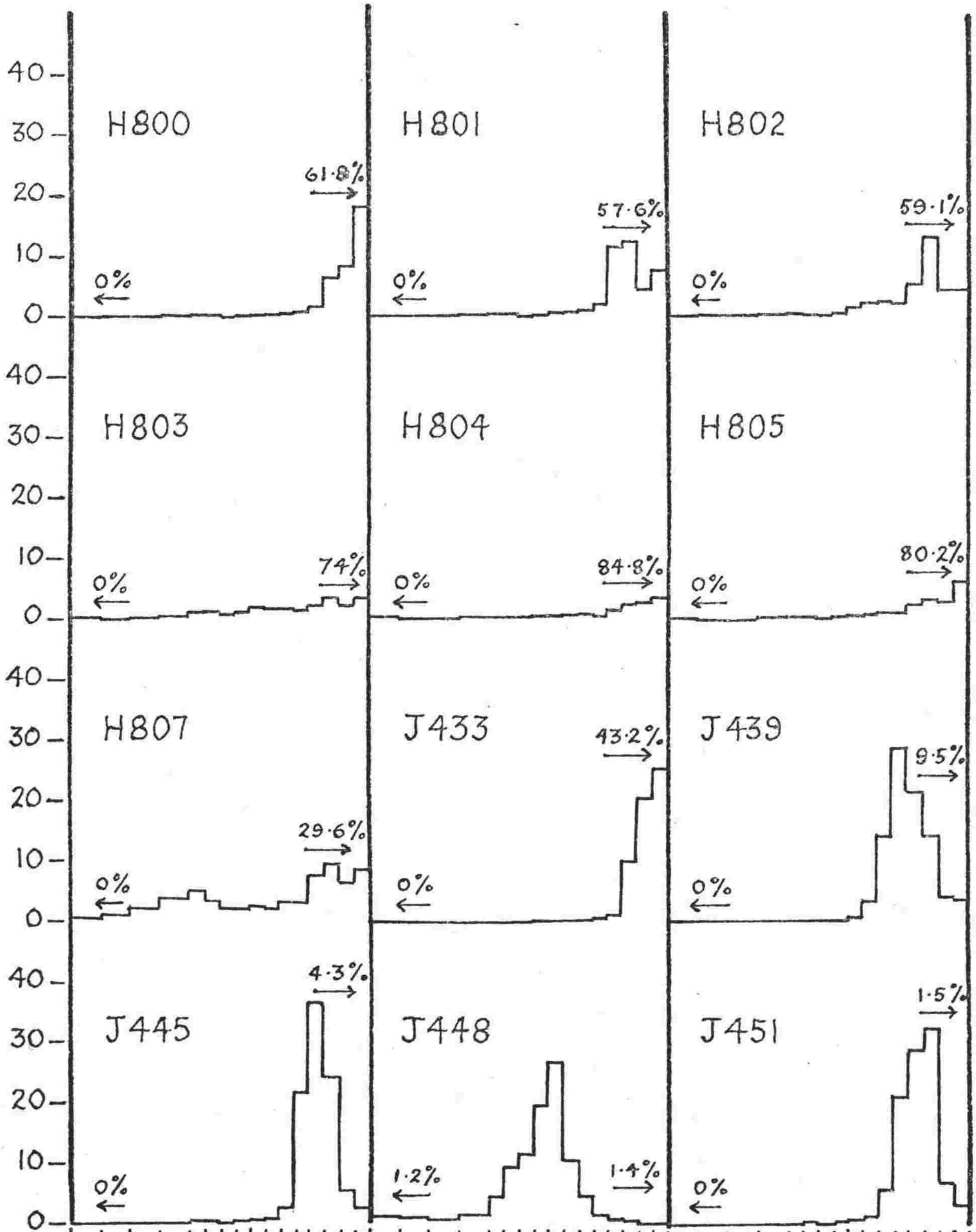
H437
18·5%
0%
H441
70·3%
0%
H442
46·3%
0%
H443
75·2%
0%
H444
0%
2%
H445
8·7%
0%
H446
5·8%
0%
H447
4·5%
0%
H450
17·6%
0%
H452
17%
0%
H453
29·5%
0%
H454
76·6%
0%
0
10
20
30
40
-1
0
1
2
3
4
-·5
0·5
1·5
2·5
3·5



