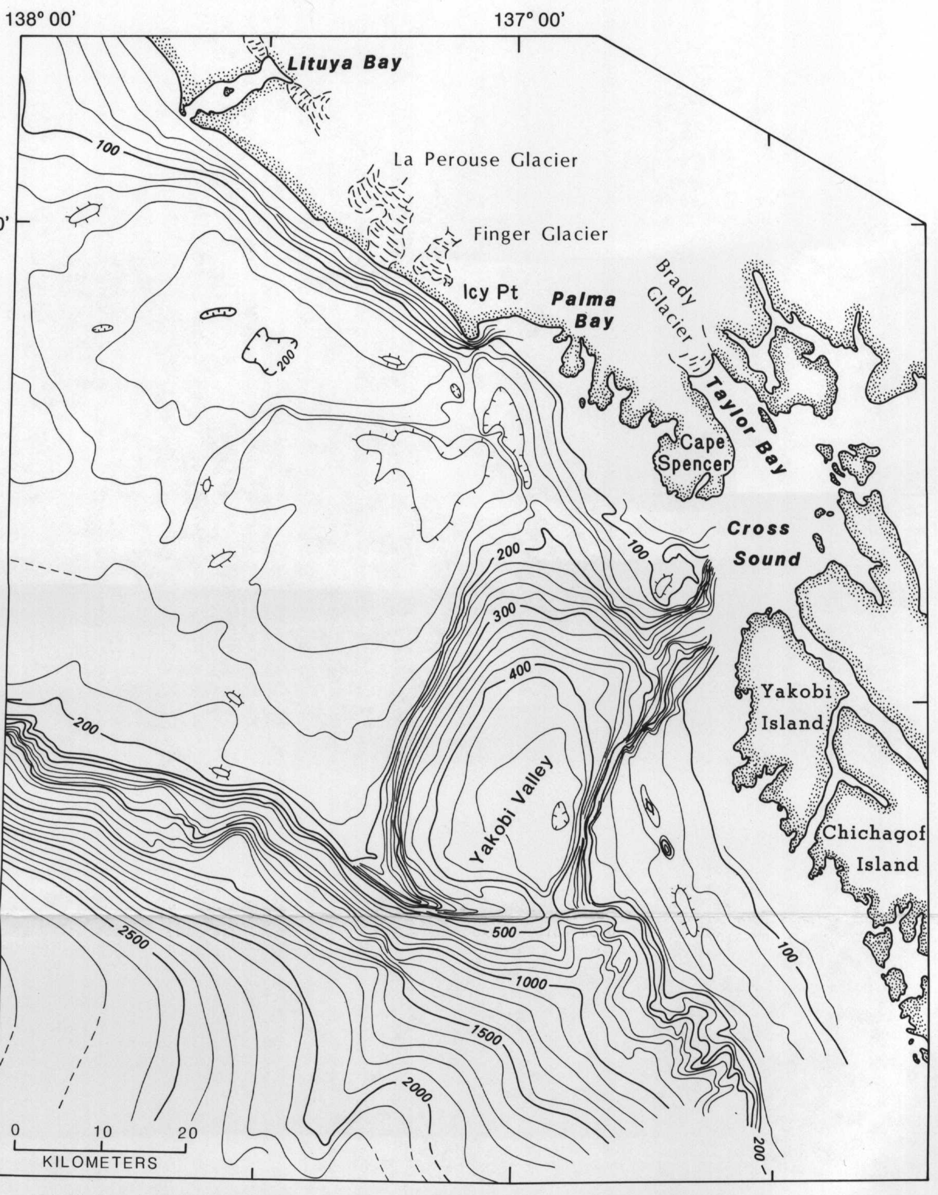
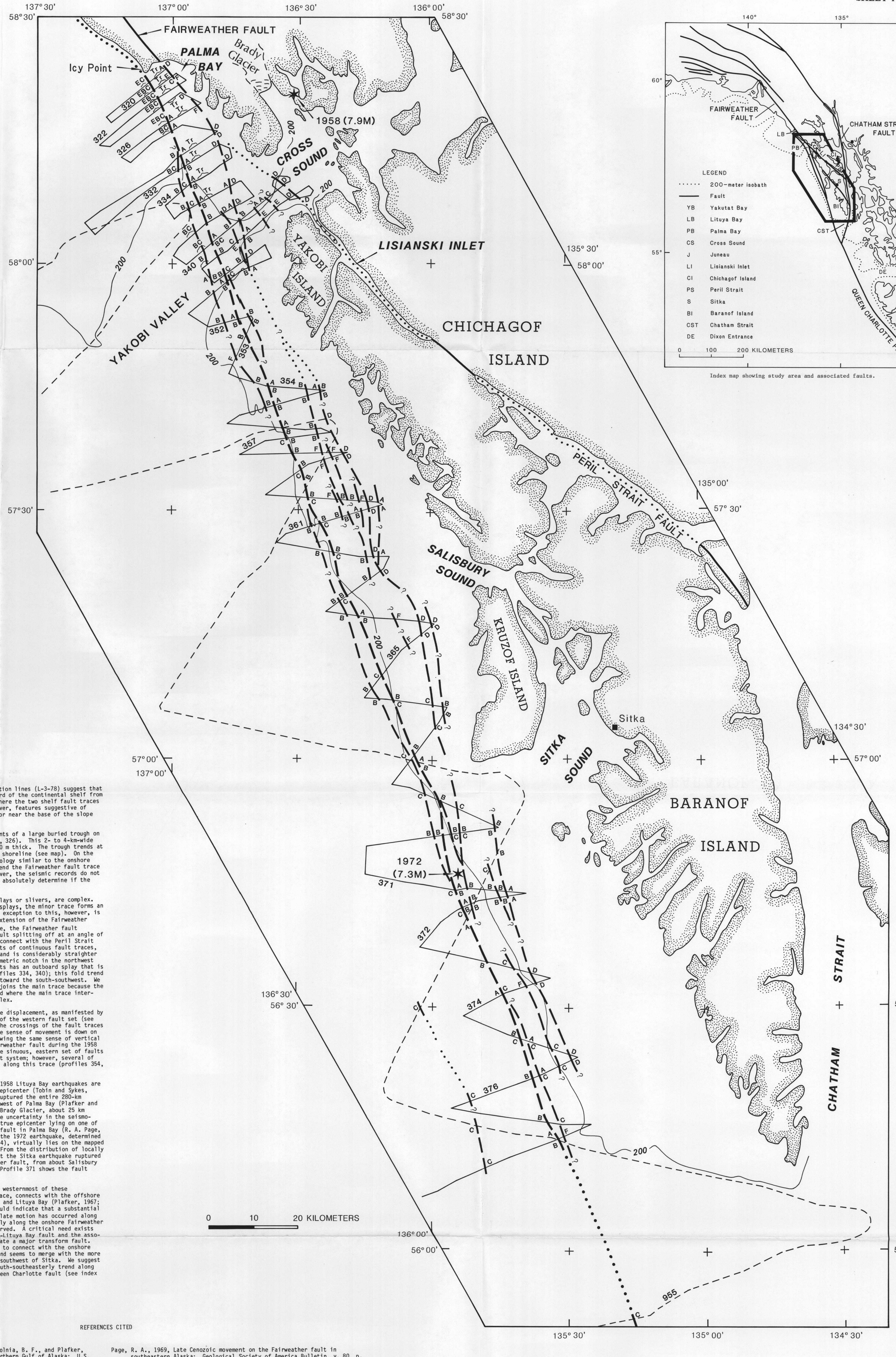
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF–1722
SHEET 1 OF 2



