UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PETROLEUM POTENTIAL OF SOUTHEASTERN ALASKA: A REPORT FOR THE NATIONAL HYDROCARBON ASSESSMENT PROGRAM

by

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Open-File Report

88-450I

1988

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INTRODUCTION

The purpose of this report is to discuss the petroleum potential (or lack thereof) of the southeastern Alaska province lying between Dixon Entrance and Cross Sound and west of the U.S./Canada border (Figure 1). The region is dominantly covered by heavily forested, mountainous terrain, with deep channels separating the mainland and the offshore islands. The entire onshore region and contiguous state offshore lands are underlain by metamorphosed, deformed and intruded pre-Cenozoic rocks that have negligible petroleum resource potential. Cenozoic rocks consist of local, thin non-marine or deltaic rocks, also with negligible petroleum resource potential. No hydrocarbon exploration has occurred in the region, and there seems to be little reason for hydrocarbon exploration in the future.

REGIONAL GEOLOGY

Southeastern Alaska is underlain by a diverse assemblage of moderately to highly metamorphosed, intruded, and deformed Paleozoic and Mesozoic rocks comprising parts of five fault-bounded tectonostratigraphic terranes (Figure 2; Monger and Berg, 1987). These terranes are the Chugach, Wrangellia, Alexander, Taku, and Tracy Arm terranes. The following descriptions of the five terranes are from Monger and Berg (1987).

The Chugach terrane is a disrupted terrane comprised of two distinctive tectonostratigraphic assemblages: (a) a strongly folded but coherent flysch assemblage of graywacke, argillite, and slate of Late Cretaceous age, and (b) a disrupted Late Jurassic to Early Cretaceous melange assemblage composed of blocks of mafic volcanic rocks, chert, ultramafic rocks, limestone, and plutonic rocks in a matrix of cherty, tuffaceous argillite. Greenschist- to amphibolite-facies regional metamorphism locally overprints sporadic remnants of blueschist-facies metamorphism. These two assemblages are structurally interleaved in many places, but in general the disrupted assemblage tends to be structurally above the coherent flysch assemblage.

The Wrangellia terrane is a coherent terrane composed of Pennsylvanian through Jurassic age rocks, and characterized by a remarkably uniform Triassic stratigraphy. The oldest rocks commonly are mafic to felsic volcanic rocks, limestones, pelites, and graywackes of Pennsylvanian age. Overlying the Paleozoic rocks are Triassic strata that include thick (greater than 6,000 m) submarine to subaerial tholeiitic basalt, overlain in turn by shallow-to deep-water carbonate and pelitic rocks. In southern Alaska, this sequence is overlain by Jurassic deep-water sedimentary rocks.

The Alexander terrane is composed of late Precambrian to Triassic rocks. Where mildly metamorphosed, the terrane is divided into three subterranes (not shown on Figure 2), which apparently amalgamated by Permian time to form the composite Alexander terrane. The terrane includes: (a) undivided greenschist- to amphibolite-facies schist and gneiss, derived largely from feldspathic sediments and felsic to mafic volcanics; (b) the Admiralty subterrane, distinguished by a coherent Paleozoic sequence of Devonian marine metabasalt and carbonate rocks overlain by late Devonian and Mississippian basaltic tuff and radiolarian chert; (c) the Annette subterrane, comprised of a heterogeneous assemblage of variably metamorphosed, Ordovician or Silurian to Triassic intrusive, extrusive, clastic, and carbonate rocks, and including an Ordovician-Silurian volcanoplutonic complex; and (d) the Craig subterrane, distinguished by a relatively complete and undeformed sequence of Ordovician to Triassic basaltic to silicic volcanic and volcaniclastic rocks and terrigenous clastic and carbonate rocks, and by a pre-Middle Ordovician metamorphic complex.

The Taku terrane is a Permian through Triassic assemblage of multiply deformed and metamorphosed rocks. The terrane includes such lithologies as Permian crinoidal marble intercalated with pelitic phyllite and felsic metatuff, upper Paleozoic basaltic metatuff and agglomerate; Middle and Upper Triassic carbonaceous and concretionary limestone, slate, phyllite, and basaltic pillow breccia; and undated metaflysch, metatuff, and quartzite.

The Tracy Arm terrane is a metamorphic terrane that may include rocks as old as Precambrian and as young as Mesozoic. Rocks of the terrane include pelitic and quartzofeldspathic schist and paragneiss, amphibolite, marble, serpentinite, and other metamorphosed sedimentary and igneous rocks.