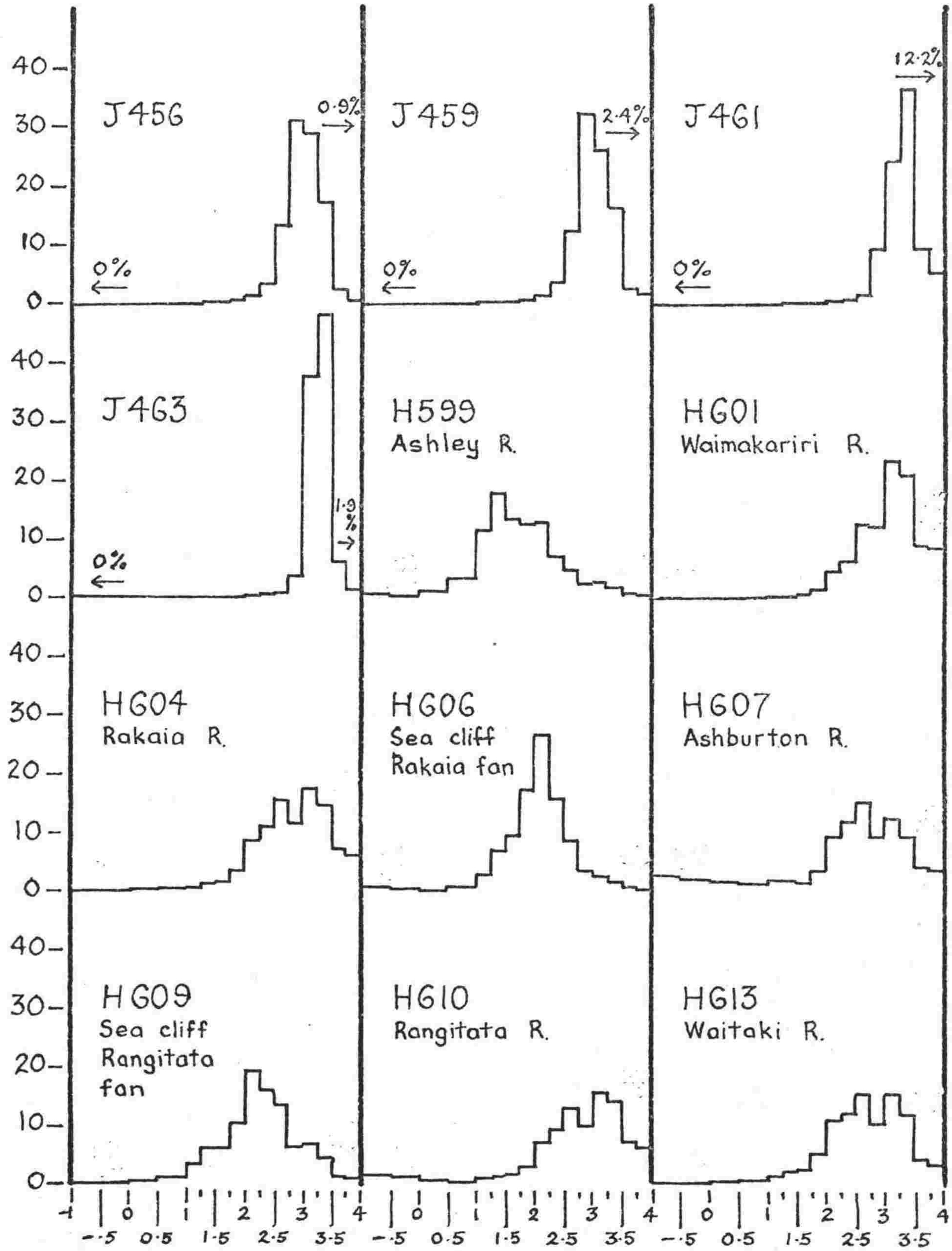
H455
56·4%
0%
H458
30·5%
0%
H460
12·5%
0%
H461
56·9%
0%
H462
13·9%
0%
H463
51·6%
0%
H466
6·6%
0%
H467
82·6%
0%
H470
35·3%
40·3%
H472
57·1%
0%
H782
49·7%
11·3%
H783
5·7%
0%
40
30
20
10
0
-1
0
1
2
3
4
-·5
0·5
1·5
2·5
3·5



