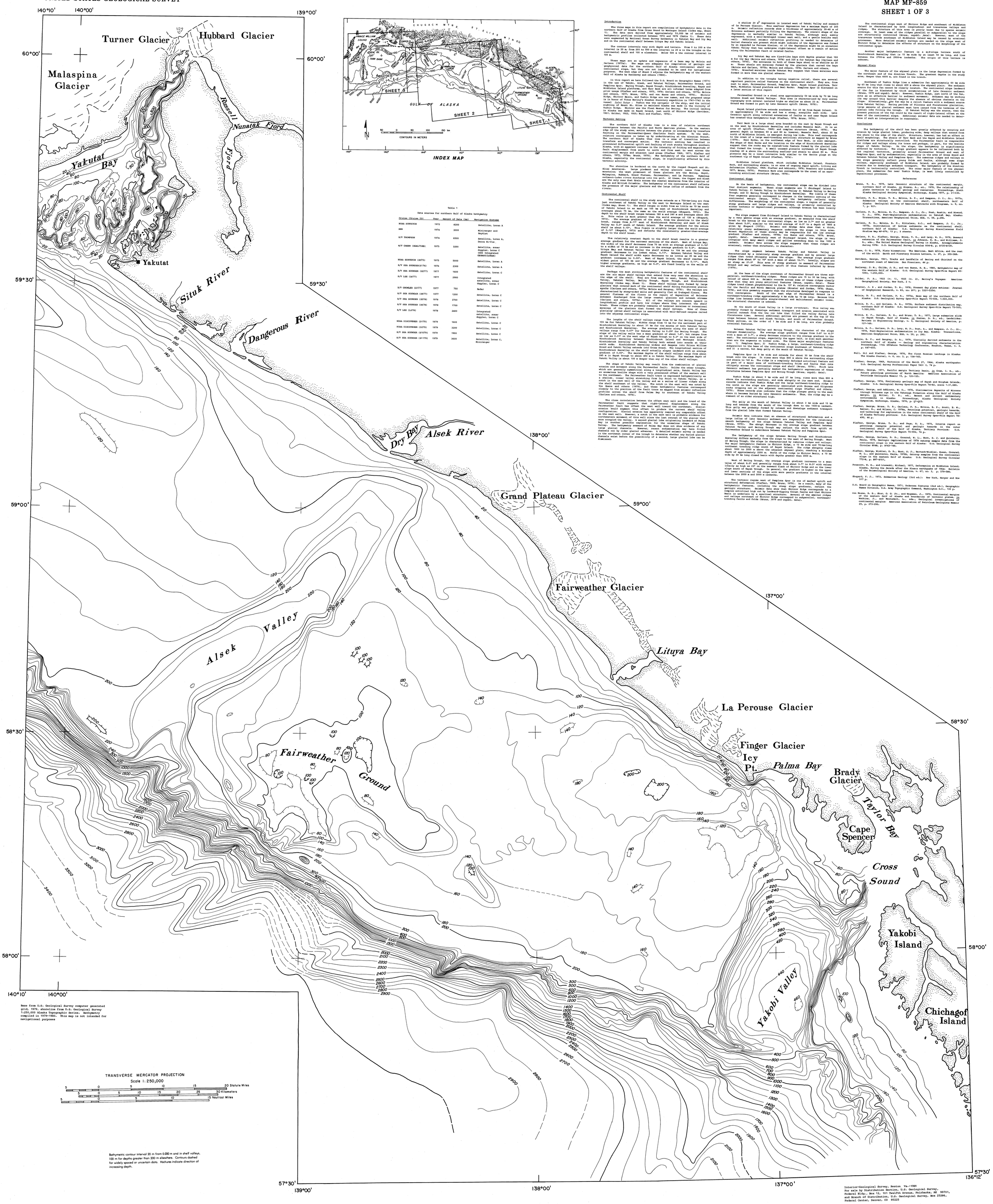

Base from U.S. Geological Survey computer generated grid, 1979, shoreline from U.S. Geological Survey 1:250,000 Alaska Topographic Series. Bathymetry compiled in 1979-1980. This map is not intended for navigational purposes

TRANSVERSE MERCATOR PROJECTION
Scale 1:250,000

Bathymetric contour interval 20 m from 0-200 m and in shelf valleys, 100 m for depths greater than 200 m elsewhere. Contours dashed for widely spaced or uncertain data. Hachures indicate direction of increasing depth.