These five terranes were amalgamated by early Tertiary time. Cenozoic tectonic activity after terrane amalgamation has included intrusion, thermal metamorphism, localized volcanism, and local deposition of nonmarine and deltaic volcaniclastic sedimentary rocks. Faulting has redistributed the Paleozoic and Mesozoic terranes along major fault zones such as the Chatham Strait, the Peril Strait, and the Fairweather-Queen Charlotte fault zones (Figures 1 and 2; Berg, 1979).

A sixth terrane, the Yakutat terrane adjoins the northern part of the southeast Alaska margin, and underlies the continental margin between Cross Sound and Kayak Island. Basement rocks of this terrane include upper Mesozoic pelite, graywacke, and melange (Yakutat Group) in the eastern part of the terrane, and Eocene basalt in the western part. The basement rocks are overlain by a thick (as much as 9 km) sedimentary section composed of Eocene and younger marine and nonmarine clastic rocks. However, immediately adjacent to southeast Alaska, sedimentary rocks overlying basement (Yakataga Formation) are less than 4 km thick, are late Cenozoic in age, and are considered to have negligible hydrocarbon potential (Bruns, 1983, 1985, 1988; Bruns and Schwab, 1983; Plafker, 1987).

No Cenozoic sedimentary basin is present onshore in the southeast Alaska region. The only nearby Cenozoic basins lie beneath the continental shelf and adjacent margin seaward of the southeast Alaska islands (Figure 3; Bruns and Carlson, 1987), in the adjacent Yakutat terrane, and south of Dixon Entrance in Canada, in the Queen Charlotte Islands and adjacent Queen Charlotte basin (Sutherland Brown, 1968; Yorath, 1987). On the southeast Alaska shelf, Cenozoic sedimentary rocks consist of up to 3 km of largely late Cenozoic strata overlying an acoustic basement inferred to consist of rocks similar to those on the adjacent islands (Bruns and Carlson, 1987). Seismic refraction velocities in the acoustic basement rocks are commonly greater than 4 km/s, indicating probable deformed and metamorphosed rocks. Beneath the lower slope and adjacent ocean plate, thick (to at least 4 km) middle Miocene and younger sedimentary strata overlie oceanic basalt.

Cenozoic sedimentary rocks in the Queen Charlotte Islands include 2 km of Miocene and Pliocene marine and nonmarine sandstone and siltstone (Skonun Formation; Sutherland Brown, 1968) on the Queen Charlotte Islands. This section thickens offshore, where coeval rocks are as thick as 4.5 km in the strait west of Queen Charlotte Island (Yorath, 1987). None of the Cenozoic sedimentary rocks from the southeast Alaska continental shelf, the Queen Charlotte Islands region, or the Queen Charlotte basin extend onshore into the southeast Alaska islands and mainland.

The various basement rocks can extend seaward no farther than the base of the continental slope because oceanic crust of middle Miocene age underlies the adjacent continental rise (Naugler and Wageman, 1973; Stevenson and Embley, 1987). Moreover, gravity modeling and seismic-refraction studies by von Huene and others (1979) indicate that the slope is underlain by low-density, low-velocity sedimentary rocks rather than by high-density basement rocks of the various terranes. Therefore, the rocks underlying the slope seaward of the Fairweather-Queen Charlotte fault are not the same as the terrane basement rocks exposed onshore.

The major tectonic feature of the southeast Alaska continental margin is the mostly submerged Fairweather-Queen Charlotte fault system, which is the active transform boundary between the Pacific and North American plates (Figures 1-3). Movement along the transform system is estimated as about 6 cm/yr by Minster and Jordan (1978). The fault system runs northward along the Canadian margin as the Queen Charlotte fault from the intersection of the Juan de Fuca spreading ridge and the North American continental margin off Vancouver Island (Yorath, 1987), and continues along the Alaskan continental margin to northwest of Cross Sound in the northern Gulf of Alaska. Here, the offshore fault system is interpreted to merge with the onshore Fairweather fault of southern Alaska (von Huene and others, 1979; Carlson and others, 1985; Bruns, 1985; Bruns and Carlson, 1987). The Fairweather-

Queen Charlotte fault forms a fundamental tectonic boundary along southeast Alaska and truncates the basement rocks of the North American continental margin.