H784
18·9%
0%
H785
24·8%
0·1%
H786
62·5%
0%
H787
40·7%
0·1%
H791
8%
0%
H792
31%
0%
H793
27·3%
0%
H794
42%
0%
H795
2·7%
0%
H796
27%
0%
H798
20·4%
0%
H799
40%
0%
0
10
20
30
40
-1
0
1
2
3
4
-·5
0·5
1·5
2·5
3·5



H800
61·8%
0%
H801
57·6%
0%
H802
59·1%
0%
H803
74%
0%
H804
84·8%
0%
H805
80·2%
0%
H807
29·6%
0%
J433
43·2%
0%
J439
9·5%
0%
J445
4·3%
0%
J448
1·2%
1·4%
J451
1·5%
0%
0
10
20
30
40
-1
0
1
2
3
4
-·5
0·5
1·5
2·5
3·5



J456
0.9%
0%
J459
2.4%
0%
J461
12.2%
0%
J463
1.9 %
0%
H599
Ashley R.
H601
Waimakariri R.
H604
Rakaia R.
H606
Sea cliff
Rakaia fan
H607
Ashburton R.
H609
Sea cliff
Rangitata
fan
H610
Rangitata R.
H613
Waitaki R.
0
10
20
30
40
-1
0
1
2
3
4
-.5
0.5
1.5
2.5
3.5

H347

Cm	
0-22	Graded. Greyish olive 10Y 4/2 foram-rich sand at top. Massive greenish grey 5GY 5/1 clay at 22 cm. Gradation caused by burrowing which decreases downwards. Sand fills burrows
22-424	Massive greenish grey 5GY 5/1 clay with sporadic indistinct lenses of dark bluish grey 5B 6/1 clay, discontinuous partings of reddish brown filamentous organic material and fine black wispy trails. Faint bedding suggested by colour differences
(41)	Sand lamina
(142-143)	Indistinct layer of dark bluish grey clay
(164-166)	Indistinct layer of dark bluish grey clay
(184-200)	Bluish grey clay layer
(245-257)	Slightly sandier due to high foram content
(397-424)	Horizontal bedding revealed by lenticular laminae of dark bluish grey clay
424	End of core

H349

Cm	
0-40	Graded. Greyish olive 10Y 4/2 foram-rich sand at top. Massive greenish grey 5GY 5/1 clay at 40 cm. Gradation caused by burrowing (intensely burrowed at top, moderately burrowed at 20 cm , sparsely burrowed at 40 cm. Sand fills burrows
40-439	Massive greenish grey 5GY 5/1 clay with sporadic, indistinct lenses of dark bluish grey 5B 6/1 clay. Extensively burrowed, some with fine black trails. Below 270 cm burrows are larger and more obvious. Numerous colonies of calcareous worm tubes throughout core
(66-67)	Indistinct layer of dark bluish grey clay
(81-82)	Lamina of medium dark grey N4 silt
(107-109)	Lamina of medium dark grey silt
(115)	Silt lamina as above
(124)	Silt lamina as above
(169)	Bivalve (articulated)
(219)	Silt lamina as above
(240-242)	Silt lamina as above
(328)	Sand pocket
(364-367)	Layer of dark bluish grey 5B 6/1 clay
(420-422)	Indistinct layer of dark bluish grey clay
439	End of core

H350

Cm	
0-8	Clay (settled out of suspension after deck handling)
8-83	Structureless, dark greenish grey 5GY 4/1 muddy, very fine (Mode IV) sand
83-100	Greyish olive 10Y 4/2 muddy, very fine (Mode IV) sand with several large shells. (Shell and sediment subsample)
100-122	Bioturbated, muddy, very fine sand of both colours (above) and dark greenish grey 5GY 4/1 sandy mud. Traces of bedding preserved
122-235	Extensively bioturbated dark greenish grey 5GY 4/1 silty, very fine (Mode IV) sand, medium greenish grey 5GY 5/1 clayey silt, and greyish olive 10Y 4/2 silty, very fine (Mode IV) sand. No trace of bedding left
235	End of core