Interior—Geological Survey, Reston, Va.—1981
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BATHYMETRIC MAPS OF THE NORTHERN GULF OF ALASKA

By
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1981

Table 1

Data sources for northern Gulf of Alaska bathymetry

Cruise (Cruise ID)	Year	Amount of Data (km)	Navigation System
NOAA SURVEYOR	1972	8200	Satellite, Loran A
BSR	1974	3000	Miniranger and Raytheon
R/V THOMPSON	1974	6500	Satellite, Loran A, Decca Hi-fix
M/V GREEN (EGAL75XB)	1975	3200	Satellite, sonar doppler, Loran C (GSI Integrated GEONAV/ZONAV)
NOAA SURVEYOR (S075)	1975	5000	Satellite, Loran A
R/V SEA SOUNDER(S176)	1976	2300	Satellite, Loran A
R/V SEA SOUNDER (S277)	1977	1600	Satellite, Loran C
R/V LEE (L677)	1977	2900	Integrated satellite, sonar doppler, Loran C
R/V GROMLER (G177)	1977	750	Radar
R/V SEA SOUNDER (S877)	1977	1200	Satellite, Loran C
R/V SEA SOUNDER (S578)	1978	3700	Satellite, Loran C
R/V SEA SOUNDER (S678)	1978	1700	Satellite, Loran C
R/V LEE (L378)	1978	2400	Integrated satellite, sonar doppler, Loran C
NOAA DISCOVERER (D179)	1979	1600	Satellite, Loran C
NOAA DISCOVERER (D279)	1979	3200	Satellite, Loran C
R/V SEA SOUNDER (S1079)	1979	1900	Satellite, Loran C
R/V SEA SOUNDER (S1179)	1979	3600	Satellite, Loran C, Miniranger

Introduction

The three maps in this report are compilations of bathymetric data in the northern Gulf of Alaska from Cross Sound to Montague Island (Index map, Sheet 1). The data were derived from approximately 53,200 km of seismic and bathymetric profiles collected between 1972 and 1979 (Table 1). These data were augmented by National Ocean Survey bathymetry in Yakutat Bay and Icy Bay and on the continental shelf between Lituya Bay and Yakobi Island.

The contour intervals vary with depth and terrain. From 0 to 200 m the interval is 20 m; from 200 to 500 m the interval is 20 m in the troughs on the continental shelf and 100 m elsewhere. Below 500 m the contour interval is 100 m.

These maps are an update and expansion of a base map by Molnia and Carlson (1975a). The maps are adequate for compilation of geologic and geophysical data for the northern Gulf of Alaska continental shelf and continental slope, but they are not intended to be used for navigational purposes. The west sheet I adjoins the bathymetric map of the western Gulf of Alaska by Dunlavey and others (1980).

In this report we have followed the U.S. Board on Geographic Names (1971) in the use of Yakobi, Alsek, and Yakutat Valleys; Grand Plateau Glacier and Pamplona Spur; Dry Bay, Palma Bay, Kayak Trough, Hinchinbrook Seavalley, Kayak and Middleton Island platforms, and Seal Rocks. Other names are all informal terms adapted from prior usage (Plafker and others, 1977, 1978; Carlson and others, 1977b; Molnia and others, 1977; Bruns, 1979; and references therein and others, 1979). Khitrov Ridge, Khitrov Basin, and Yushin Ridge are new names and the proposed usage is in honor of Vitus Bering's Alaskan discovery expedition in 1741-1742 in the vessel *Saint Peter*. Yushin was the navigator of the ship, and the initial sighting of Mount St. Elias in mainland Alaska was made from the ship. Khitrov was the first master for Bering. The initial landing in Alaska was made on Kayak Island, just north of Khitrov Ridge (Davidson, 1901; Golder, 1922, 1925; Hull and Plafker, 1976).