Detailed bathymetry of continental margin between Lituya Bay and Yakobi Island. From Atwood and others (1981).



Index map showing study area and associated faults.

EXPLANATION

ONSHORE FAULT

OFFSHORE FAULT -- Approximately located; dotted where inferred; queried where connection, continuation, or extent uncertain

REFLECTOR CHARACTERISTICS USED TO IDENTIFY FAULTS

- A Offset seafloor
- B Disrupted subbottom reflectors (broken, truncated, abrupt change in reflector attitude)
- C Structurally complex zone
- D Buttress unconformity
- E Broad topographic high
- F Zone of irregular anomalous subbottom reflectors
- Tr Large buried trough

1958 (7.9M) EPICENTER OF EARTHQUAKE -- Showing date and magnitude

SHIP TRACK LINES -- Numbered lines show location of selected profiles, sheet 2
- S-5-78
- L-3-78

200 200-METER ISOBATH

INTRODUCTION

The seismically active Fairweather fault (Tocher, 1960; Page, 1969; Plafker and others, 1976) has been mapped from Yakutat Bay to the shoreline of Palma Bay (Plafker, 1967). This strike-slip fault is believed to represent the boundary between the Pacific and North American plates in the Gulf of Alaska region (Plafker and others, 1978). Numerous authors have speculated on the seaward extension of this major structural feature (St. Amand, 1957; Grantz, 1966: Stoneley, 1967; Plafker and others, 1978; von Huene and others, 1979). Widely spaced seismic profiles acquired prior to 1978 across the shelf south of Palma Bay (Bruns and Bayer, 1977; Molnia and others, 1978; von Huene and others, 1979; Carlson and others, 1980) showed faults and submarine scarps, including some that appeared to line up with the onshore trace of the Fairweather fault. However, line spacing was inadequate to map the offshore faults in detail.

During two cruises in the summer of 1978, we collected seismic reflection data covering 1,500 km across the shelf southeast of Palma Bay (see map, sheet 1). A major objective of the R/V SEA SOUNDER cruise (S-5-78) was to trace the offshore extension of the Fairweather fault. To accomplish this objective, three seismic reflection profiling systems (80-kJ sparker, 500-J minisparker, and 3.5-kHz transducer) were used to obtain tight seismic line spacings of <5 km between Icy Point and Yakobi Island and spacings of 10-20 km between Cross Sound and Chatham Strait on the shelf in line with the onshore trace of the Fairweather fault. In addition, the R/V S.P. LEE (L-3-78) made seven more widely spaced crossings of the continental margin between Chatham Strait and Cross Sound using a multichannel seismic system, a 500-J minisparker, and a 3.5 kHz transducer. Geologic interpretation is significantly enhanced by the combination of data from these systems.

Features interpreted as possible faults or fault zones were found on all of the seismic lines. We have labeled the intersections of seismic lines and faults on both the map (sheet 1) and on selected profiles (sheet 2) with letters that represent the characteristics used to identify the fault; the most active fault trace is marked by the heavier line and subordinate traces with lighter lines. All but one of the seismic profiles shown on sheet 2 were made with an 80-kJ sparker system and have a vertical exaggeration of about 5-7X; line 955 is a 24-fold multichannel profile (vertical exaggeration about 3X).

EXAMPLES OF FAULT EXPRESSION ON PROFILES

Many of the seismic profiles show well-defined scarps having relief of 20-40 m (profiles 332, 334, 352, 374) on the sea floor. Some of the profiles, however, show sea-floor scarps that are less sharp, giving the appearance of being more eroded (profile 326). Many crossings of the fault traces show no surface offset but commonly show broken reflectors or abrupt changes in bedding (reflector) attitudes that are best explained by faulting (profiles 340, 361). On several profiles, the seismic expression of faulting is similar to a buttress unconformity (profiles 361, 365, 374); this type of expression is most common on the eastern trace (see map). Some crossings of the faults are much less sharply defined, such as in the area immediately south of Icy Point where the faulted zone is expressed on the seismic profiles as a broad (~3 km wide) low-relief topographic high (profiles 320, 322). In numerous places the fault expression is recorded on the seismic profiles as a structurally complex zone. This zone might consist of folded strata through which a number of faults might be drawn (profiles 334, 340, 365). In a few places where seismic lines cross the projected trends of the faults, the character of the seismic profiles consisted of a zone of irregular anomalous subbottom reflectors (profiles 353, 365). Those profiles that cross the seaward projection of the Fairweather fault between Icy Point and Cross Sound contain reflectors that suggest the presence of a large buried trough (see profiles 322, 326). The fault expression can vary greatly in appearance on the seismic profiles, and not all of the characteristics listed above were found on each line.