H353

Cm	
0-8	Greyish olive 10Y 4/2 fine to medium (Mode III/II) shelly sand. (Sediment subsample)
8-32	Shell bed in sand as above. No preferred orientation of shells. (Shell and sediment subsample)
32-160	Medium greenish grey 5GY 5/1 and greyish olive mottled fine to medium (Mode III/II) sand and scattered shells
160	End of core

H403

Cm	
0-24	Graded unit. Greyish olive 10Y 5/2, fine to medium (Mode III/II) sand grading downwards to moderate olive grey 5Y 4/2 shelly, pebbly sand at base. Pebbles are iron-stained, well rounded quartz. (Grading may be due to settling in core after deck handling)
24-50	Light greyish olive 10Y 5/2 fine to medium (Mode III/II) sand with scattered shells and well rounded quartz pebbles (commonly iron-stained). Pebble concentration increases downwards. Shells tend to show preferred convex up orientation. (Shell and sediment subsamples)
(33-35)	Blebs of muddy sand
50	End of core

H405

Cm	
0-13	Clay (settled out of suspension after deck handling)
13-74	Graded, structureless, greenish grey 5GY 5/1, fine silty to medium to coarse sand
74-83	Pale olive 10Y 6/2 structureless, very fine sandy silt
83-163	Dark greenish grey 5GY 4/1, muddy, fine sand (Mode III/II). Bioturbated but with remnant bedding. Many shell fragments
(103)	Oyster shell (subsampled)
163-189	Dark greenish grey 5GY 4/1 medium sand grading downwards to coarse and very coarse sand with shell fragments
189-206	Dark greenish grey 5GY 4/1 muddy, fine sand with shell fragments
206-222	Shell bed with medium to coarse muddy sand and pebbles. Sand is locally cemented. Pebbles are well rounded quartz (some iron-stained) and greywacke. Shells mainly concave up and stained black or blue. (Shell and sediment subsample)
222	End of core

H433

Cm	
0-14	Graded, structureless sand and mud. Greyish olive 10Y 4/2 mud and fine sand at top - moderate olive grey 5Y 4/2 medium sand and shell hash at bottom. Probably graded during deck handling
14-20	Moderate olive grey 5Y 4/2 medium sand (Mode III/II) and shell hash. No preferred orientation of shells
20-28	Dark greenish grey 5GY 4/1 fine muddy sand (Mode III/II)
28-39	Moderate olive grey 5Y 4/2 medium sand (Mode III/II) and shell hash. Few well rounded pebbles of iron-stained quartz. No preferred orientation of shells. (Shell and sediment subsample)
39	End of core

H435

Cm	
0-5	Clay (settled out of suspension after deck handling)
5-40	Structureless, dark greenish grey 5GY 4/1, very fine (Mode IV) muddy sand
40-87	Strongly bioturbated, medium greenish grey 5GY 5/1, very fine (Mode IV) muddy sand. Bedding evident but poorly preserved
(69)	Large gastropod *Austrofusus* sp. (Shell subsample)
87	End of core

H440

Cm	
0-19	Medium to dark greenish grey 5GY 4-5/1 muddy very fine (Mode IV) sand. Lightly bioturbated with mud-filled burrows
19-30	Bioturbated medium greenish grey 5GY 5/1 very fine (Mode IV) sandy mud. Some remnant bedding
30-40	Dark greenish grey 5GY 4/1 finely laminated silt and clay. Beds are partly disturbed and contain abundant clay-filled burrows
(38-40)	Shelly
40-47	Highly disturbed dark greenish grey silt and clay with few shell fragments
47-78	Highly disturbed medium greenish grey clay and silt with few shell fragments
78	End of core.

