UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

REPORT ON THE ENVIRONMENTAL GEOLOGY

OCS AREA, EASTERN GULF OF ALASKA

OPEN-FILE REPORT 76-206

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature

Menlo Park, California
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By

Bruce F. Molnia, Paul R. Carlson, *and* Terry R. Bruns

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I. INTRODUCTION

In anticipation of oil and gas leasing of the outer continental shelf (OCS lease area 39) in the northeastern Gulf of Alaska, the U. S. Geological Survey began a regional reconnaissance in 1974. The study area, which extends from Prince William Sound on the west to Yakutat Bay on the east, is in a region fraught with natural hazards. The tectonic history of the area suggests that future major earthquakes could pose serious hazards to installations on the continental shelf or along the coast of the Gulf of Alaska. The hazard may be either direct, by ground shaking or fault displacement, or indirect, through ground failure or generation of tsunami waves. Storm waves sometimes are responsible for ground failures, especially in areas of rapid accumulation of sediment.

Because of the paucity of non-proprietary marine geological and geophysical data, the U. S. Geological Survey operated a cruise in the northern Gulf of Alaska OCS area (fig. 1) in September and October 1974 aboard the University of Washington's R/V *Thomas G. Thompson.* Data collected include three types of continuous acoustic profiles; energy sources were a 3.5 kHz transducer, two minisparkers (800 Joules) and two 40 $in.^3$ air guns. Two later cruises aboard NOAA ships, *Surveyor* (April - May 1975) and FRS *Townsend Cromwell* (May - June 1975) added more high resolution seismic data and approximately 425 sediment samples. In all, more than 12,000 km of high resolution seismic data were collected within the study area. Several types of navigation equipment were used

because of intermittent power and equipment failures; the instruments included Decca Hi Fix, Satellite, Loran A Radar, and Radist.

The seismic reflection data from the Thompson cruise have been released in an open-file report (von Huene and others, 1975), which is available to the public. The remaining data are being prepared for open-file report.

The locations of the Thompson tracklines are shown on figure 2, the Surveyor tracklines on figure 3, and the Cromwell sediment samples on figure 4. Figure 1 is a base map compiled from Thompson and 1972 Surveyor data.

This report is a synthesis of our preliminary evaluations of sediment types, distributions (both areally and stratigraphically) and thicknesses, sea floor hazards (slumps and faults) and geologic structure.

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II. SURFACE SEDIMENTARY UNITS

by

Bruce F. Molnia and Paul R. Carlson

Description of Sedimentary Units

Four major sedimentary units occur on the continental shelf of the northern Gulf of Alaska (fig. 5). These units, which are characterized by their "seismic signatures", are: (1) Holocene sediments (fig. 6); (2) Holocene end moraines (fig. 7), (3) Quaternary glacial marine sediments (fig. 8) and (4) Tertiary and Pleistocene strata (fig. 9).

The ages assigned to these units are based on their relative stratigraphic positions. The term "Holocene" is applied to sediment accumulating today and to end moraines formed during historic time. The most widespread of these two Holocene units is largely clayey silt and appears on seismic profiles as relatively horizontal, parallel reflectors (fig. 6), except where disrupted locally by slides and slumps (Carlson and others, 1975). The second Holocene unit appears as a jumbled mass of irregular reflectors representing recent end moraines off the Malaspina and Bering Glaciers (fig. 7).

Holocene sediments are underlain locally by a glacial marine unit of pebbly mud which is characterized on the seismic profiles by very irregular, contorted reflectors (fig. 8). This unit is assigned a Quaternary age because of its stratigraphic position between Holocene sediments and Tertiary to Pleistocene rocks. Elsewhere this glacial marine unit is absent and the

Holocene deposits overlie folded, faulted and truncated strata of probable Tertiary or Pleistocene age (fig. 9). This age assignment is based on similarities in lithology and structure of these rocks to onshore lithified strata which have been dated as Tertiary and Pleistocene (Plafker, 1967).

Distribution of Sedimentary Units

Holocene sediments blanket the near shore area between Hinchinbrook Island and the south end of Kayak Island. These deposits are thickest southeast of the main channel of the Copper River, where fine sands and clayey silts of the Copper River prodelta are 350 m thick (fig. 10). Thick sequences of sediment also are present: (1) seaward of Icy Bay near Malaspina Glacier (260 m), (2) south of the Bering Glacier (200 m), (3) betwen Hinchinbrook and Montague Island (250 m), and (4) at the southwest end of Kayak Trough (155 m). In addition, Holocene sediments compose the surface fill in the Hinchinbrook Sea Valley and cover parts of the area between Tarr Bank and Middleton Island. Holocene sediments also blanket the near shore area east of Kayak Island except where Holocene morainal deposits are present at Icy Bay and the Bering Glacier, and where Tertiary and Pleistocene bedrock crops out southwest of Cape Yakataga between Cape Suckling and Icy Bay. Holocene sediments also occur in a series of isolated pods toward the outer edge of the continental shelf.

Holocene end moraines are found at the mouth of Icy Bay and south of the Bering Glacier (fig. 5). A portion of the Bering Glacier moraine is shown in figure 7. Morainal sediments also were collected south of the Malaspina Glacier and at the mouth of Yakutat Bay. However,

until these deposits are better defined by seismic profiling they cannot be identified positively as end moraines.

Quaternary glacial marine sediments are found in a narrow arc along the north and west side of Tarr Bank and in a broad arc along the outer shelf and upper slope between Kayak Island and Yakutat Bay (fig. 5). Samples of glacial marine sediment generally are composed of pebbly or sandy mud. Figure 8 is a typical seismic profile of glacial marine sediments.

Tertiary or Pleistocene stratified sedimentary rocks, commonly folded, faulted and truncated , crop out on the sea floor south of Montague Island and at several localities southeast and southwest of Cape Yakataga (fig. 5). Folded Pleistocene and Tertiary strata on Tarr Bank are shown in figure 9. Dart coring was attempted in many areas of submarine outcrop during the Cromwell cruise. Few samples were recovered, although the presence of bedrock commonly was indicated by dented core barrels.

Bedrock also crops out at Seal Rocks and Wessels Reef between Cape Hinchinbrook and Middleton Island; these exposures were examined in June 1975. Seal Rocks consist of well indurated sandstone and argillite that are indistinguishable from rocks assigned to Orca Formation on Montague and Hinchinbrook Islands (Winkler, 1973). Wessels Reef is composed of friable sandstone and granule conglomerate that is similar lithologically to rocks of the Katalla-Poul Creek Formation

on Kayak Island (Plafker, 1974; Winkler, pers. commun., 1975).

Sampling on Tarr Bank revealed that large areas are covered by a thin veneer (approximately one metre thick) of recent sediment. This veneer is not detectable on seismic profiles because of the transparency of the sediments and the limited resolution (<2m) of seismic systems, and is not shown on the sediment distribution map.

Sources of Holocene Sediment

The main sources of Holocene sediment are the Copper River, which supplies 107 x 10^6 metric tons of detritus annually (Reimnitz 1966), and the Bering and Malaspina Glaciers. The sediment being supplied by the two large piedmont glaciers is primarily suspended matter; the resultant plumes are easily visible more than 30 km from shore on satellite imagery (Reimnitz and Carlson, 1974). A secondary but significant source is the Copper River Plateau and Delta; fine sediment is carried by strong north winds which in fall and winter are funneled through the Copper River Gorge with sufficient force to carry dark clouds of silt over 50 km into the northern Gulf of Alaska (Carlson and others, in press).

The sediment, whether supplied by river, glacial runoff, or wind, is exposed to near shore currents which, with the exception of local eddies, move in a counterclockwise direction as does the offshore Alaska Current (Reimnitz and Carlson, 1974). The counterclockwise movement transports the suspended sediment west. Much Copper River sediment is carried into Prince William Sound through passes east and west of Hinchinbrook Island. Sediments which are part of the Bering Glacier runoff plume are transported around Kayak Island; satellite imagery shows complex gyres of turbid water on both sides of the island

(Reimnitz and Carlson, 1974). Some suspended sediment probably settles out over Kayak Trough. However, high-resolution seismic profiles indicate that very little suspended matter either from the Copper River or from sources east of Kayak Island accumulates on Tarr Bank or on the Middleton Island platform. The lack of sediment cover on these topographic highs may result from scouring action of rapid bottom currents and from the frequent storm waves that are particularly large and forceful during the winter season of intense low pressure activity in the Gulf of Alaska.

III. Clay Mineralogy of Sediment Samples

By

Bruce F. Molnia and Paul T. Fuller

Nineteen selected sediment samples (fig. 11) collected during the June 1975 cruise of FRS Cromwell were processed and analyzed to determine their clay mineralogy. Individual minerals were identified x-raying Mg-saturated <2μ clay separates with a Norelco diffractometer. The quantity of each clay mineral was estimated using the peak-area technique described by Hein, Scholl and Gutmacher (in press).

Chlorite is the predominant clay mineral, averaging 52.6%; illite averages 37.8%; kaolinite 9.2% and montmorillonite 0.6%. No other clays were detected. Quartz, feldspar and amphibole were present in the clay size fraction. The percentages of clay minerals present in each sample, are shown in the following table.

Table 1

Percentages of Clay Minerals Present

Sample	Montmorillonite	Illite	Kaolinite	Chlorite
#63	3	35	9	53
#6	3	36	9	52
#148	0-1	39	9	52
#131	0-1	37	9	54
#296	0	30	10	60
#243	0	35	10	55
#350	0	33	10	57
#225	0	33	10	57
#88	1	40	9	49
#70	0	56	7	37
#325	0	45	8	47
#227	0	35	10	55
#87	0-1	54	7	39
#81	0-1	37	9	54
#259	0	31	10	59
#299	0	35	10	55
#239	0	34	10	56
#54	0	39	9	52
#111	0-1	34	10	56
Range, all samples	0-3	30-56	7-10	37-60
Average, all samples	0.6	37.8	9.2	52.6

IV. BENTHONIC FORAMINIFERA AND CALCAREOUS NANNOPLANKTON

by

Paula Quinterno

Twenty selected samples from the northeastern Gulf of Alaska (fig. 12), taken from the undisturbed upper 2 cm of sediment in grab samples or box cores, were examined for Quaternary benthonic foraminifera. Seven samples were split (using a micro splitter) to get representative specimens from the greater than 150µ fraction; approximately 350 specimens were obtained. These were counted and the relative frequency percentages of benthonic foraminiferal species were determined. On the basis of the percentage distributions, four faunal assemblages were distinguished. Cursory examination of the remaining 13 samples showed that most samples could be assigned to one of these four groups. Characteristics of the faunal assemblages are as follows:

Group I (6 samples--stations 28, 34, 124, 137, 141, 305). *Cassidulina californica*, *C. limbata* and *C. subglobosa* dominant; *Cibicides lobatulus* and *Angulogerina fluens* present in significant numbers; foraminiferal fragments common; the tests of most calcareous foraminiferal specimens present are opaque; arenaceous specimens less than 10% of total.