BATHYMETRIC EXPRESSION

In addition to the network of seismic profiles that have been used to map the seaward extension of the Fairweather fault system southeast of Icy Point, sea-floor morphology clearly depicts the linear trend of part of the fault system. The 200-m isobath that outlines Yakobi Valley seaward of Cross Sound exhibits well-defined notches on both the northwest and southeast walls of the sea valley (see fault and track-line map). R. von Huene and others (1979) first reported the offset southeast bank of Yakobi Valley. Additional morphologic evidence has been shown on a detailed bathymetric map (see inset) by Atwood and others (1981). Their bathymetric map also outlines a shallow (relief ~30 m) elongate trough that extends from Icy Point to the northwest wall of Yakobi Valley.

The boxlike shape of Yakobi Valley may have resulted from a combination of displacement along the Fairweather fault and glacial erosion, with the northwest wall of the glacial valley having been systematically offset about 20 km to the northwest. Also note the box-shaped depression west-southwest of Icy Point and La Perouse Glacier; this feature is similar in form but shallower than Yakobi Valley and could be an offset (~70 km) ancestral Yakobi Valley. This depression and Yakobi Valley are both cut in strata of Pliocene and younger age, probably mostly Pleistocene (Carlson and others, 1982; Bruns, 1982, 1983). These bathymetric features indicate Pleistocene and Holocene offset along the offshore Fairweather fault. If the two boxlike depressions resulted from movement along the fault, they could indicate as much as 70 km of right-lateral offset from Cross Sound. However, more studies are needed to determine if they actually define a displacement. At present, the only measurement of displacement along the Fairweather fault is the 5-6-km late Cenozoic offset of major drainages where they cross the onshore trace of the fault (Plafker and others, 1978). Southeast of Yakobi Valley, the south-southeasterly morphologic trend shown by Atwood and others (1981) continues for about 30 km as a chain of elongate low (relief ~20-30 m) hills or ridges. An absence of detailed bathymetric data and the impingment of the fault trace on the shelf break prevent further morphologic delineation.

MAP TRENDS OF FAIRWEATHER SYSTEM

The seismic reflection lines that cross the shelf between Palma Bay and Chatham Strait show evidence for the existence of two relatively continuous sets of fault traces and a third, shorter set of traces about 50 km long south of Kruzof Island (see map). The western set consists of two or three subparallel traces characterized primarily by sea-floor offsets and disrupted subbottom reflectors; the eastern set consists of as many as five subparallel traces largely characterized by disrupted reflectors and buttress unconformities. On lines closest to Icy Point, the eastern set of fault traces, which is less well defined than the western set (profile 326), appears to trend directly into the mapped onshore segment of the Fairweather fault. The western set seems to line up with a reverse fault that has been inferred, on the basis of structural features along the shore, to lie just offshore along the coastline northwest of Icy Point, extending at least as far northward as Lituya Bay (Plafker, 1967; Bruns, 1979, 1982, 1983). An abrupt 15° to 25° change in strike is present between both the onshore Fairweather fault and the inferred nearshore fault and their extensions southeast of Icy Point.

The two sets of fault traces extend across the shelf in a south-southeasterly direction for about 225 km where they appear to merge on the upper continental slope just southwest of Sitka (profile 372). The separation between the eastern and western subparallel sets of fault traces varies from 6 km on the seismic line that is about 1 km from Icy Point to about 12 km off southern Chichagof Island. Southwest of Sitka, our data indicate that the combined faults are present near or seaward of the shelf break and extend along the same trend for at least another 95 km. There is evidence for a fault east of and parallel to the 200-m isobath that extends for about 40 km southeast of the Sitka 1972 epicenter (profile 371). This fault could connect with the easternmost trace; however, additional seismic lines would be needed in the area west-southwest of Sitka to test this possibility.

Widely spaced multichannel seismic reflection lines (L-3-78) suggest that no faulting of recent sediments occurred seaward of the continental shelf from Icy Point to the position southwest of Sitka where the two shelf fault traces appear to merge. Southeast of this area, however, features suggestive of faulting are present on the continental slope or near the base of the slope (profiles 376, 955).