Tectonic Setting

The northern Gulf of Alaska lies in a zone of relative northwest convergence between the Pacific and North American plates. On the eastern edge of the study area, motion between the plates is accommodated by transform faulting on the Fairweather-Queen Charlotte fault system. To the west, relative convergence is taken up by underthrusting at the Aleutian Trench. The northern Gulf of Alaska thus lies in a zone of transition between transform and convergent motion. The tectonic setting has resulted in pronounced differential uplift and faulting of rock strata throughout southern Alaska, with an apparent increase in the magnitude of folding and amplitude of fault displacement from south to north and from east to west across the continental margin and adjacent land areas (Plafker 1969, 1971, Plafker and others, 1975, 1978a; Bruns, 1979). The bathymetry of the northern Gulf of Alaska, especially the continental slope, is significantly affected by this tectonic activity.

The shoreline is bordered on the north by the rugged Chugach and St. Elias mountains. Large piedmont and valley glaciers issue from these mountains; the most prominent of these glaciers are the Bering, Guyot, Malaspina, Hubbard, Agassiz, Platform, Fairweather, and La Perouse. Numerous sediment-laden rivers discharge into the gulf. Of these, the Copper and Alsek are the only ones that drain across the coastal mountains from the interior of Alaska and British Columbia. The bathymetry of the continental shelf reflects the presence of the major glaciers and the large influx of sediment from the rivers.

Continental Shelf

The continental shelf in the study area extends as a 750-km-long arc from just southeast of Yakobi Valley on the east to Montague Island on the west (Index map, Sheet 1). The shelf ranges in width from as little as 19 km south of Yakobi Island to as much as 105 km east of Hinchinbrook Seavalley and averages about 75 km, the same as the world average (Shepard, 1973). The depth to the shelf break ranges between 180 m and 240 m and averages about 200 m. This value is much greater than the world average of 130 m (Shepard, 1973). The average gradient of the shelf, from the shoreline to the shelf break, ranges from 0.0° and generally increases from east to west. Yakobi Valley has 0.5° south of Yakobi Island. The average gradient for the entire shelf is about 0.15°. This figure is slightly larger than the west coast average of 0.12° (Shepard, 1973) and reflects the consistently greater-than-average depth to the shelf break.

The relatively constant depth to the shelf break results in a greater average gradient for the narrower sections of the shelf. East of Lituya Bay, the width of the shelf decreases from 70 km with an average gradient of 0.16° to a width of 19 km and an increase in the average gradient to 0.5°. Between Lituya Bay and Yakutat Valley the shelf widens to 104 km and the average gradient decreases to its lowest value, 0.11°. Between Yakutat Valley and Kayak Island the shelf width again decreases to as little as 35 km and the gradient increases to 0.19°. West of Kayak Island, the shelf reaches its widest point of 105 km and the average gradient decreases to 0.11°. Much higher average gradients, as high as 6.3°, are found locally on the walls of the shelf valleys.

Perhaps the most striking bathymetric features of the continental shelf are the six major shelf valleys that extend from very near the shoreline to the edge of the shelf. They are from east to west: Yakobi Valley, Alsek Valley, Yakutat Valley, Bering Trough, Kayak Trough, and Hinchinbrook Seavalley (Index map, Sheet 1). These shelf valleys were formed by large glaciers that covered much of the continental shelf during Pleistocene glacial epochs (Carlson and others, 1977a; Molnia and Hampton, 1979). The valleys are characterized by steep-sided walls and generally flat or irregular floors. The general flatness of the floors is the result of deposition of glacial sediment discharged from the large coastal glaciers and outwash streams (Carlson and others, 1977b). All of the valleys are concave upward in longitudinal profile and have low ridges where they intersect the shelf break. These ridges are probably remnants of terminal moraines or recessional moraines of the glaciers that formed the shelf valleys. None of these glacially gouved shelf valleys is associated with well-defined canyons carved into the adjacent continental slope.