Group II (4 samples--stations 12, 14, 59b and sample from Resurrection Bay). *Nonionella pulchella*, *Globobulimina auriculata*, and *Nonion labradoricum* dominant; specimens very well preserved; arenaceous specimens are more than 10% of total.

Group III (7 samples--stations 26, 38, 105, 127, 128, 225 and 258). Approximately 30% of the specimens are arenacous and

consist mainly of Haplophragmoides subglobosum, Recurvoides turbinatus, Adercotryma glomeratum and Alveolophragmium crassimargo; the calcareous foraminifera, Epistominella pacifica is present in most samples; specimens are very well preserved.

Group IV (2 samples--stations 6, 9). Uvigerina peregrina, Cassidulina teretis and C. californica dominant; arenacous specimens are more than 10% of total.

Although the Group I faunal assemblage is widespread throughout the area, it occurs only at stations with the coarsest sediment. Of the six samples assigned to this groups, two are sandy gravels and four are sandy or pebbly muds.

Of the 13 samples with Group II, III, and IV faunal assemblages, eleven are muds and two are sandy muds. Group II and IV assemblages occur only west of Middleton Island.

Well-consolidated sediment was obtained from the bottoms of dart and gravity cores at stations 65D, 68C, 222, 230, 302C, 329, and 359B (fig. 12). Samples from these stations, as well as two samples from a beach approximately eight km southeast of Lituya Bay (PC-1 and PC-2) and one from Wessells Reef, were examined for pre-Quaternary calcareous nannoplankton and benthonic foraminifera. According to David Bukry (USGS), most samples were barren of nannofossils; where nannofossils were present, they were Quaternary or not age-diagnostic. Preliminary study of pre-Quaternary benthonic foraminifera by Weldon Rau (State of Washington and USGS) indicates a middle to outer shelf environment of deposition and a late Miocene to Pliocene age for station PC-1. The foraminiferal assemblage from station 302C, an area southwest of Yakutat Seavalley, suggests a Pliocene

or Pleistocene age and deposition on the shelf, probably at greater than littoral depths. The fauna from station 359B, on the northwest side of Pamplona Ridge, is within the Pliocene-Pleistocene age range and is probably Pleistocene; depositional environment was probably outer to middle shelf. A sample from station 329 contains a very shallow water fauna no older than Pleistocene and probably of Holocene age.

Glauconite, a green iron-rich mineral, occurs as internal casts in the tests of foraminifera in several samples collected from the top 2 cm of sediment as well as from one sample (station 222) taken from the bottom of a dart core. As the formation of glauconite is favored by slow sedimentation and slightly reducing conditions, further study of the distribution of this mineral in samples from the northeastern Gulf of Alaska may provide information on depositional environments.

Another topic under study is the species composition and geographic distribution of the living benthonic foraminifera. Samples from the undisturbed upper 2 cm of sediment from grab samples and box cores were preserved in buffered formalin and stained with Sudan Black B according to the procedure described by Walker and others (1974). Specimens that were living at the time of collection can be recognized because they contain protoplasm which will be stained a dark blue-black. As yet, no analysis have been completed.

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V. Submarine Faults and Slides

by

Paul R. Carlson, Terry R. Bruns, and Bruce F. Molnia

Nearsurface Faults

Traces of near surface and surface faults (fig. 13) were interpreted largely from minisparker records (figs. 14 and 15); air-gun and 3.5 kHz records were aids. Most of the faults cut strata similar and possibly equivalent to the upper Yakataga Formation, which is middle Miocene to lower Pleistocene in age (Plafker, 1967). These strata commonly are covered only by a thin veneer of Holocene sediment (fig. 15) and in many places they crop out at the sea floor (fig. 14). A few of the faults appear to cut Holocene sediments (fig. 15), but none were found that unequivocally offset Holocene sediment at the sea floor. The near surface faults mapped thus far occur mostly in four areas: (1) south of Cape Yakataga, (2) on or adjacent to the Kayak Island platform; (3) on Tarr Bank and (4) near Middleton Island.

Recent and Potential Slides and Slumps

Areas of slumping and sliding, both real and potential, are shown on figure 13. Seismic profiles showing the disrupted bedding and irregular topographic expression commonly associated with submarine slides or slumps (figs. 16 and 17) are most prominent in two areas. The slumped section south of Icy Bay and the Malaspina Glacier has a surface area of about 1770 km^2. It occurs on a very gradual slope (less than $1/2^{o}$) but is in an area of thick (>150m) Holocene sediment.

A second large slumped section is present on the Copper River prodelta. This slumped section has an area of about 1730 km^2, and also is associated with gentle slopes ($\sim 1/2^{o}$) and a thick (>200 m) wedge of rapidly deposited Holocene sediment. According to Morgenstern (1967), in regions with high rates of sedimentation such as deltas, the time lag between accumulation and consolidation gives rise to excess pore pressure, thus weakening the deposit; such under consolidated material is prone to slumping. The Copper River prodelta was investigated with seismic profiling equipment by Reimnitz (1972) shortly after the 1964 Alaska earthquake. He attributed the slump structures seen on high resolution seismic records to this earthquake. These slump structures are similar in size and shape to those visible on our profiles over this same area (fig. 16).

Acoustic profiles show a massive submarine slide at the east edge of the Copper River (fig. 17). This 17 km long slide has a volume of about $5.9 \times 10^{11} m^3$ (Carlson and Molnia, 1975a), and has moved down a slope of about one degree to the bottom of Kayak Trough. Sediment samples collected from the upper metre of this slide consist of structureless, gray clayey silt of extremely low strength (laboratory tests with a vane shear device yield a peak shear strength of .02 kmg/cm^2).

Swarms of small, discontinuous scraps were found along several seismic lines at the outer edge of the continental shelf south of Kayak Island (fig. 13). Tertiary strata are disrupted at the sea floor and the relief along these numerous scarps is about 2-5 m. These scarps may outline slump blocks at the edge of the shelf.

Several large potential slump or slide areas are delineated on figure 13. In these areas slopes range from 1° to 8° and the thickness of unconsolidated sediments exceeds 25 m. Although slump or slide features are not prominent on the seismic profiles, a strong possibility of ground failure exists if a large earthquake provides rapid ground accelerations or if a large tsunami or storm wave disrups the sea floor. Such catastrophic events were experienced by many communities in the Prince William Sound region and along the shoreline of the Gulf of Alaska during the 1964 Alaska earthquake (Grantz and others, 1964; Coulter and Migliaccio, 1966; and Plafker and others, 1969).

VI. GEOLOGIC STRUCTURE

This chapter provides a brief preliminary interpretation of the geologic structure of a portion of the offshore Gulf of Alaska Tertiary Province between Icy Bay and Montague Island (Fig. 18). Some of the data and interpretations were presented orally at the 1975 meeting of the Pacific Section American Association of Petroleum Geologists, (Bruns and Plafker, 1975). The seismic records on which this chapter is based are publicly available in U. S. Geologic Survey Open File (von Huene and others, 1975).

General Setting

The Gulf of Alaska Tertiary Province is a compound continental margin basin made up almost entirely of terrigenous clastic rocks with minor coal intercalated with subordinate mafic volcanic and volcaniclastic rocks. The topography, basin architecture, structural style, and seismotectonic activity within this province reflect the interactions that have occurred during late Cenozoic (post-Oligocene) time along the interface between the North American and Pacific plates. As a consequence of these movements, the western part of the province adjacent to the Aleutian Trench and arc is essentially a zone of compressive deformation along which the Pacific plate is underthrusting the continental margin, the easternmost part is a zone of shear in which the oceanic plate is moving laterally past the continent along the Queen Charlotte transform and related strike-slip faults, and the central part of the province is a zone of combined compression and shear due to oblique underthrusting of the continental margin (Plafker, 1969). The structural traps for petroleum accumulation

and the geologic hazards in the region are direct results of this unique setting in an arc-transform transition zone.

The sedimentary sequence in the province ranges in age from Paleocene through Pleistocene (Plafker, 1971). It is broadly divisible into (1) a thick lower unit of well-indurated, intensely deformed deep marine to continental rocks, mainly of Paleocene and Eocene age, and (2) an upper unit, largely of bedded marine sedimentary and volcanic rocks of Oligocene through Pleistocene age, that is notably less deformed and indurated. Most indications of petroleum in the basin are in rocks of the younger sequence, which has a composite thickness of 6,000 - 7,600 m. The early Tertiary sequence is too indurated and too intensely deformed to have more than modest potential for petroleum.

Data Interpretation

Interpretation of offshore structure is based mainly on the unprocessed analog single channel air gun seismic records from the 1974 Thompson cruise; line spacings are between 9 and 15 km. and acoustic penetration is generally less than 2 seconds (two-way time). Interpretation is complicated by relatively shallow penetration and by persistent water bottom multiples, especially in areas of shallow dip.

Preliminary interpretation of the data indicates that offshore, the province is structurally complex and consists of several areas with markedly differing structural styles. Complexity appears to increase from east to west. Figure 18 shows offshore structural contours and trends in the near surface, based on a highly interpretative study of the available data. For comparison, major onshore structural trends evaluated previously by Plafker (1971) are depicted. Offshore contours are in unmigrated, two-way travel time (seconds); no attempt has been made to convert to depth

due to lack of adequate velocity control. Mapping of the horizons is based on dip projections, record characteristics, and the assumption that near surface geologic horizons are relatively conformable which permits them to be projected based on the dip of overlying events. Available data indicate this assumption to be valid. The structural contours primarily depict shallow structure, probably within the upper part of the Yakataga Formation of late Miocene and younger age (Plafker, 1971). Although the configuration of the deeper basins is somewhat speculative, the shallow structural highs probably are accurately shown. Deeper structural complexities are not identified from available data. By analogy with the adjacent onshore geology, the deeper structure offshore may be considerably more complex than is indicated by the near surface structural contours.

Structural contours between Kayak Island and Icy Bay are shown on two horizons. The westernmost horizon is structurally the deeper of the two by 3/4 to 1 second. The section appears to thicken towards the shelf edge, particularly in area where the change in horizons occurs. Total section penetrated is a maximum in the area around Icy Bay and thins to the west. This interpretation is based on the truncation of seismic events at the sea floor. The total thickness of section in the basin cannot be estimated from the reflection data because of the shallow penetration. However, relatively low velocities encountered in the sedimentary column on five seismic refraction lines acquired during the 1974 Thompson cruise suggest a clastic section, predominantly of sandstone

and shale, as much as 12 km thick in the eastern part of the area south of Icy Bay and at least 9 km thick southeast of Kayak Island (Ken Bayer, personal communication).

Structural contours in the area between Kayak Island and Montague Island are shown on three horizons. Due to the structural complexity and lack of critical data, the relationships between these horizons cannot be adequately determined. The contoured horizon between Kayak Island and Middleton Island appears structurally deeper than the contoured area landward of it; comparison with the area southwest of Middleton Island is not possible due to the complexity of the Middleton Island Platform. The contours in this area are more speculative than those between Icy Bay and Kayak Island. Shoreward of the contoured areas, and in the area immediately west of Kayak Island, acoustic basement appears to be shallow and definition of the structure is not adequate for contouring.