H451

Cm	
0-52	Silty clay. No structure evident. Spectacular black N1 and light olive 10Y 5/4 mottling on fresh cut indicates extreme bioturbation. Core changed colour within 3 hours to uniform pale olive 10Y 6/2
52	End of core

H459

Cm	
0-6	Medium greenish grey clay 5GY 5/1 with a few burrows .
6-8	Distorted silt bed
8-22	Medium greenish grey silty clay with burrows, clay lenses (approximately 1 cm thick), and some remnant lamination
22-30	Dark greenish grey 5GY 4/1 laminated silt. Beds broken, distorted and penetrated by burrows filled with silty clay
30-42	Bioturbated greenish grey silt and silty clay. Burrows filled with silty clay
42-49	Dark greenish grey laminated silt. Moderately bioturbated
49-355	Medium greenish grey 5GY 5/1 silt and silty clay. Strongly bioturbated. Visible burrows generally silt filled. Some remnant bedding. Few scattered shell fragments
(60)	(Shell subsample)
(100-105)	Broken and tilted laminated silt bed
(133)	Laminated silt lens
(147-149)	Laminated silt bed perforated with burrows full of silty clay
(163-164)	Pocket of shell hash (coprolite?)
(203-207)	Laminated silt bed perforated by burrows full of silty clay
(272-277)	Moderate olive brown 5Y 4/4 plant material
(295-298)	Plant material as above
355	End of core

H473

Cm	
0-497	Massive, structureless, greenish grey 5GY 6/1 mud. Bioturbated but indistinct due to uniformity of grain size. Scattered shells of *Stiracolpus* and *Dosinia* and some plant material
(23-32)	Shell bed
(60)	Gas pocket
(72-78)	Shells
(100)	Plant material
(113-114)	Woody material
(131-132)	Plant material
(345-350)	Shell bed
(360-366)	Shells
(418-432)	Shells (subsampled)
(442-450)	Shells (subsampled)
(461-467)	Shells (subsampled)
497	End of core

H474

Cm	
0-10	Interlaminated dark greenish grey 5GY 4/1 very fine Mode IV sand and medium greenish grey 5GY 5/1 mud - slightly bioturbated
10-18	Very fine sand as above with mud filled burrows
18-107	Medium greenish grey 5GY 5/1 very fine sandy mud. Bioturbated with remnant bedding. Sand fraction is Mode IV
(38-44)	Sandy shell bed with plant material
(101-107)	Shells and plant fragments
107-382	Medium greenish grey very fine sandy mud as above but strongly bioturbated with bedding completely destroyed
(201-219)	Shells
287-294	Mussel shells
382	End of core

H777

Cm	
0-13	Clay (settled out of suspension after deck handling)
13-58	Graded, structureless, olive grey 5Y 5/2, medium to fine (Mode III/II) sand
58-73	Shelly, pebbly, muddy medium to fine (Mode III/II) sand. Sandier at the top (moderate olive grey 5Y 4/2) and muddier at the bottom (greyish olive 10Y 4/2). Pebbles mainly well rounded iron-stained quartz. Shell material generally fragmented and encrusted. Possible indistinct cross bedding
73-167	Pebbly, sandy, shell bed. Upper 10 cm is mainly sand. Pebbles well rounded, mostly quartz (commonly iron-stained) with some argillite. Sand is medium to fine (Mode III/II). Shells generally fragmented and highly to slightly abraded. Intermittent cross bedding
(80-122)	(Shell and sediment subsample)
(100-110)	Cross bedding with 30° apparent dip
(122-167)	(Shell and sediment subsample - ^{14}C)
(124-129)	Cross bedding with 15° apparent dip
(158-167)	Cross bedding with 40° apparent dip
167	End of core

H778

Cm	
0-20	Clay (settled out of suspension after deck handling), and sand disturbed during handling
20-31	Graded, structureless, grey, silty, micaceous, medium to fine sand (Mode III/II). Grey colour due to silt content
31-44	Light olive grey 5Y 5/2 medium sand (Mode III/II) with shell fragments
44-80	Greyish olive 10Y 4/2, muddy, medium sand with shell fragments
80-140	Partly laminated, bioturbated, grey silt with three thin layers of shelly medium to fine sand (Mode III/II) at 87-90 cm, 96-100 cm and 110-113 cm. Quartz pebble in lowest sand layer. The sand also occurs in burrows and burrowed layers
140	End of core