Single-channel air-gun records contain hints of a large buried trough on the shelf north of Yakobi Valley (profiles 322, 326). This 2- to 4-km-wide trough contains sedimentary strata at least 600 m thick. The trough trends at least 35 km south-southeast from the Palma Bay shoreline (see map). On the basis of the straight alinement with and morphology similar to the onshore trench of the Fairweather fault, one might extend the Fairweather fault trace through the middle of the buried trough. However, the seismic records do not show sufficient acoustic penetration for us to absolutely determine if the buried trough is fault controlled.

The mapped fault traces, consisting of splays or slivers, are complex. At several places where a fault bifurcates or splays, the minor trace forms an arc and appears to rejoin the major trace. An exception to this, however, is the northernmost bifurcation in the offshore extension of the Fairweather fault about 20 km southeast of Palma Bay. Here, the Fairweather fault undergoes a major bifurcation with a branch fault splitting off at an angle of about 35° toward Lisianski Inlet where it may connect with the Peril Strait fault (Loney and others, 1975). Of the two sets of continuous fault traces, the western one is clearly the better defined and is considerably straighter than the eastern one. Starting near the bathymetric notch in the northwest wall of Yakobi Valley, the western set of faults has an outboard splay that is associated with a zone of complex folding (profiles 334, 340); this fold trend has been mapped for a distance of about 60 km toward the south-southwest. We are uncertain whether this fault splay ever rejoins the main trace because the seismic reflectors off central Chichagof Island where the main trace intersects the shelf-slope break are extremely complex.

The most unequivocal evidence for Holocene displacement, as manifested by sea-floor displacements, is on the main trace of the western fault set (see map and profiles 332, 334, 352). In most of the crossings of the fault traces where sea-floor offsets are well displayed, the sense of movement is down on the northeast side (profiles 322 and 334), showing the same sense of vertical displacement as occurred along the onshore Fairweather fault during the 1958 Lituya Bay earthquake (Tocher, 1960). The more sinuous, eastern set of faults appears to be a less active strand of the fault system; however, several of the profiles also showed some sea-floor offset along this trace (profiles 354, 361).

The epicenters of the 1972 Sitka and the 1958 Lituya Bay earthquakes are plotted on the fault and track-line map. The epicenter (Tobin and Sykes, 1968) of the 1958 earthquake, which probably ruptured the entire 280-km onshore segment of the Fairweather fault northwest of Palma Bay (Plafker and others, 1978) is south of the terminus of the Brady Glacier, about 25 km northeast of the Fairweather fault system. The uncertainty in the seismological data, however, is consistent with the true epicenter lying on one of the mapped offshore traces of the Fairweather fault in Palma Bay (R. A. Page, oral communication, 1983). The epicenter for the 1972 earthquake, determined by the International Seismological Centre (1974), virtually lies on the mapped active trace about 50 km southwest of Sitka. From the distribution of locally recorded aftershocks, Page (1973) inferred that the Sitka earthquake ruptured a 190-km-long length of the offshore Fairweather fault, from about Salisbury Sound to the southern tip of Baranof Island. Profile 371 shows the fault trace near the 1972 epicenter.

Seismic reflection data indicate that the westernmost of these continental margin fault traces, the active trace, connects with the offshore fault that has been inferred between Icy Point and Lituya Bay (Plafker, 1967; Bruns, 1979, 1982, 1983). This observation could indicate that a substantial part of late Cenozoic Pacific-North American plate motion has occurred along the Icy Point-Lituya Bay fault, rather than only along the onshore Fairweather fault where limited displacement has been observed. A critical need exists for more studies to examine both the Icy Point-Lituya Bay fault and the associated depressions to see if they indeed indicate a major transform fault. The eastern, less-active set of traces appears to connect with the onshore Fairweather fault at the Palma Bay shoreline and seems to merge with the more active western trace on the continental slope southwest of Sitka. We suggest that the merged fault traces continue their south-southeasterly trend along the continental margin and connect with the Queen Charlotte fault (see index map).

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FAULT AND TRACK-LINE MAP

MAP AND SELECTED SEISMIC PROFILES OF THE SEAWARD EXTENSION OF THE FAIRWEATHER FAULT, EASTERN GULF OF ALASKA

By
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1985

Interior—Geological Survey, Reston, Va.—1985

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