Offshore Structural Features

Between Icy Bay and Kayak Island the shelf is underlain by two types of structures. The first type is a series of asymmetric linear folds that trend obliquely across the shelf, roughly between northeast-southwest and east-west. These structures appear more open and less complex than those on the adjacent land areas. Some of the offshore anticlines are bounded on the southeast by north - dipping thrust faults along which there may have been substantial displacement. The second type of structure is a large shelf-edge arch east of Kayak Island trending sub-parallel to the coast and having very gentle surface dip. Between this arch and the coast is a broad downwarp as much as 48 km. wide within which there are some upwarped areas. A possibly similar

arch occurs southwest of Icy Bay at the shelf edge although more data are required to define the structure in this area. No structure is apparent in the area between Pamplona Ridge and the shelf edge high to the west; however, weak indications of deeper structural complexity are seen on one line which extends off the shelf into deep water.

The shelf between Kayak and Middleton Island is underlain by a broad zone of complex structures trending between east-west and north-east-southwest, subparallel to major on-land structures and to the eastern Aleutian Trench. Structural highs tend to be asymmetric and bounded by thrust faults on their south or southeast limbs. Uplift, deformation and faulting are greater than on the Icy Bay structural features, and the crests of many of the highs appear to have been truncated by erosion exposing complexly deformed Tertiary rocks at or near the sea floor. Northwest of Middleton Island are two large northwest trending structural highs separated by a deep basin. These complex structures, which are divergent from the Icy Bay and Kayak-Middleton trends, show severe deformation and probably faulting on their flanks, and no structure can be resolvable within their cores. Middleton Island lies on the northwest flank of a large northeast-trending structural high and appears to be separated from the northwest trending structures by a relatively deep basin. Most of the highs between Kayak and Montague Islands are shown as closed anticlines; however, lack of definition in profiles from this area does not preclude these highs that could result from block faulting. If such were the case, the closure shown on figure 18 would not be accurate.

VII. Summary

Four major sedimentary units, which are characterized by their seismic signatures, occur on the sea floor of the continental shelf in the study area. They are: (1) Holocene sediments which range from sands to silty clays, (2) Holocene end moraines which consist of gravelly, sandy muds, (3) Quaternary glacial marine sediments which are primarily pebbly muds, and (4) Tertiary and Pleistocene lithified deposits, which vary from dense, well-cemented sandstones to poorly consolidated pebbly mudstones.

Holocene sediment blankets: (1) the entire near shore area between Hinchinbrook Island and the south end of Kayak Island (2) most of the near shore area east of Kayak Island, (3) the surface fill in the Hinchinbrook Sea Valley, and (4) the area south of Tarr Bank and north of Middleton Island. Holocene end moraines are found at the mouth of Icy Bay, south of the Bering Glacier, and at the mouth of Yakutat Bay. Quaternary glacial marine sediment occurs in a narrow arc along the north and west sides of Tarr Bank and along the outer shelf and upper slope between Kayak Island and Yakatat Bay. Stratified sedimentary rocks, often folded, faulted, or truncated, crop out: (1) on Tarr Bank, (2) offshore of Montague Island, (3) in several localities southwest and southeast of Cape Yakataga, (4) on Seal Rocks, and (5) on Wessels Reef. These outcrops apparently are offshore extensions of onshore formations such as the Orca, Katalla, Poul Creek and Yakataga. The lack of Holocene cover over a shallow area so close to major sources of sediment indicates the presence of strong bottom currents which prevent deposition, and also the strong erosive capabilities of the frequent storm waves which

periodically scour the banks bare of sediment.

High rates of sediment accumulation seaward of the Copper River and the Bering and Malaspina Glaciers are verified by high-resolution seismic profiles which show thick sections of Holocene sediment (200-350 m). Rapid accumulation of the glacially derived sands, silts, and clays results in high pore-water pressures and underconsolidation of the sediment, creating a high potential for submarine slides or slumps even on slopes of less than one degree. Two areas, both more than 1700 km^2, of thick Holocene sediment show evidence of submarine mass movement: (1) south of Icy Bay and the Malaspina Glacier, and (2) seaward of the Copper River. Several other areas have been mapped as potentially unstable because of relatively thick accumulations of Holocene sediment on slopes greater than one degree.

Slumping is also a common feature at the shelf edge and on the continental slope. Near the shelf edge south of Kayak Island, the surficial sedimentary units (probable Tertiary age) are cut by a swarm of discontinuous step-scarps. Two scarps have relief of 2-5 m and may delineate slump blocks at the edge of the shelf. These features represent a very serious hazard to any sea floor construction.

Near surface faults were mapped in four main parts of the northern Gulf of Alaska OCS region: (1) south of Cape Yakataga, (2) on or adjacent to the Kayak Island Platform, (3) on Tarr Bank, and (4) near Middleton Island. Most of these faults cut Tertiary marine sedimentary

rocks; along several faults the sea floor was offset from 5 to 20 m. A few of the faults may cut Holocene sediments, but none of these showed offset at the sea floor.

Preliminary interpretation of the medium-resolution seismic reflection profiles indicates that the northeastern Gulf of Alaska is structurally complex and consists of several areas with markedly differing structural styles. Complexity in the near surface section appears to increase from east to west. Between Icy Bay and Kayak Island the shelf is underlain by two type of structures. The first type is a series of asymmetric linear folds that trend obliquely across the shelf, roughly between northeast-southwest and east-west. The second type of structure is a large shelf-edge arch, east of Kayak Island, trending subparallel to the coast and having a very gentle surface dip.

The shelf between Kayak and Middleton Island is underlain by a broad zone of complex structures trending between east-west and northeast southwest, subparallel to major onland structures and to the eastern Aleutian Trench. Structural highs tend to be asymmetric and bounded by thrust faults on their south or southeast limbs. Uplift, deformation and faulting are greater than on the Icy Bay structural features, and the crests of many of the highs appear to have been truncated by erosion, exposing complexly deformed Tertiary rocks at or near the sea floor. Northwest of Middleton Island are two large northwest trending structural highs separated by a deep basin.

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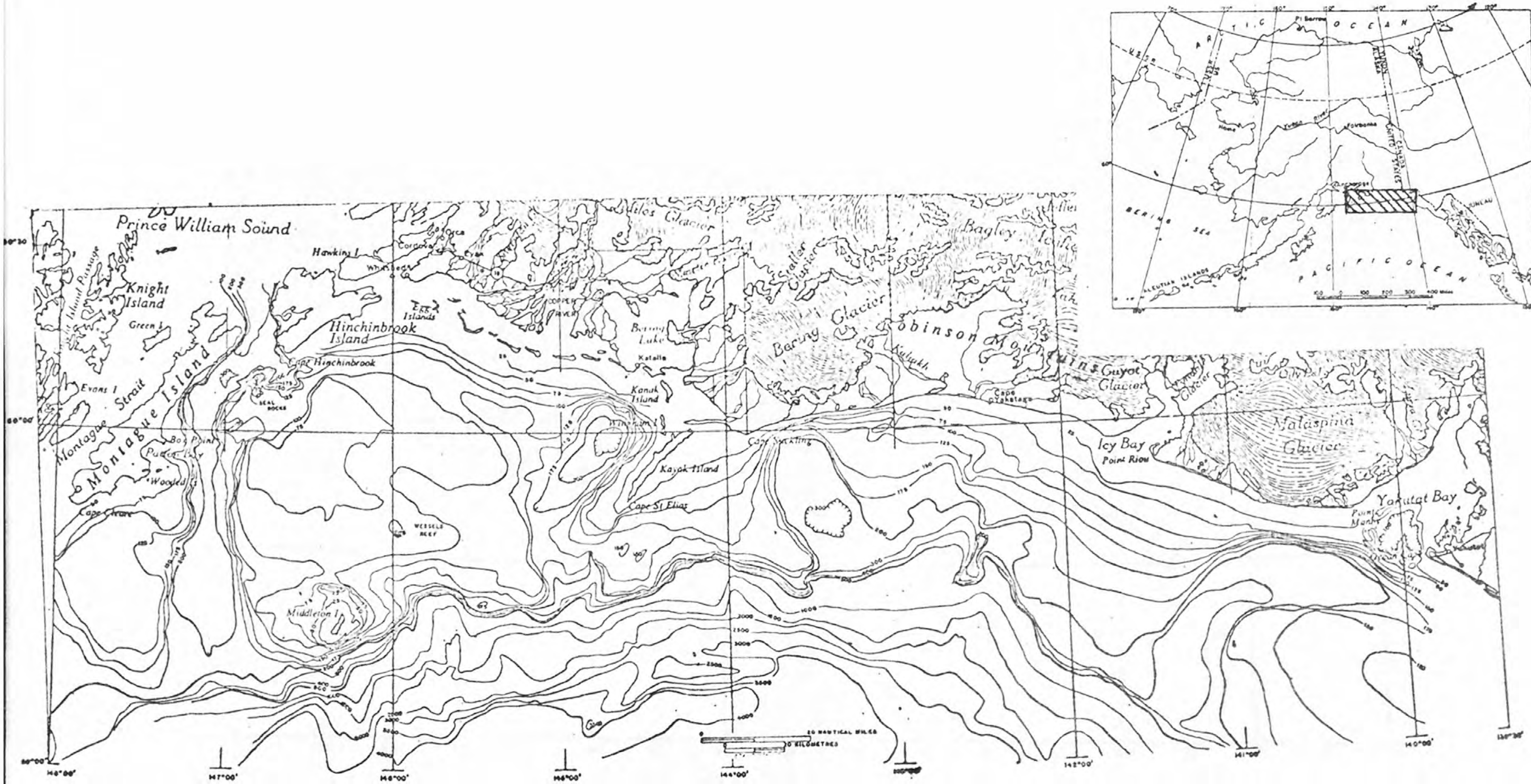


Figure 1. Base map, northeastern Gulf of Alaska; inset is index showing location of map area. Modified from Molnia and Carlson, 1975a.