The lengths of the shelf valleys range from 52 km for Bering Trough to 155 km for Yakutat Valley. Widths range from 13 km for the narrowest part of Hinchinbrook Seavalley to about 31 km for the mouths of Yakutat Valley and Hinchinbrook Seavalley. The average gradients along the axes of shelf valleys range from 0.29° for Yakutat Valley to 0.29° for Bering Trough. The slope of the valley walls has a mean gradient of about 1.8°, but ranges from as low as 0.3° on the west side of Kayak Trough to 6.3° on the east side of Hinchinbrook Seavalley between Hinchinbrook Island and Montague Island. Hinchinbrook Seavalley and Yakobi Valley both extend into sounds at their north ends. Hinchinbrook Seavalley widens and deepens into Prince William Sound and Yakobi Valley extends into Cross Sound. The longitudinal section of Hinchinbrook Seavalley on the shelf actually slopes landward with an average gradient of 0.05°. The maximum depths of the shelf valleys range from about 245 m in Kayak Trough to about 450 m in Yakobi Valley. The maximum depth of Yakobi Valley is about 100 m deeper than any of the other shelf valleys.

The shape of Yakobi Valley may result from the combination of glacial erosion and movement along the Fairweather fault. Unlike the other troughs, which are generally symmetrical along a longitudinal axis, Yakobi Valley has an anomalous hoelike shape with a very pronounced offset of the western wall to the northwest. The Fairweather fault trough is expressed bathymetrically as a shallow, linear valley stretching from Icy Point to Yakobi Valley, as a notch in the east wall of the valley and as a series of linear ridges along the shelf southeast of the valley. The notch in the east wall was noted by Von Huene and others (1979), and these bathymetric features correspond closely to the position of the fault trace as mapped from seismic reflection profiles across the shelf from Palma Bay to southeast of Yakobi Valley (Carlson and others, 1979).

The close correlation between the offset west wall and the trend of the Fairweather fault suggests that right-lateral displacement along the Fairweather fault has offset the west wall toward the northwest. Glacial erosion would augment this offset to produce the current shelf valley configuration. Glacial erosion has apparently removed any comparable offset on the east wall. However, a notch in the east wall is probable evidence for northwestern movement of this wall since the last retreat of the glacier that once occupied the valley. A second glacial lobe originating landward of Palma Bay is another possible explanation for the anomalous shape of Yakobi Valley. The bathymetry seaward of Palma Bay does not show evidence of any large glacial channels. However, recent sedimentation may have filled channels cut by older glacial advances. A detailed seismic survey is needed in the northwest corner of the trough to determine whether any buried glacial channels exist before the possibility of a second, large glacial lobe can be dismissed.

A shallow 20 km^2 depression is located west of Yakobi Valley and seaward of La Perouse Glacier. This seafloor depression has a maximum depth of 205 m. Seismic reflection records show a thickness of approximately 30-40 m of Holocene sediment partially filling the depression. The overall shape of the depression is markedly similar to Yakobi Valley, although more subtly expressed, with a well-developed linear shelf wall, and a gentle hoelike west wall. Additional seismic reflection profiling is needed to determine if buried channels are present which might indicate the depression was formed by an expanded La Perouse Glacier, or if the depression might be an ancestral Yakobi Valley that has undergone right-lateral offset as a result of motion along the Fairweather fault or related faults.