H780

Cm.	
0-11	Clay (settled out of suspension after deck handling)
11-102	Graded, structureless, dark grey N3-4, fine to medium muddy sand (Mode III/II). Horizontal bedding near base
102-118	Light greyish olive 10Y 5/2, fine to medium (Mode III/II) sandy mud. Extensively burrowed. Burrows filled with sand
118-124	Dark grey N3-4 fine to medium muddy sand (Mode III/II)
124-205	Light greyish olive 10Y 5/2 fine to medium (Mode III/II) sandy mud with shell fragments and some whole shells. Moderately bioturbated. Horizontal bedding becomes more distinct towards base
(128-129)	Shell bed. Valves mainly concave up
(177-205)	Sandier
(205-215	Medium dark grey N4 very fine sand (Mode IV). Horizontally laminated and moderately to lightly bioturbated. Burrows filled with fine to medium (Mode III/II) sandy mud. Well rounded quartz pebbles at top of bed
215-223	Very fine Mode IV sand as above with fine to medium Mode III/II sand, abundant shell debris and well rounded quartz and greywacke pebbles
223	End of core

H781

Cm	
0-21	Clay and structureless sand (settled out of suspension after deck handling)
21-63	Structureless, greyish olive 10Y 4/2 sandy mud with abundant shell fragments, shells, scattered subrounded pebbles and granules of mudstone, and rare well rounded quartz granules. Shell material increases in size and abundance downwards and becomes a shell bed from 52 cm - 63 cm. Shells show no preferred orientation. Sand fraction is very fine grained Mode IV
63-75	Grey, silty, very fine Mode IV sand. Laminated and slightly bioturbated
75-165	Greyish olive 10Y 4/2 sandy mud with abundant shell fragments, shells and scattered subrounded pebbles of mudstone as above. However, grading is absent. Sand fraction is very fine grained Mode IV
(94-113)	Numerous large shells (subsampled - ^{14}C)
(133-139)	Slightly higher shell and pebble content
(139-165)	Scattered large shells
165	End of core

H788

Cm	
0-6	Clay (settled out of suspension after deck handling)
6-83	Structureless, light olive grey 5Y 5/2 fine to medium (Mode III/II) sand. Horizontally bedded at base
(79-83)	Rusty coloured fine to medium (Mode III/II) sand with scattered shell fragments
83-120	Breccia of shapeless to oblong clay clasts and shells with horizontal to steeply inclined orientations in a matrix of greyish olive 10Y 4/2, fine to medium (Mode III/II) sand. (Shell and sediment subsample - ^{14}C)
120-155	Greyish olive 10Y 4/2 fine to medium (Mode III/II) sand with scattered shell fragments. Horizontal bedding evident below 140 cm
155-189	Shell and clay-clast breccia in greyish olive 10Y 4/2 fine to medium (Mode III/II) sand. Shells mainly concave up
(162-173)	Shell bed coarsens downwards, has apparent dip of 30°
(170-183)	(Shell and sediment subsample - ^{14}C)
189-202	Greyish olive 10Y 4/2 fine to medium sand (Mode III/II) with scattered subhorizontal shell fragments
202-240	Shell and clay-clast breccia as above
(213-227)	Shell bed, coarsens downwards, has apparent dip of 30°. Shells concave up. (Shell and sediment subsample - ^{14}C)
240-263	Greyish olive 10Y 4/2 medium to fine (Mode III/II) sand with many small clay and shell fragments

263-316	Shell and clay-clast breccia as above but very shelly. Shells mainly concave up. Both shells and breccia clasts have apparent dip of 20° - 40°. (Shell and sediment subsample -- ^{14}C)
316	End of core