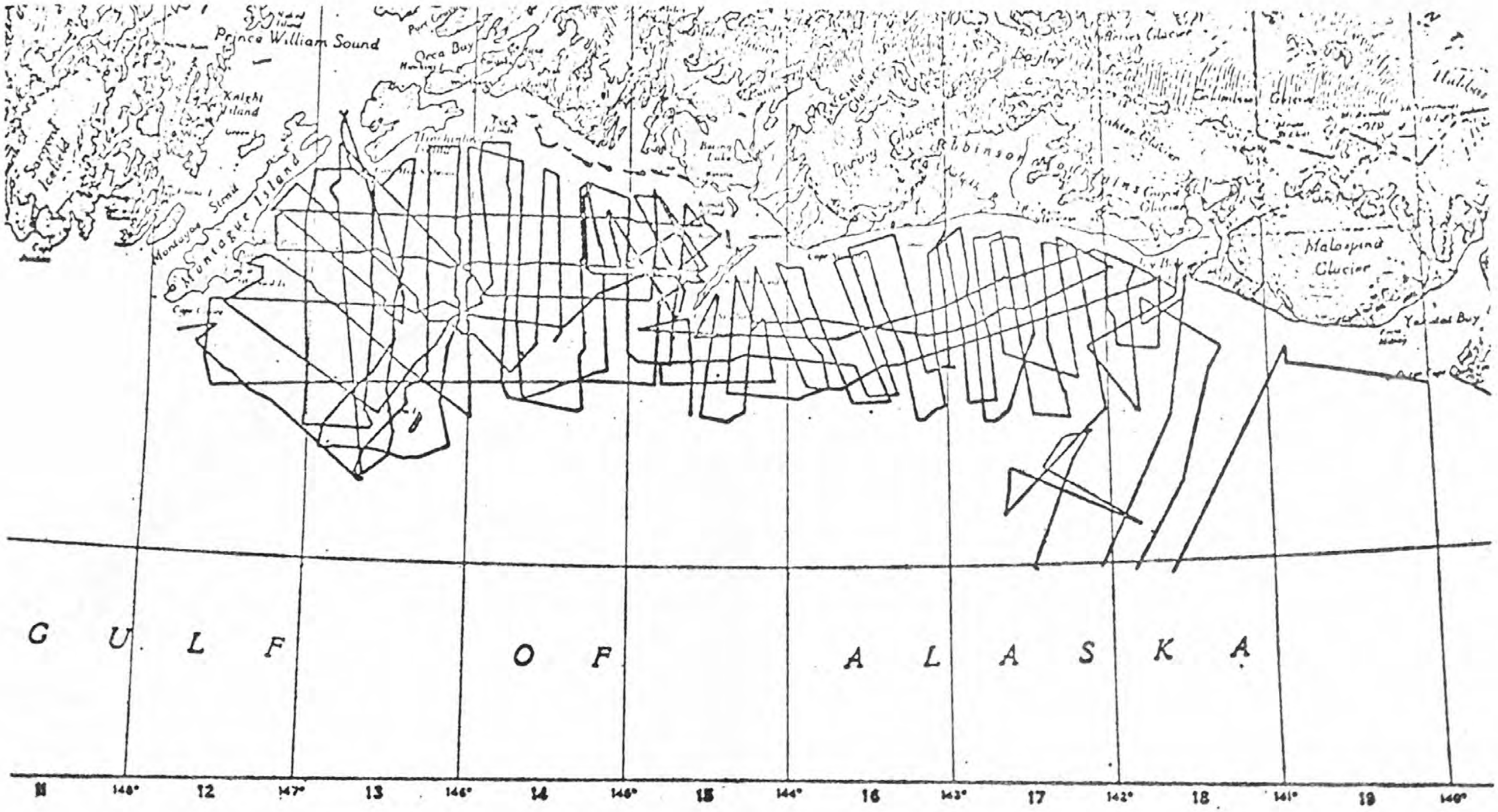


Figure 2. Trackline map of R/V Thomas G. Thompson cruise (September - October 1974).

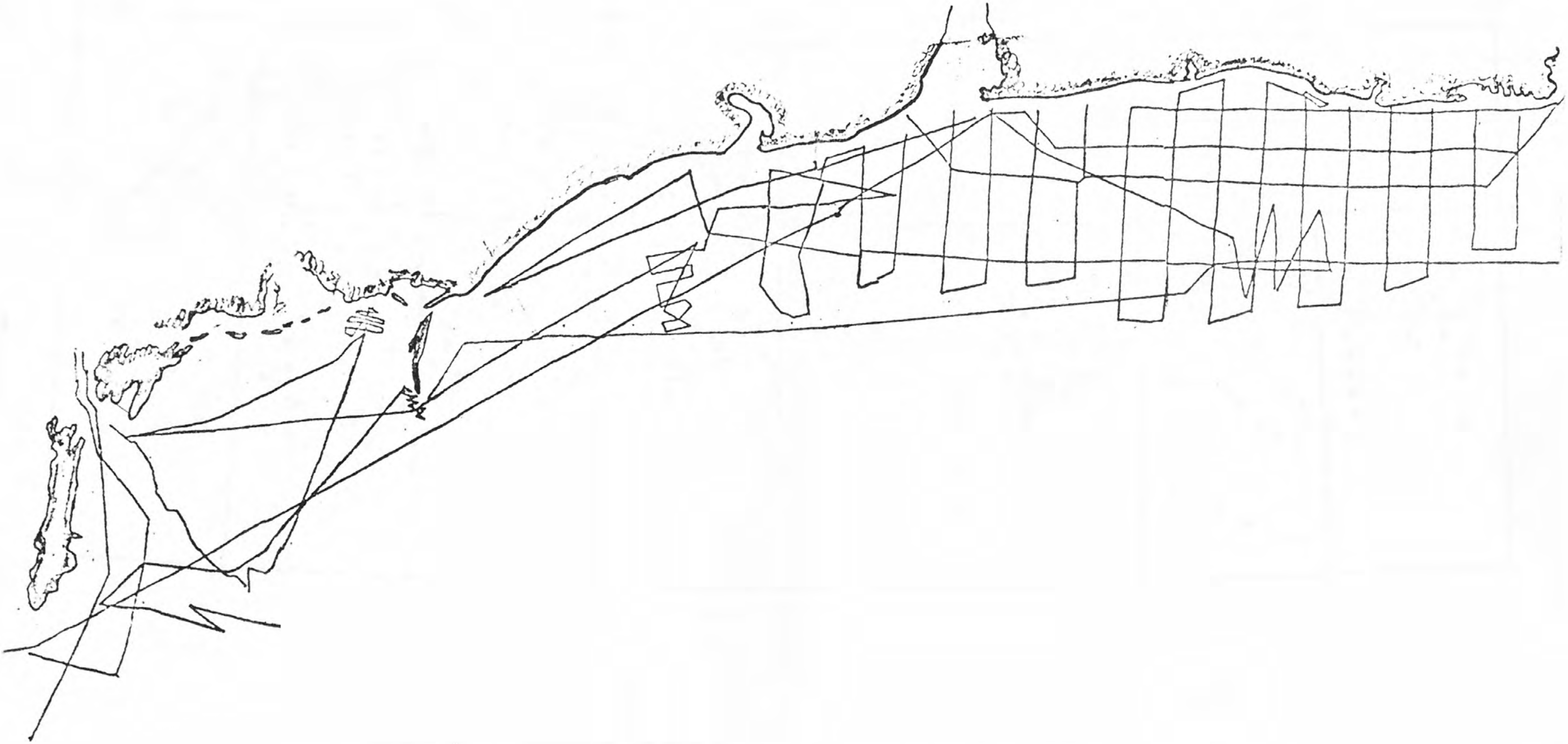


Figure 3. Location of Surveyor (April - May 1975) track lines.

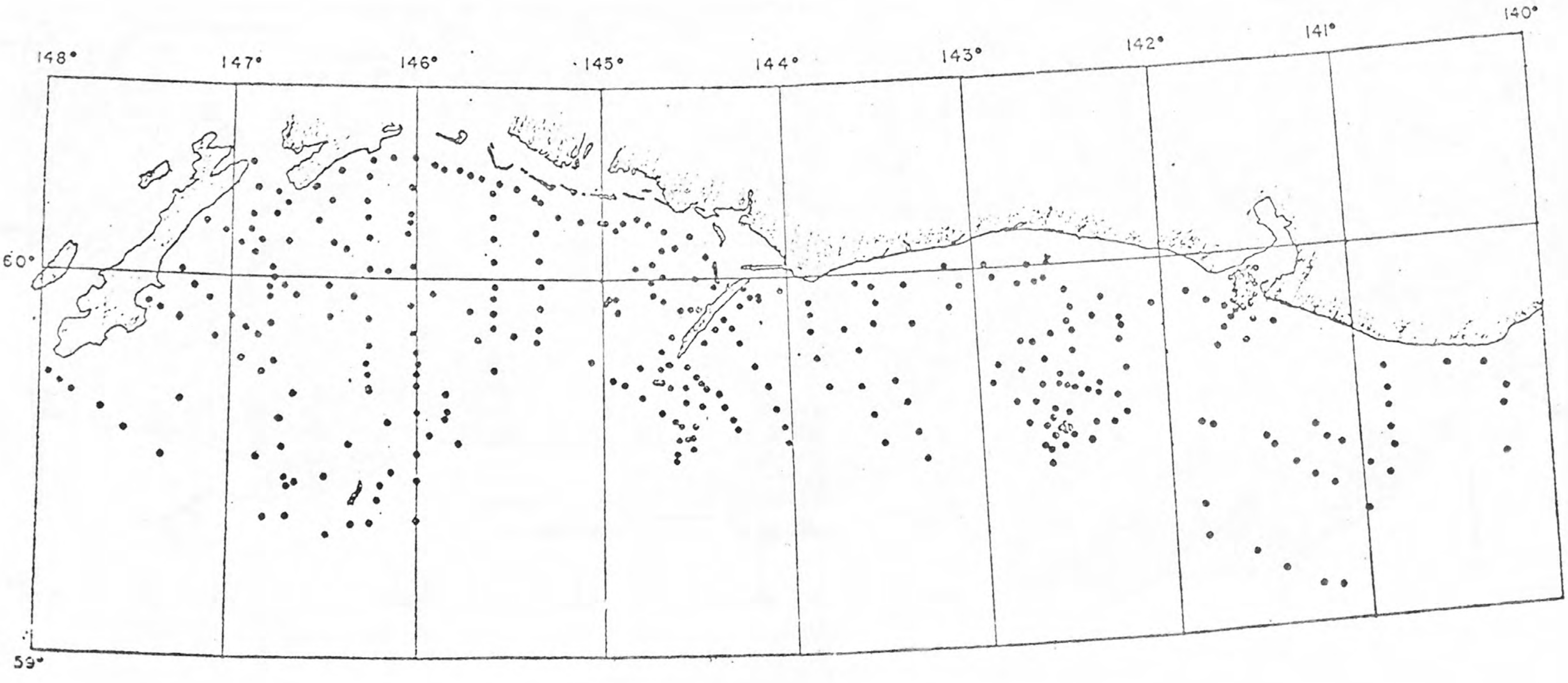
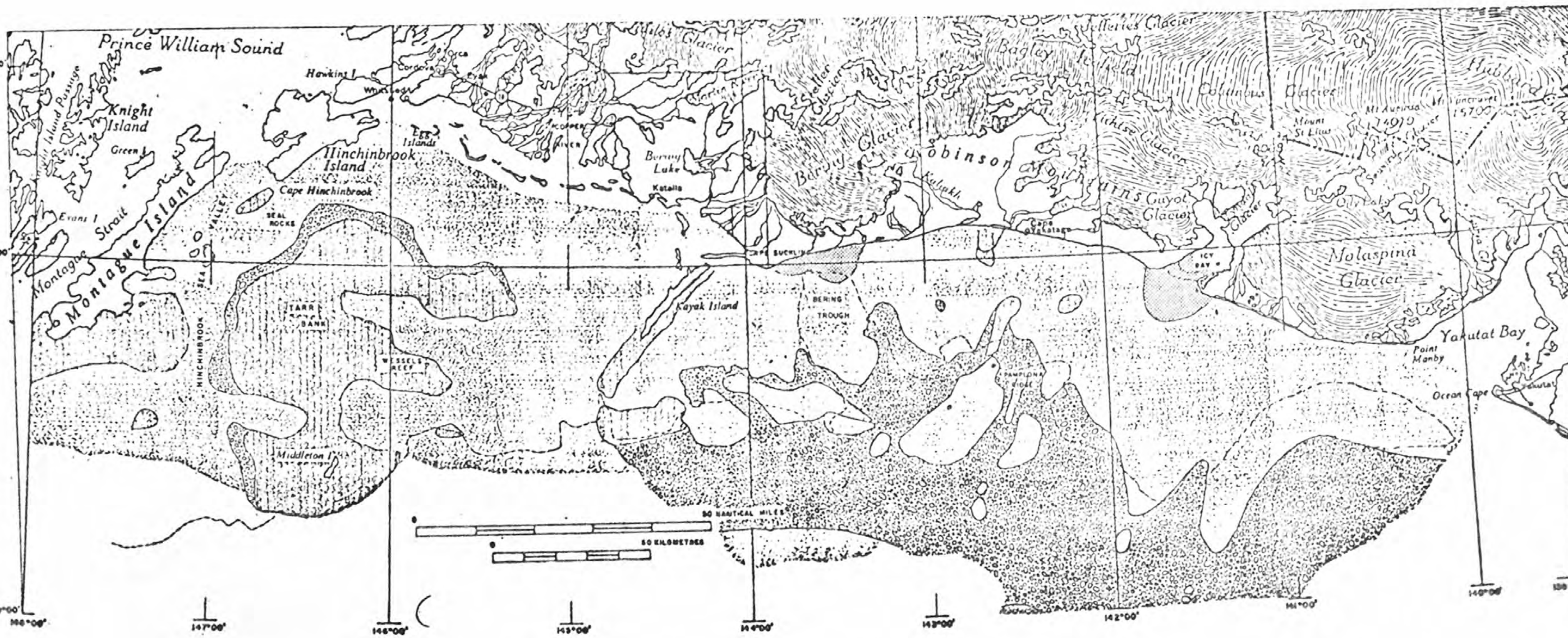