Icy Bay and Yakutat Bay are fjord-like bays with depths greater that 100 m for Icy Bay (Molnia and others, 1978) and 320 m for Yakutat Bay (Carlson and others, 1978). The entrances to both of these bays shoal to as shallow as 20 m. These shoals are moraines formed by the glaciers that carved the bays (Molnia and Carlson, 1975b; Molnia and others, 1978; Carlson and others, 1978). Breached moraines inside Yakutat Bay suggest that these moraines were formed in more than one glacial advance.

In addition to the troughs having negative relief, there are several important positive relief features on the continental shelf. They are, from east to west, Fairweather Ground, Pamplona Spur, Kayak Island platform, Tarr Bank, Middleton Island platform and Seal Rocks. Pamplona Spur is discussed in a later section of this report

Fairweather Ground is a shoal area approximately 50 km wide by 70 km long between Alsek and Yakobi Valleys. This area is characterized by very uneven topography with several isolated highs as shallow as about 23 m. Fairweather Ground was formed in part by late Cenozoic uplift (Bruns, 1979).

Kayak Island platform extends southwest for 20 km from Kayak Island. It is approximately 10 km wide and has a steep, irregular west side. Late Cenozoic uplift along inferred extensions of faults on and near Kayak Island has created this bathymetric high (Plafker, 1974; Bruns, 1979).

Tarr Bank is a large shoal area bounded on the east by Kayak Through and on the west by Hinchinbrook Seavalley and includes Wessels Reef. It is an area of uplift (Plafker, 1969) and complex structure (Bruns, 1979). The general depth is between 50 m and 80 m; however, Wessels Reef, about 35 km north of Middleton Island, is exposed during low tide. This reef corresponds to the crest of a large east-trending anticlinal structure as mapped by Bruns (1979). Seal Rocks, on the northwestern edge of Tarr Bank, is also emergent. The shape of Seal Rocks and the location only of edge of Hinchinbrook Seavalley suggest that the rocks may be sunstack-like features formed by the glacial lobe that formed the trough. A small unnamed pinnacle southwest of Kayak Through reaches 40 m above the surrounding seafloor and shoals to about 80 m. This pinnacle may be a local intrusive body similar to the dacite plugs at the southwest tip of Kayak Island (Plafker, 1974).

Middleton Island platform, which includes Middleton Island, Fountain Rock, and surrounding shoals, is an area of ongoing rapid uplift, tilting and deformation (Plafker, 1969; Plafker and Addicott, 1976; Prescott and Lisowski, 1977; Bruns, 1979). Fountain Rock also corresponds to the crest of an east-trending anticlinal structure (Bruns, 1979).

Continental Slope

On the basis of bathymetry, the continental slope can be divided into four distinct segments. These slope segments are 1) Chichagof Island to Yakobi Valley; 2) Yakobi Valley to Yakutat Valley 3) Yakutat Valley to Bering Trough; and 4) Bering Trough to Hinchinbrook Seavalley. The limits of these four segments generally correspond to changes in the tectonic setting of the continental margin (Bruns, 1979), and the bathymetry reflects these differences. The morphology of the continental slope, a region of generally steep gradients and large ridges and valleys, is primarily controlled by either tectonic or depositional processes, although erosion has been locally important.

The slope segment from Chichagof Island to Yakobi Valley is characterized by a very gentle slope with an average gradient, as measured from the shelf break to the bottom of the continental slope, as low as 2.7° and no greater than about 5.0°, similar to the world average of 4.3° to a depth of 1800 m given by Shepard (1973). Seismic and dredge data show that a thick, relatively young sedimentary sequence underlies the slope in this area. Recent deposition of these sediments is responsible for the low average gradient (Plafker and others, 1978b; von Huene and others, 1979; Bruns, unpubl. data). Immediately west of Chichagof Island, the slope is very irregular with many small ridges and gullies extending down to the 1000 m isobath. Seismic data across the slope suggests that these ridges are erosional, rather than structural, in character.