H789

Cm	
0-8	Clay (settled out of suspension after deck handling)
8-170	Light olive grey 5Y 5/2 fine to medium (Mode III/II) sand (fine sand at top and grading downwards to medium sand). Sand becomes peppered with shell fragments downward (shell fragments increasing in size and abundance) and passes very gradually into a graded shell bed around 170 cm
170-252	Graded shell bed in fine to medium (Mode III/II) sand matrix. Shells become coarser downwards
(170-210)	Shell fragments horizontal and generally less than 1 cm across
(210-252)	Intact <u>Tawera spissa</u> shells (1.5 - 2 cm diameter) become dominant. Shells oriented horizontally on the cut face. Curved shells are dominantly concave up
252-290	Coarse shell bed in Mode III/II sand as above. Shells oriented concave side up but have apparent dip of 25° - 30°. (Shell subsample - ^{14}C)
290-308	Coarse shell bed in Mode III/II sand as above, but sandier. No preferred orientation of shells
308	End of core

H790

Cm	
0-1	Clay (settled out of suspension after deck handling)
1-170	Graded, structureless, fine to medium sand (Mode III/II). (Largely disturbed during deck handling)
170-207	Sandy shell bed. Sand is fine to medium grained (Mode III/II) and dark olive brown 5Y 4/3. Shells show no preferred orientation. (Shell and sediment sub-sample - ^{14}C)
207	End of core

H810

Cm	
0-6	Clay (settled out of suspension after deck handling)
6-52	Graded, structureless, light olive grey 5Y 5/2 Mode III/II sand. Silty at top; shelly below 44 cm. Fine shell fragments horizontally bedded at 44 cm but have apparent dip of 30° at 52 cm
52-118	Coarse pebbly shell bed with fine to medium (Mode III/II) sand matrix. Shells have dominant concave up orientation and subhorizontal to 30° apparent dip. Pebbles are mainly quartz, well rounded and commonly iron-stained
(62-86)	Matrix sand is greyer and finer. May be mixture of Modes III/II and IV. (Shell and sediment subsample)
(95-142)	(Shell and sediment subsample - ^{14}C)
118-129	Structureless light olive grey 5Y 5/2 fine to medium Mode 111/11 sand and well rounded pebbles
129-142	Coarse pebbly shell bed in fine to medium (Mode III/II) sand matrix. Shells concave up. Pebbles well rounded, mainly quartz
142	End of core

H811

Cm	
0-12	Clay (settled out of suspension after deck handling)
12-50	Greyish olive 10Y 4/2, bioturbated, muddy, fine to medium (Mode III/II) sand with scattered shell fragments
50-55	Zone of mixing of unit above with unit below
55-137	Structureless, light olive grey 5Y 5/2 fine to medium (Mode III/II) sand with rare muddy wisps and blebs increasing downwards
(120-125)	Mud blebs
137-140	Shelly, fine to medium (Mode III/II) sand - looks like beginning of a shell bed
140	End of core

H812

Cm	
0-3	Clay (settled out of suspension after deck handling)
3-26	Olive grey 5Y 5/2, graded, structureless, medium to fine (Mode III/II) sand. Disturbed during deck handling
26-85	Structureless, greyish olive 10Y 5/2, pebbly, shelly, medium to fine sandy (Mode III/II) mud. Pebbles mainly well rounded quartz and greywacke
(55-56)	Pebbly olive grey sand lamina
(72-82)	Shell bed. Valves mainly convex up. (Shell and sediment subsample)
84-86	Sharp, sloping contact
85-208	Medium to fine, sandy (Mode III/II), shelly pebble gravel. Mainly structureless but with possible indistinct cross-bedding. No obvious preferred orientation of shells. Sand is olive grey 5Y 5/2. Pebbles mainly well rounded quartz and greywacke
(100-111)	Muddy, sandy gravel
(166-208)	(Shell and sediment subsample - ^{14}C)
208	End of core

H813

Cm	
0-5	Clay (settled out of suspension after deck handling)
5-35	Greyish olive 10Y 4/2 very fine (Mode IV) sand. Muddy towards top. Horizontally bedded with a small amount of burrowing
(33-35)	Small pocket of shell fragments
35-71	Light greyish olive 10Y 5/2 very fine (Mode IV) foram-rich muddy sand with scattered shell fragments. Horizontally bedded with a small amount of bioturbation
54-71	Shell bed in muddy sand as above. Shells subhorizontal but otherwise no preferred orientation
71	End of core