Figure 4. Location of FRS Townsend Cromwell (May - June 1975) samples.



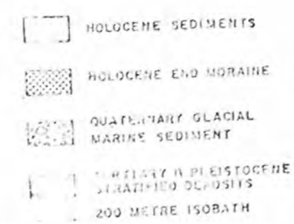


Figure 5. Distribution of sedimentary units on sea floor. Modified from Molnia and Carlson, 1975b.

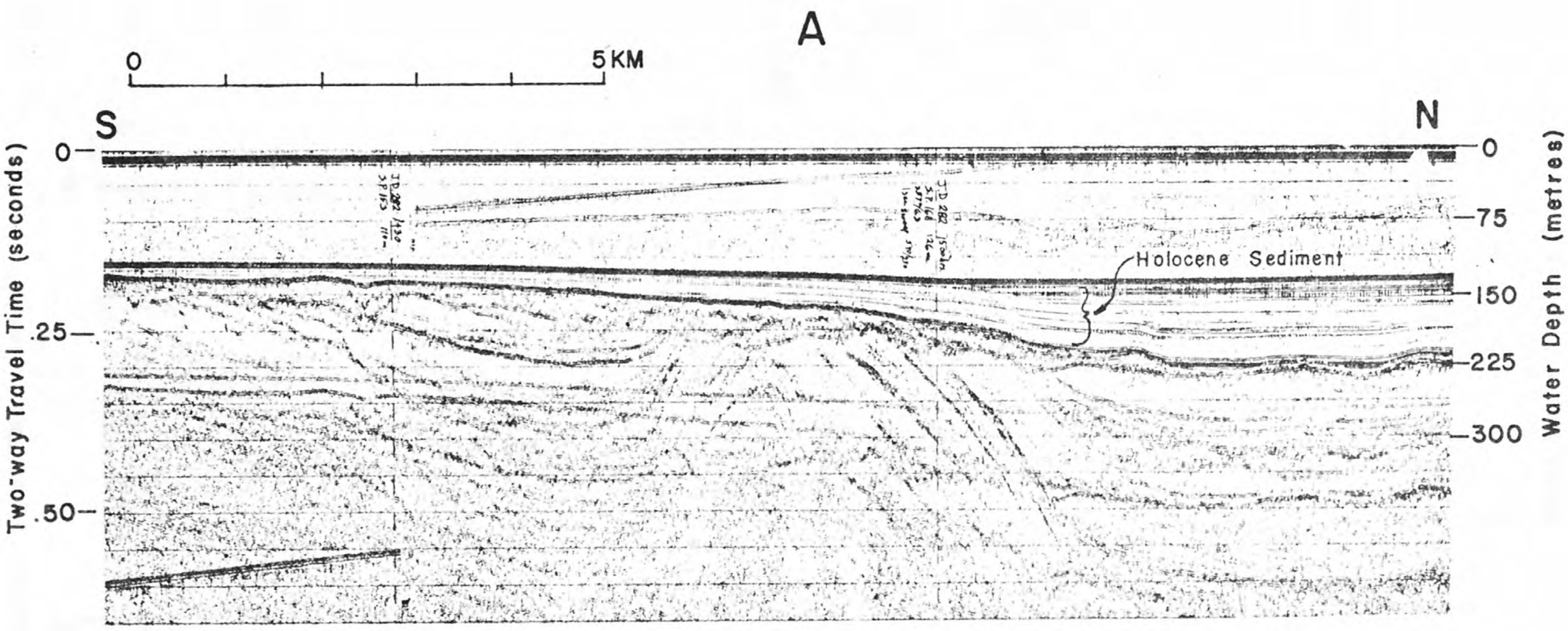


Figure 6. Holocene sediment overlying folded strata south of Copper River (vertical exaggeration (v, e,) ≈10X).

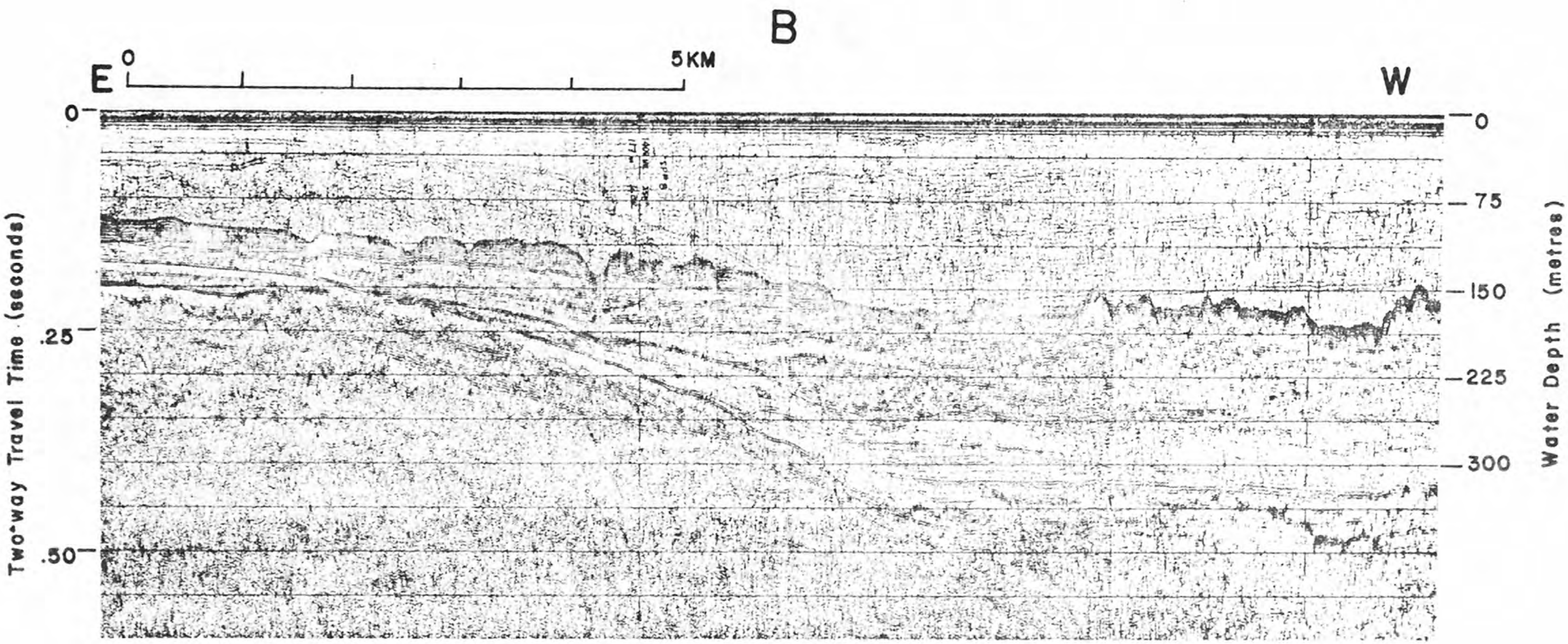


Figure 7. A portion of the Bering Glacier end moraine (v. e. ≈10X).

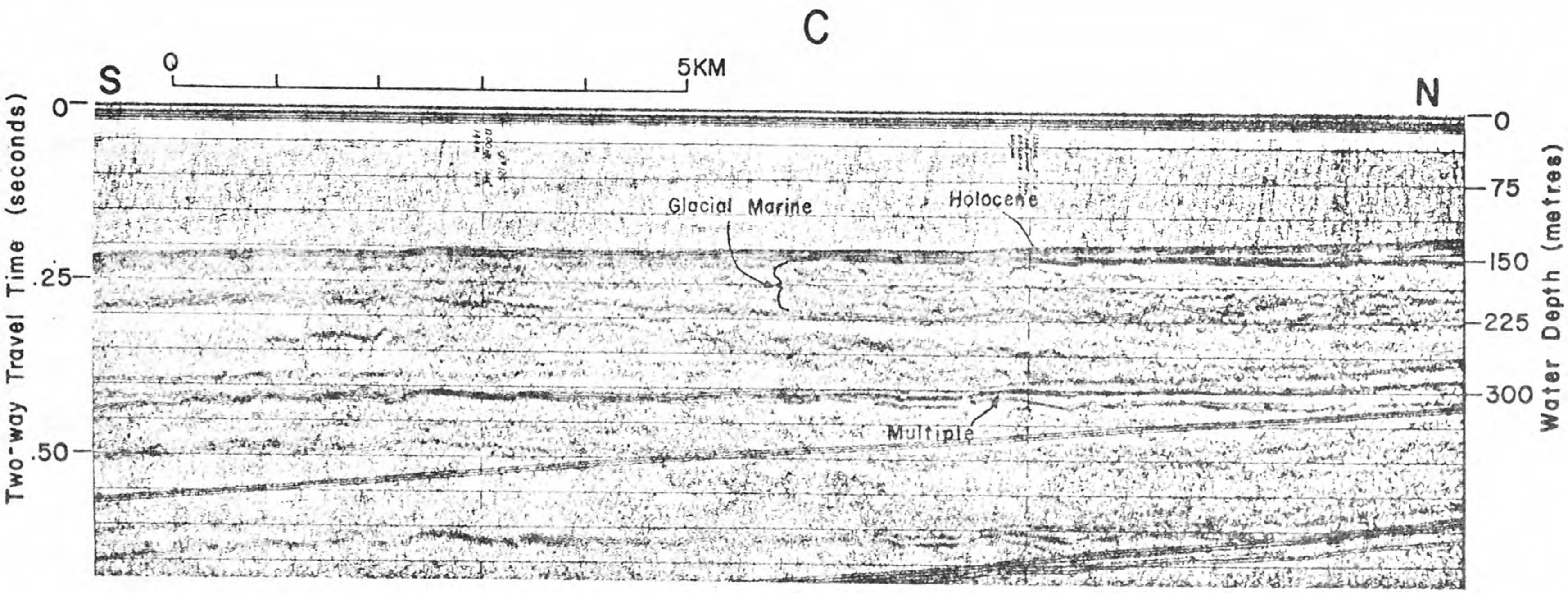


Figure 8. Quaternary glacial marine sediments in the Bering Trough (v. e. ≈10X).