The slope segment between Yakobi Valley and Yakutat Valley is characterized by a relatively steep average gradient and by several large ridges that trend obliquely across the slope. The average slope gradient ranges from about 8° to 16° with a mean of about 10.7°. Locally, slopes are as steep as 21.0° This area of steep gradient is seaward of Fairweather Ground and may reflect Cenozoic uplift of this feature inferred by Bruns (1979).

At the base of the slope southwest of Fairweather Ground are three subparallel, northeast-trending ridges. These ridges are 15 to 30 km long, with relief of about 600 m. Seismic records across some of these ridges clearly show that they are young anticlinal features (Bruns, unpubl. data). These ridges trend almost perpendicular to the N. 15° W. relative convergence vector for the Pacific and North America plates (Minster and Jordan, 1978; Chase, 1978), and this geometry suggests that the structures developed in response to this convergence. South of the general flatness of Fairweather Ground is a northeast-trending ridge approximately 4 km wide by 15 km long. Because this ridge lies between available single-channel and multichannel seismic lines, the structural character is unknown.

At the mouth of Alsek Valley is a large re-entrant. This valley was probably formed by downslope sediment transport and erosion associated with glacial outwash from the the lobe that filled the valley during late Pleistocene time. Several additional gullies are present at the top of the slope between Yakutat and Alsek Valleys, and south of Fairweather Ground. These gullies are on the order of 1 km wide and 5 km long, are also probably erosional features.

Between Yakutat Valley and Bering Trough, the character of the slope changes dramatically. The average slope gradient ranges from 2.8° to 4.3° with a mean of 3.7°, a sharp decrease relative to the average gradient to the east. The continental slope, especially the upper half, is also much smoother than are the segments on either side. The three major morphologic features are: 1) Pamplona Spur, 2) Yushin Ridge, a large, northwest-trending ridge subparallel to the base of the continental slope southwest of Yakutat Valley, and 3) a narrow, but deep gully at the mouth of Yakutat Valley.

Pamplona Spur is 5 km wide and extends for about 30 km from the shelf break onto the slope. It rises more than 800 m above the surrounding slope and shoals to 140 m. The ridge is a complexly deformed anticlinal feature and is part of a major zone of northeast-trending folds and faults that cut obliquely across the continental slope and shelf (Bruns, 1979). Thick late Cenozoic sediment has partially masked the bathymetric expressions of these structures between Pamplona Spur and Bering Trough (Bruns, unpubl. data).

Yushin Ridge is about 5 km wide and 27 km long; rises more than 800 m above the surrounding seafloor, and ends abruptly on its east end. Seismic records indicate that Yushin Ridge and the large northwest-trending ridge to the north on the slope are generally associated with Eocene and Oligocene rocks cropping out on the adjacent continental slope (Plafker and others, 1979). These records also indicate that the ridge plunges gently to the west where it becomes buried by late Cenozoic sediments. Thus, the ridge may be a remnant of an older structural high.

The gully at the mouth of Yakutat Valley is about 2 km wide and 15 km long and extends from the mouth of the trough down to the 1500-m isobath. This gully was probably formed by outwash and downslope sediment transport from the glacial lobe that formed Yakutat Valley.

Seismic data indicate that an absence of structural deformation and a large influx of late Cenozoic sediment are responsible for the relatively smooth bathymetry of the slope between Yakutat Valley and Pamplona Spur (Bruns, 1979). The abrupt decrease in the average slope gradient between Yakutat Valley and Bering Trough may reflect the shift from uplift at Fairweather Ground to subsidence between Yakutat Valley and Pamplona Spur.

The bathymetry of the slope between Bering Trough and Hinchinbrook Seavalley differs markedly from the slope to the east of Bering Trough. West of Bering Trough, the slope is characterized by numerous ridges and valleys. The major bathymetric feature is Khitrov Ridge, a 12 km wide and 70-km-long northeast trending ridge south of Kayak Island. The ridge abruptly rises about 1000 to 2000 m above the adjacent abyssal plain, reaching a minimum depth of approximately 2200 m. North of the ridge is Khitrov Basin, a 10 km wide by 30 km long closed basin with depths greater than 3000 m.