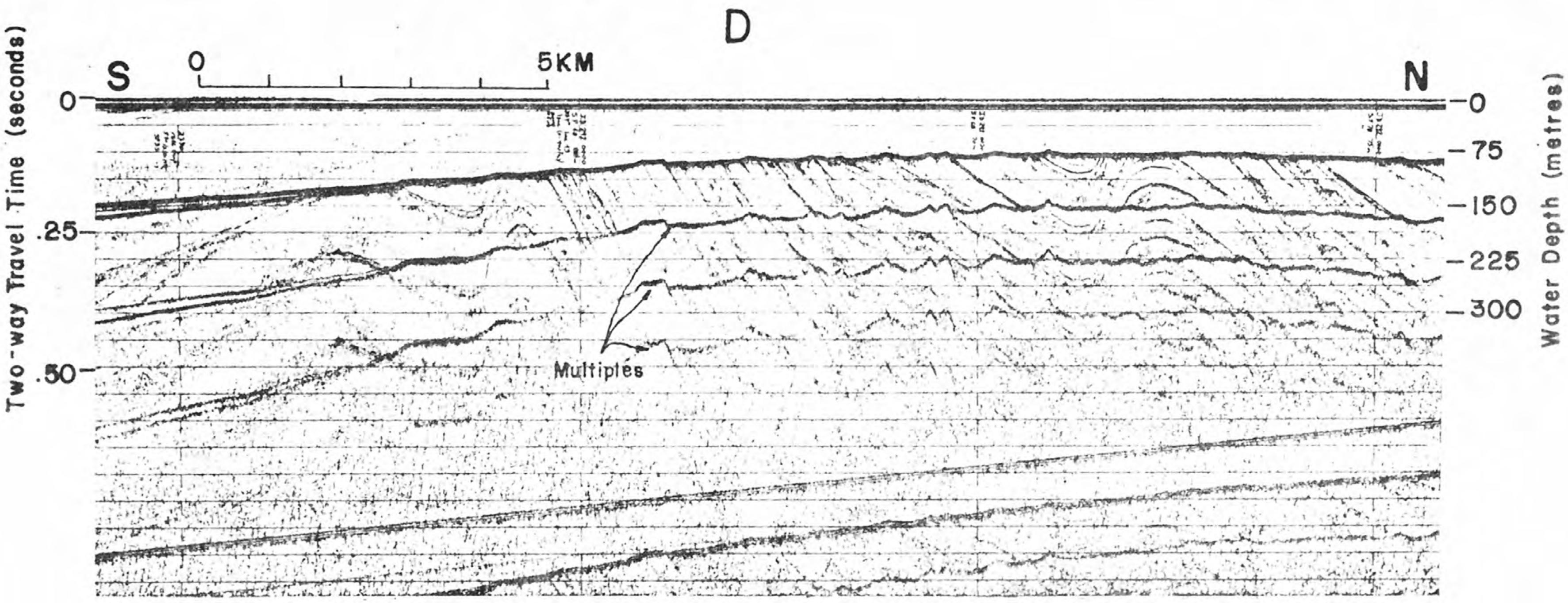


Figure 9. Seismic profile showing folded and truncated Tertiary and Pleistocene strata on Tarr Bank (v. e. ≈10X).

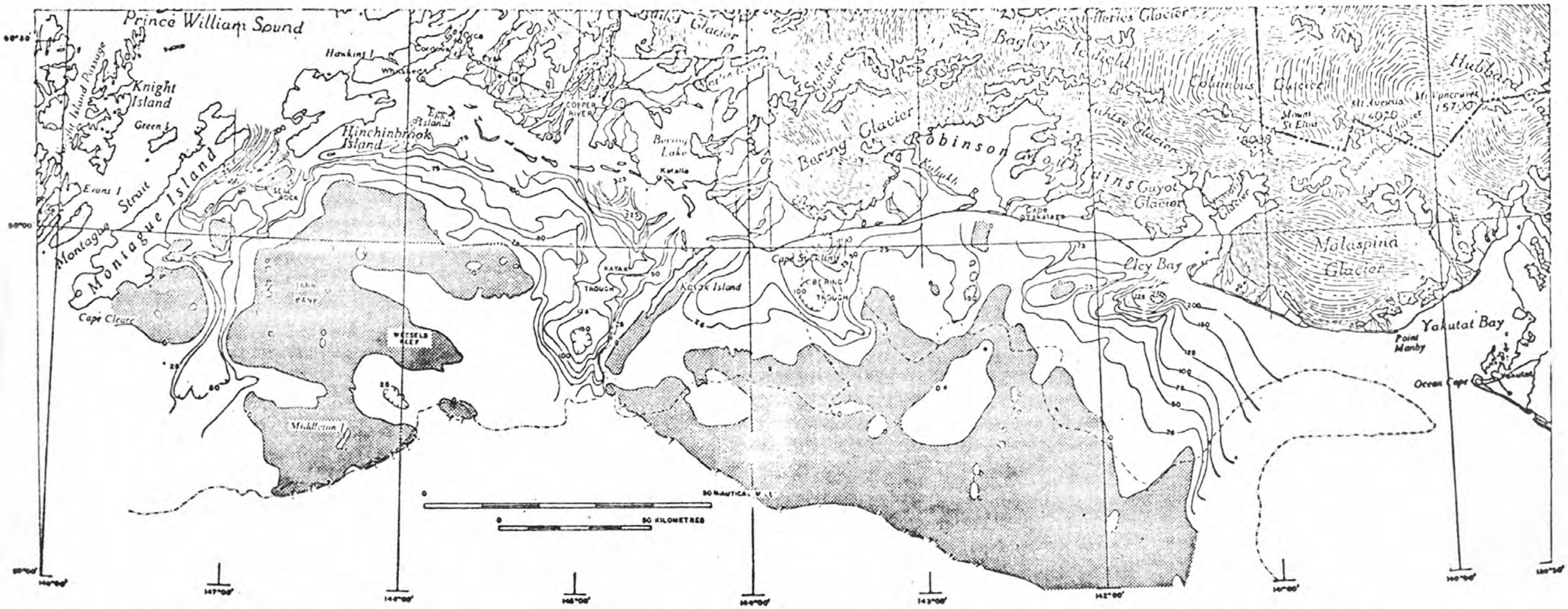


Figure 10. Iospach map of Holocene sediments. Modified from Carlson and Molnia, 1975b.

EXPLANATION

DEVOID OF HOLOCENE SEDIMENTS

—?--?— BOUNDARY UNCERTAIN, LIMIT OF SEISMIC PROFILE

—25— THICKNESS CONTOURS, 25 METRE INTERVAL

—·—·— 200 METRE ISOBATH

TICKS SHOW DIRECTION TOWARD THICKER SEDIMEN

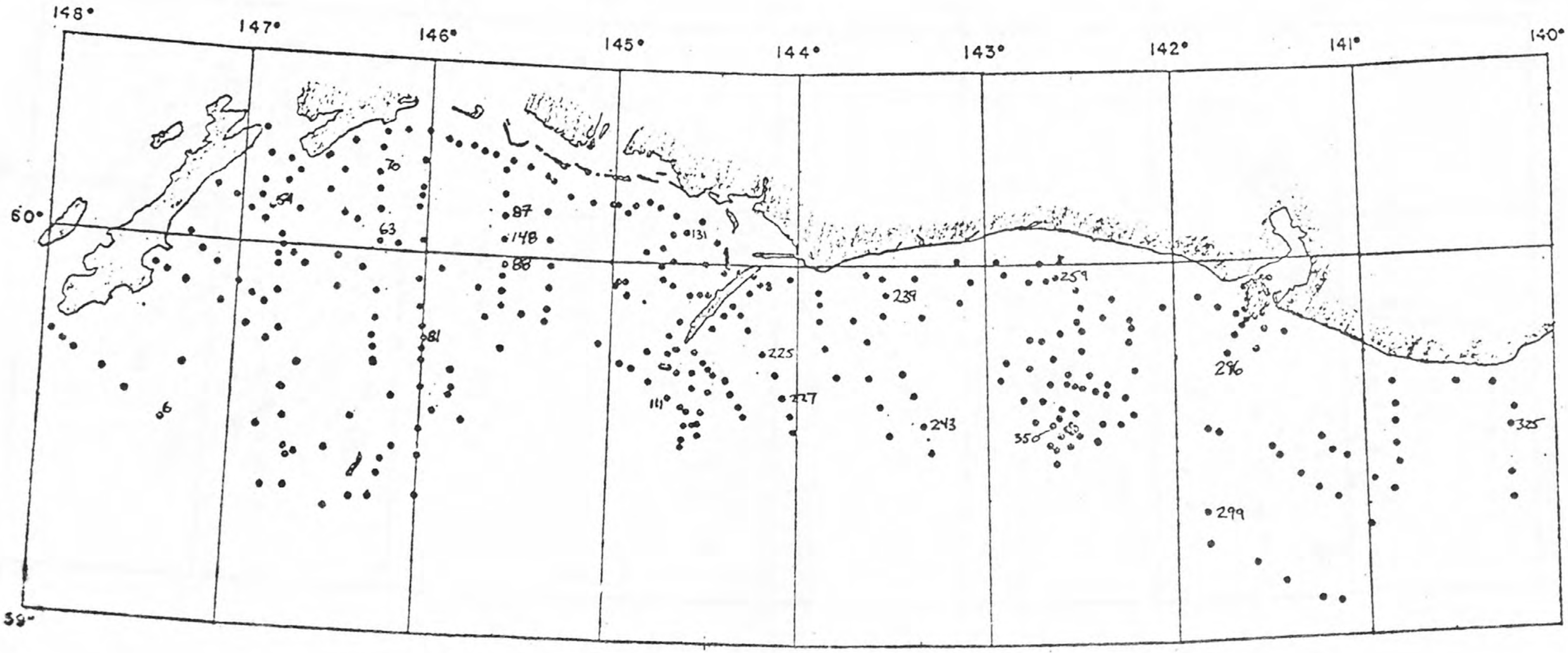


Figure 11. Locations of sediment samples (numbered) analyzed for clay mineralogy.