West of Bering Trough, the average slope gradient increases to a mean value of about 6.0° and generally ranges from about 3.7° to 8.5° with values locally as high as 23° on the seaward flank of Khitrov Ridge and on the lower slope south of Kayak Trough. In general, the gradient is higher on the upper and lower sections of the slope with more gentle gradients in the interval between the 2000 m and 3000 m isobaths.

The tectonic regime west of Pamplona Spur is one of marked uplift and structural deformation (Plafker, 1969; Bruns, 1979). As a result, many of the bathymetric features, including the steep slope gradients, reflect the geologic structure. Seismic data show that Khitrov Ridge corresponds to a complex anticlinal high cut by landward-dipping thrust faults and that Khitrov Basin is underlain by a synclinal structure. Several of the smaller ridges and valleys northeast of Khitrov Ridge correspond to subparallel, northeast-trending faults and folds (Bruns, 1979 and unpubl. data).

The continental slope west of Khitrov Ridge and southeast of Middleton Island is characterized by both longitudinal and transverse valleys and ridges. The structure of this area is poorly known due to sparse seismic coverage. At least some of the ridges parallel or subparallel to the slope are structurally controlled (Bruns, unpubl. data). However, most of the transverse trends southeast of Middleton Island may be caused by erosional processes. More detailed seismic surveys are needed on the slope west of Khitrov Ridge to determine the effects of structure on the morphology of the continental slope.

Another major bathymetric feature is a mid-slope terrace south of Hinchinbrook Seavalley that is 15 km wide by at least 50 km long, and lies between the 2700-m and 2900-m isobaths. The origin of this terrace is unknown.

Abyssal Plain

The major feature of the abyssal plain is the large depression formed by the northeast end of the Aleutian Trench. The greatest depths in the study area, deeper than 4600 m, are found in the trench.

Southwest of Yushin Ridge lies a submarine fan approximately 60 km wide by 65 km long that rises to about 400 m above the abyssal plain. The sediment source for this fan cannot be clearly located. The continental slope landward of the fan is blanketed by thick accumulations of late Cenozoic sediment (Bruns, 1979 and unpubl. data). However, Yushin Ridge, just north of the fan, acts as an effective barrier to sediment movement. Sediment may be working its way around this barrier despite the absence of obvious channels on the slope. Alternatively, the fan may be a relict feature with a sediment source from Yakutat Valley. During periods of Pliocene and Pleistocene glaciation, large amounts of glacial sediment must have issued from the termini of the glacial lobe filling the trough. If Yakutat Valley was the source, then the present position of the fan could be the result of right-lateral offset at the base of the continental slope. Additional seismic data are needed to determine if such an interpretation is reasonable.

Conclusions

The bathymetry of the shelf has been greatly affected by scouring and erosion by large glacial lobes, producing wide, deep valleys that extend from the shore to the edge of the shelf. Structure has been a major factor affecting shelf morphology. The shoals of Tarr Bank and the Kayak and Middleton Island platforms are structurally controlled. The Fairweather fault is responsible for ridges and structures along its trace and perhaps, in part, for the boxlike shape of Yakobi Valley. The slope, in the study area, has been glacially affected by tectonics. The slope gradient appears to be influenced both by the regional tectonics, primarily uplift, and by sediment volume and wedge of Pamplona Spur, and by sedimentation, especially in the gulf of Cross Sound and between Yakutat Valley and Pamplona Spur. The numerous ridges and valleys on the slope generally reflect young folds and faults, although some slope valleys, especially southeast of Middleton Island, are probably formed by erosion due to downslope sediment transport. The bathymetry of the Aleutian Trench is tectonically controlled. The other major feature of the abyssal plain, the submarine fan near Yushin Ridge, is most likely controlled by depositional processes.

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