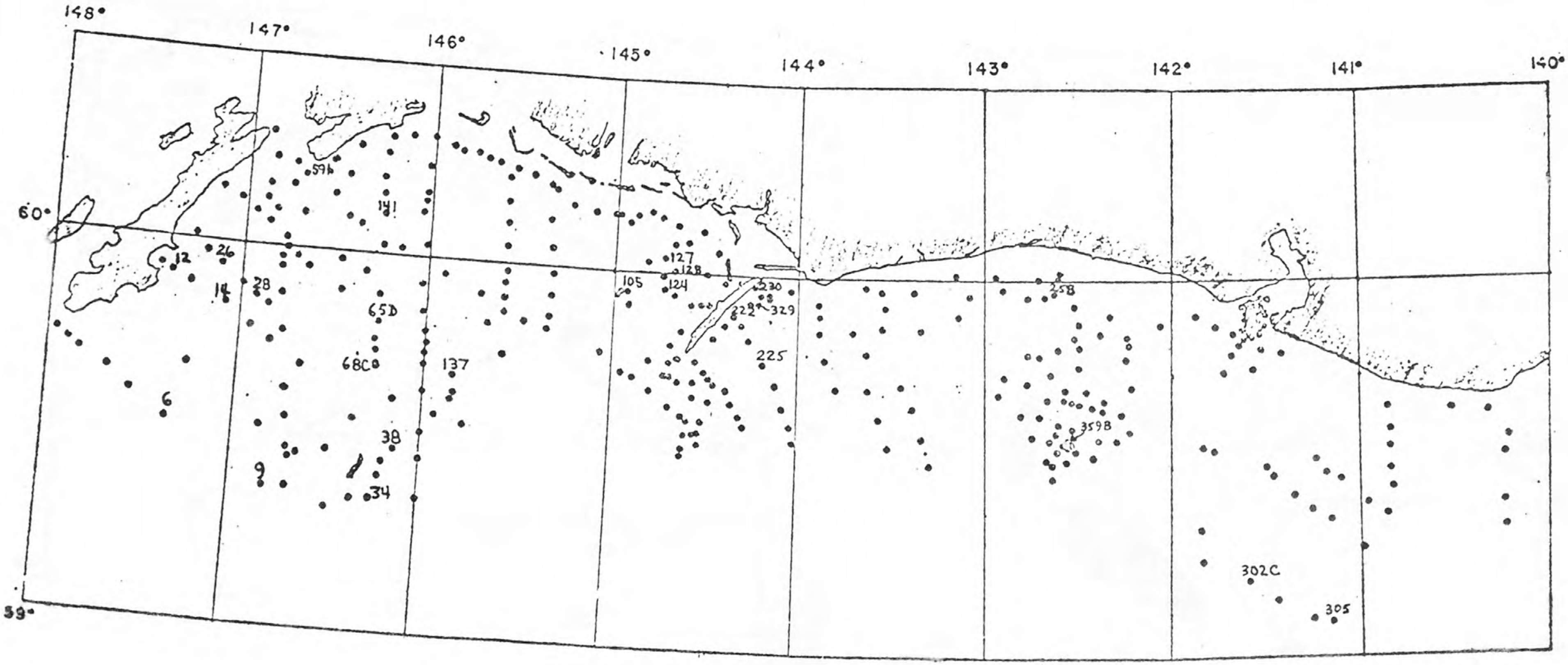


Figure 12. Locations of foraminiferal samples (numbered) together with all samples collected on the <u>FRS Cromwell</u> cruise of May - June 1975.

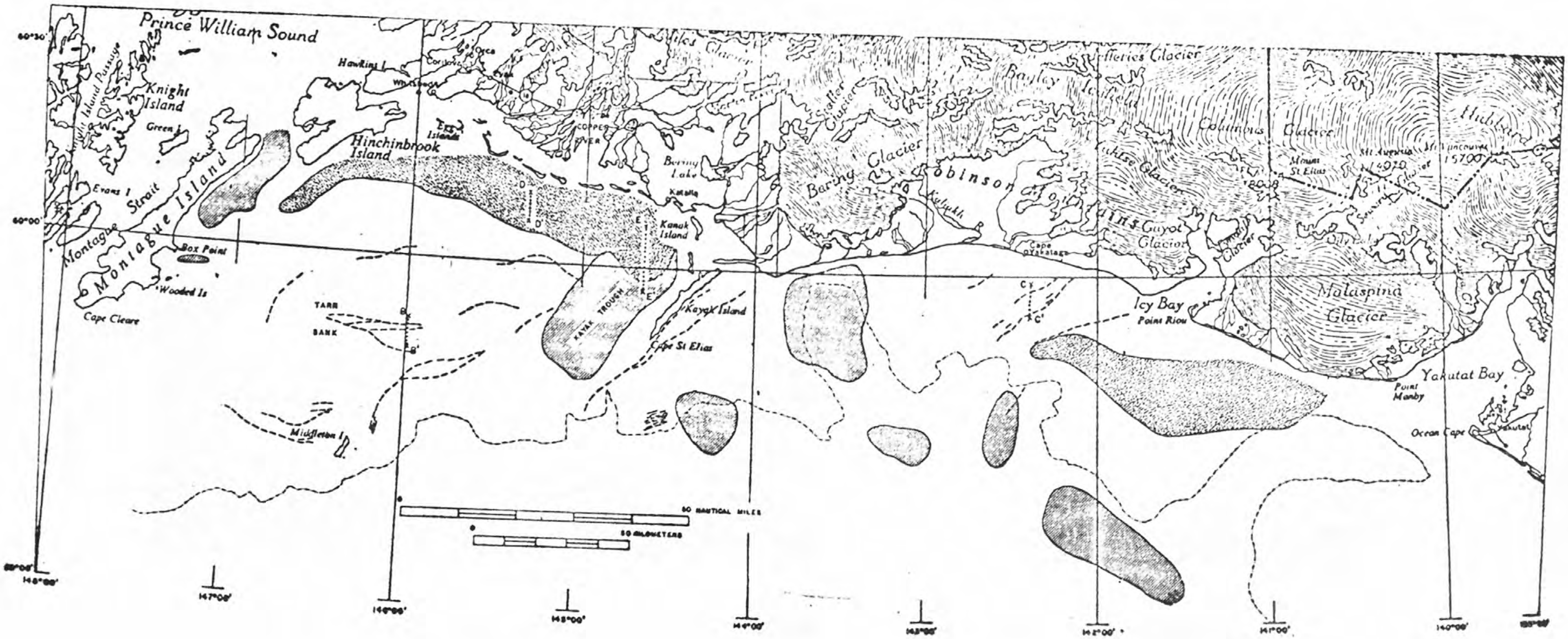
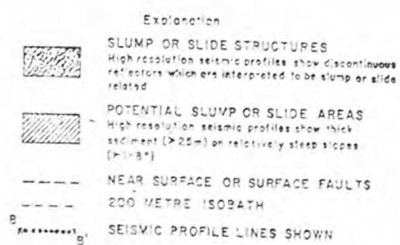


Figure 13. Preliminary map of submarine slides and near surface faults. Modified from Carlson and others, 1975.



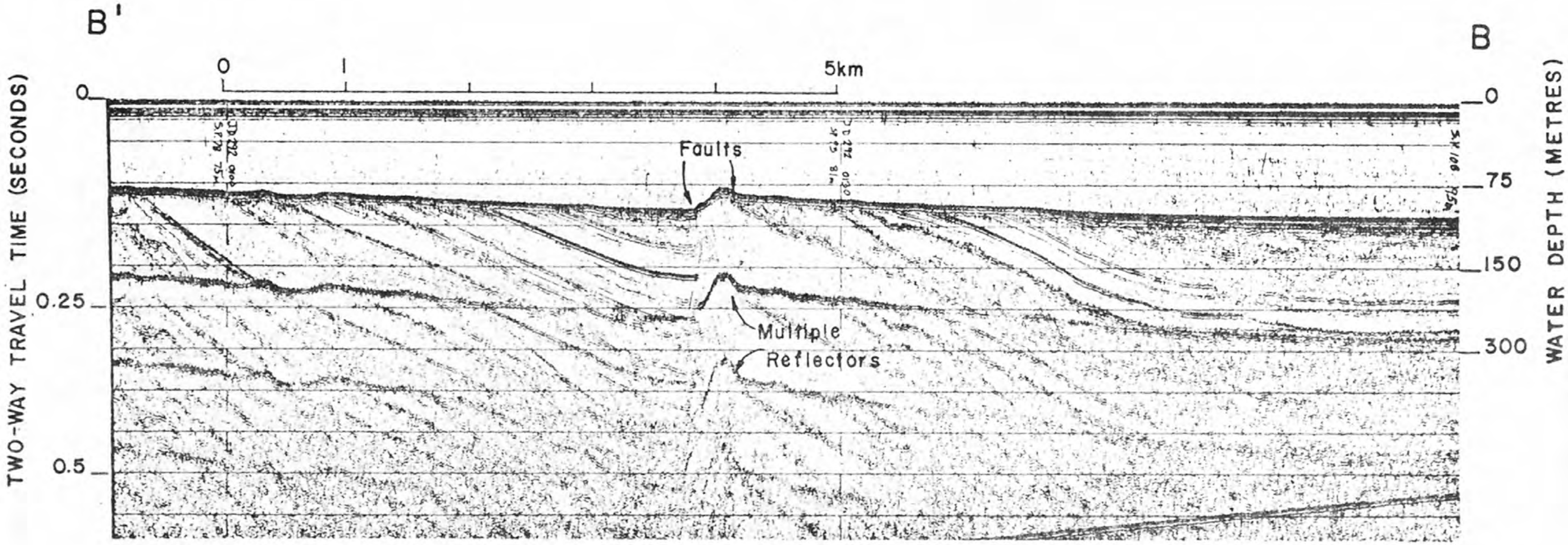


Figure 14. Minisparker profile showing faulted and folded older strata (Tertiary-Pleistocene) cropping out at the sea floor (v. e. ≈10X).

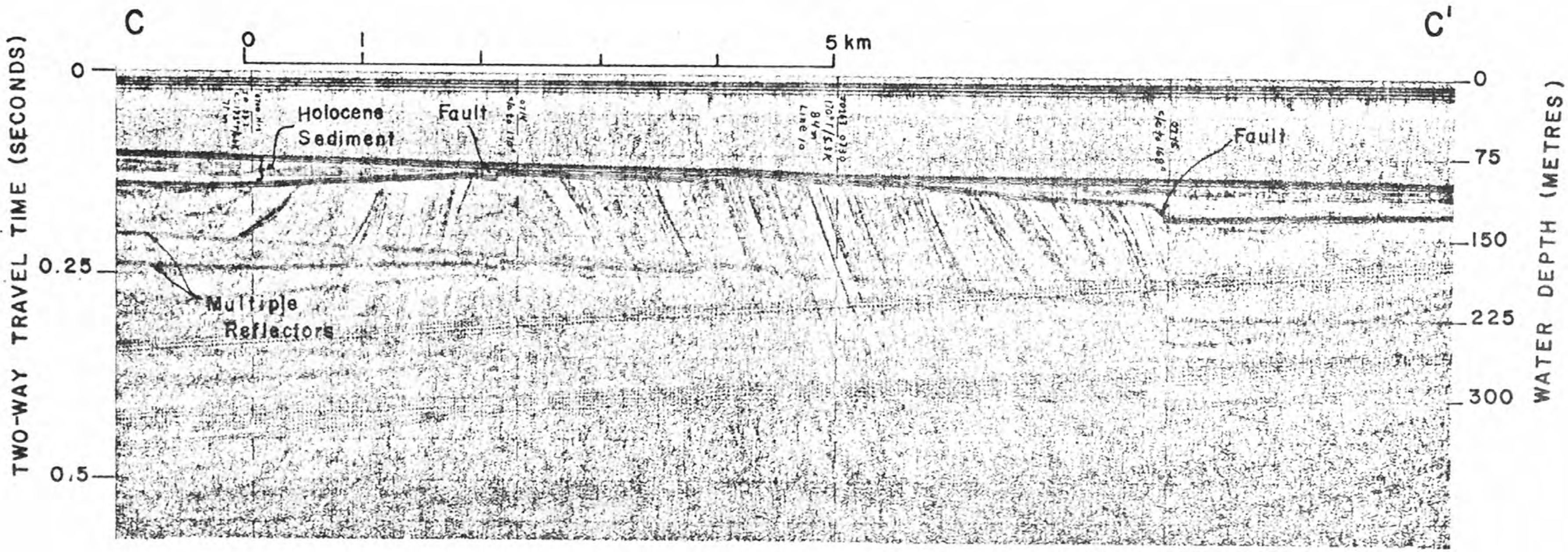


Figure 15. Minisparker profile south of Cape Yakataga showing faulted and folded older strata (Tertiary - Pleistocene?) overlain by a thin blanket of Holocene sediment (v. e, ≈10X).

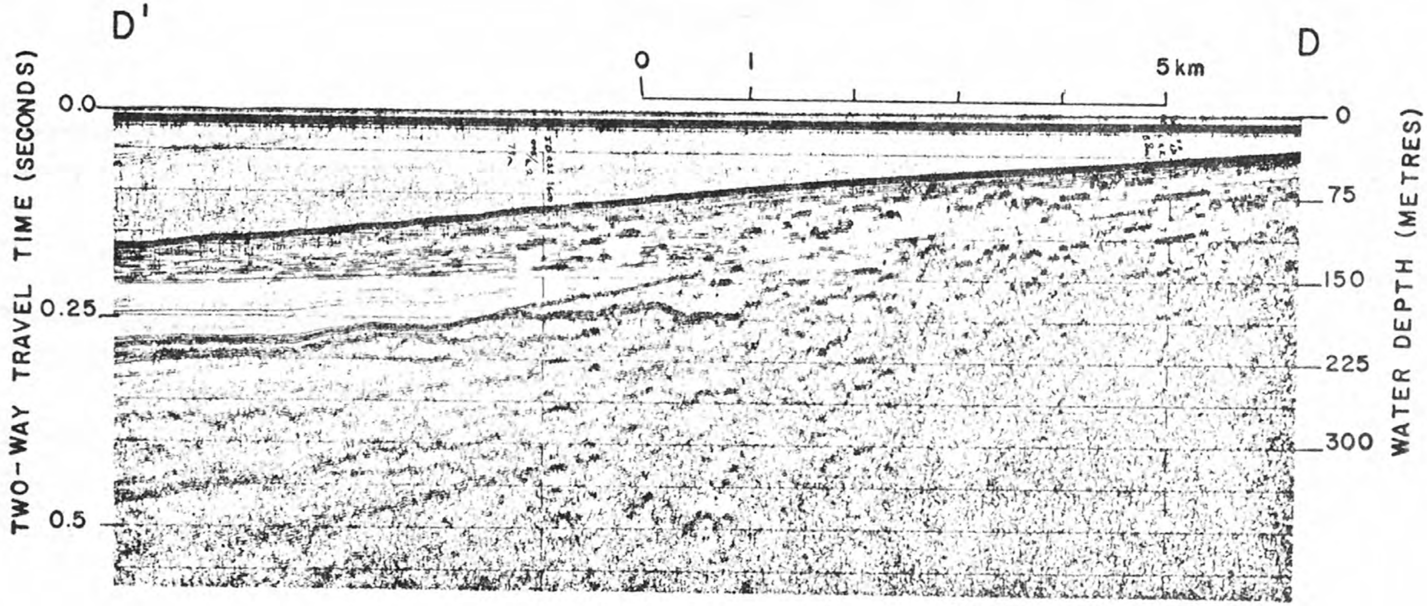


Figure 16. Minisparker profile showing disrupted reflectors of slump structures (left 1/3) and gas-charged sediments (right 2/3) in Copper River prodelta sediments (v. e. ≈10X).

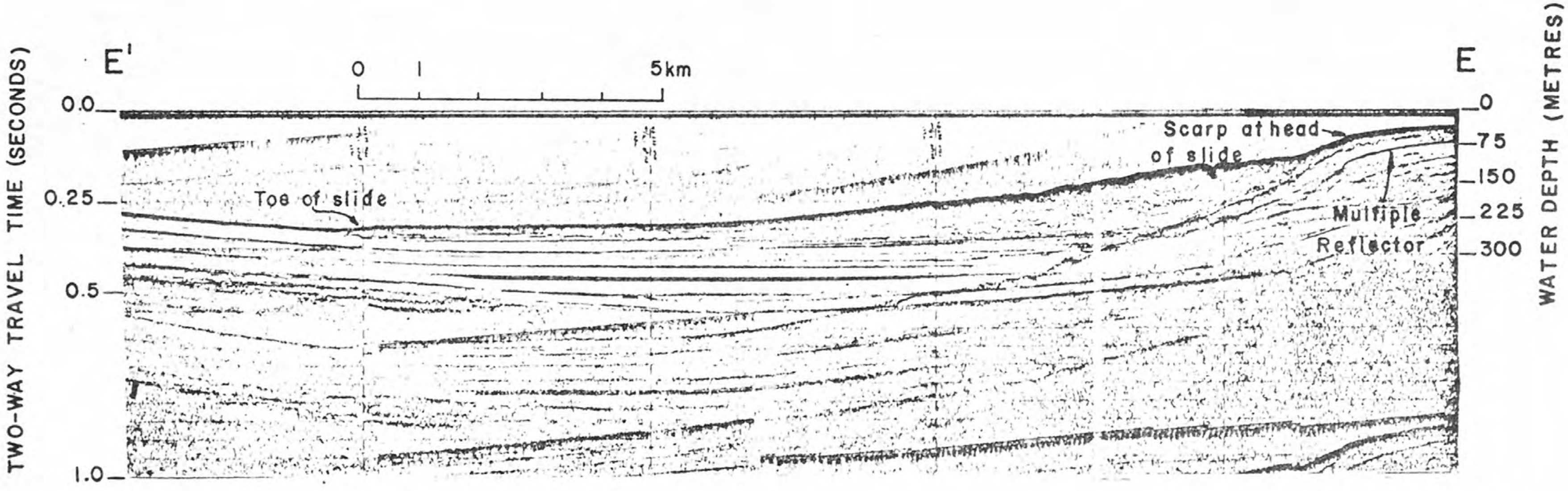


Figure 17. Minisparker profile of massive slide in Holocene sediments south of Katalla (v. e. ≈10X).

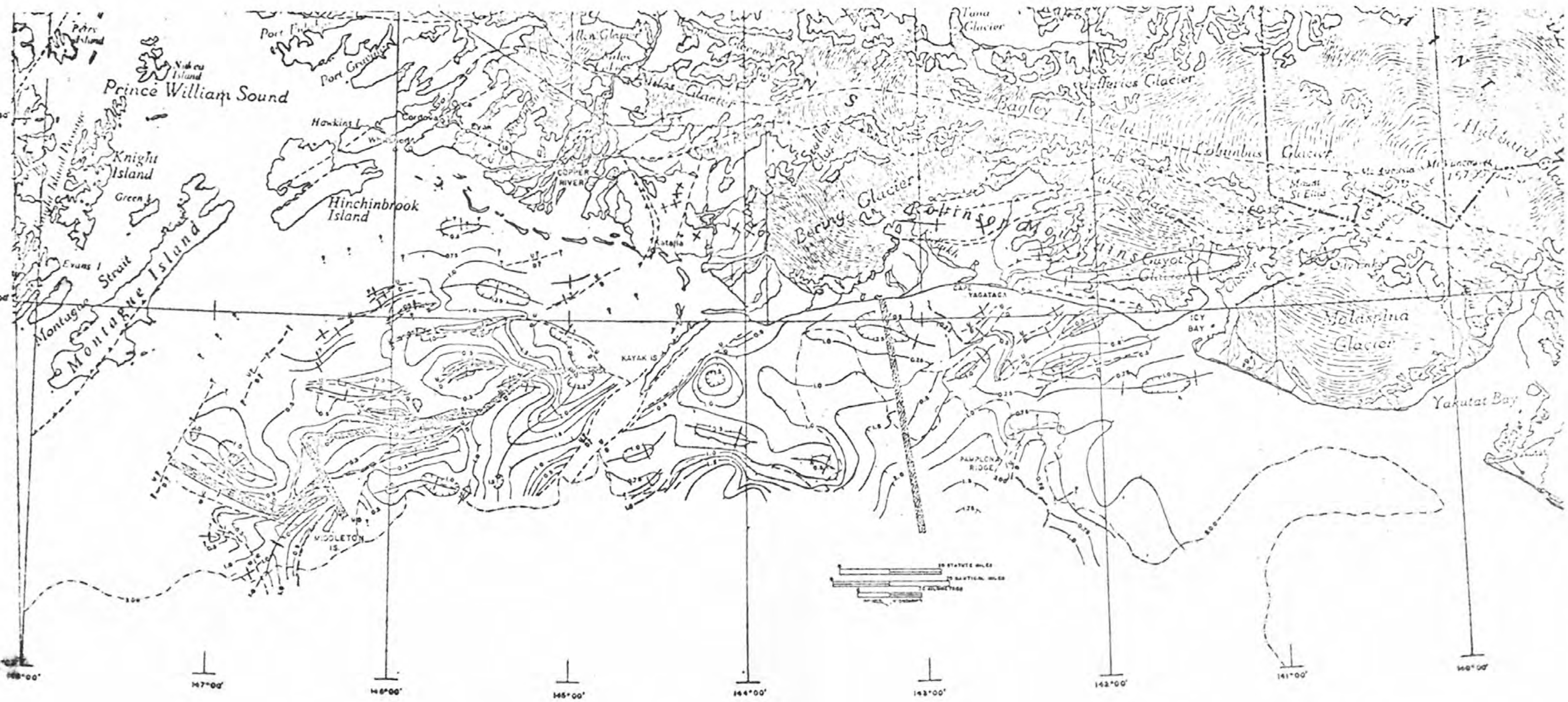


Figure 18. Preliminary map of geologic structure, Modified from Bruns and Plafker, 1975.