PETROLEUM GEOLOGY

None of the criteria required for petroleum generation and accumulation are known to be present onshore in southeast Alaska. With the exception of local, thin nonmarine and deltaic Cenozoic deposits, all the rocks underlying the islands are intruded, indurated, metamorphosed, and/or deformed to a degree that makes these rocks effective economic basement for hydrocarbons. No potential source or reservoir rocks are known. Cenozoic rocks present in the adjacent offshore basins around southeast Alaska do not outcrop onshore, and the petroleum potential of these offshore Cenozoic basins is considered as poor (Bruns and Carlson, 1987; Yorath, 1987). Thus, there is also little potential for migration of hydrocarbons from these Cenozoic basins updip into the onshore region, even if reservoir rocks and traps existed onshore. No meaningful hydrocarbon plays can be identified. The onshore and immediately adjacent offshore regions of southeast Alaska must be considered as having negligible hydrocarbon resource potential.

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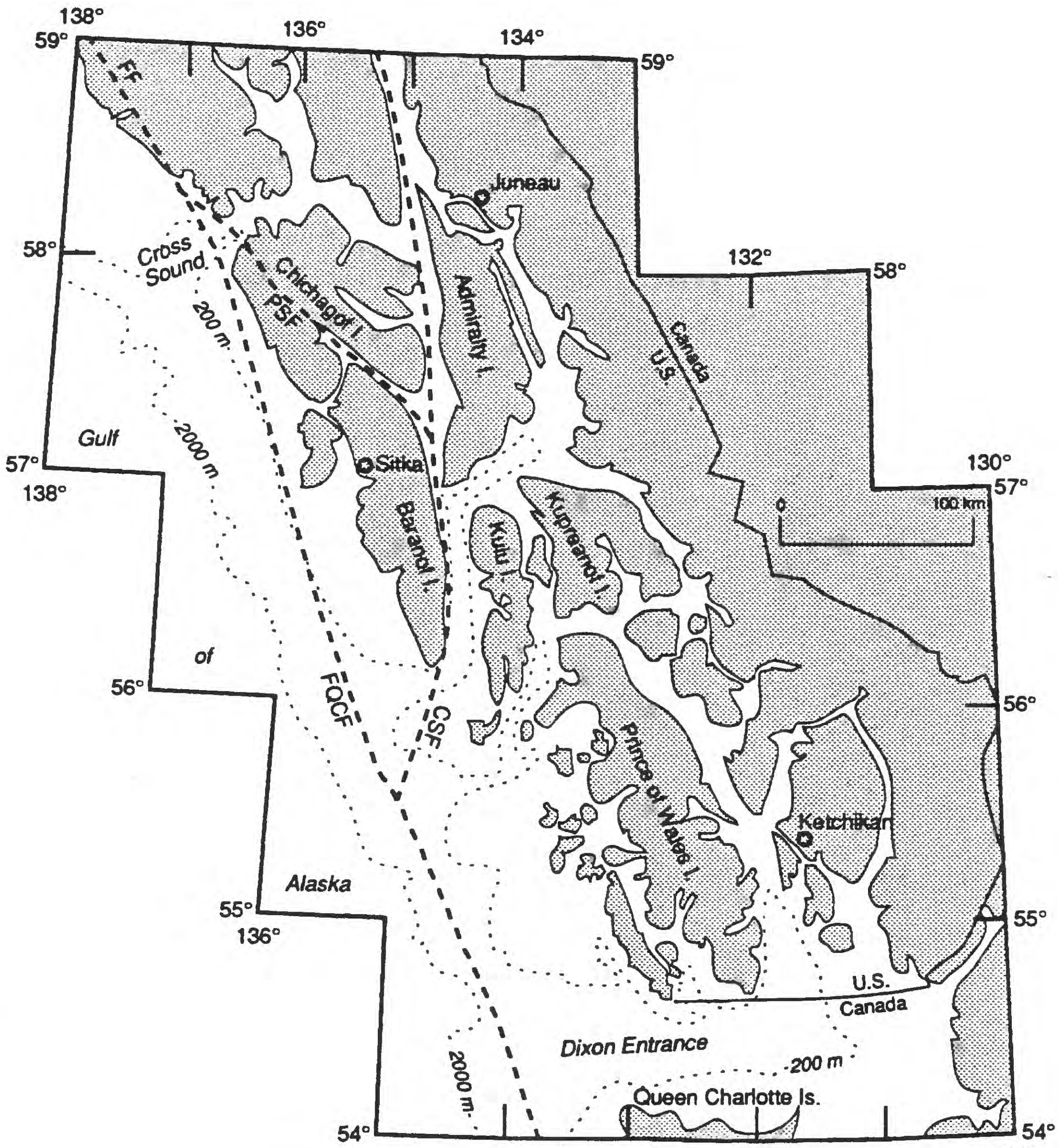

Figure 1. Location map and tectonic setting of southeast Alaska. CSF-Chatham Strait fault; FF-Fairweather fault; FQCF-Fairweather-Queen Charlotte fault; PSF-Peril Strait fault.

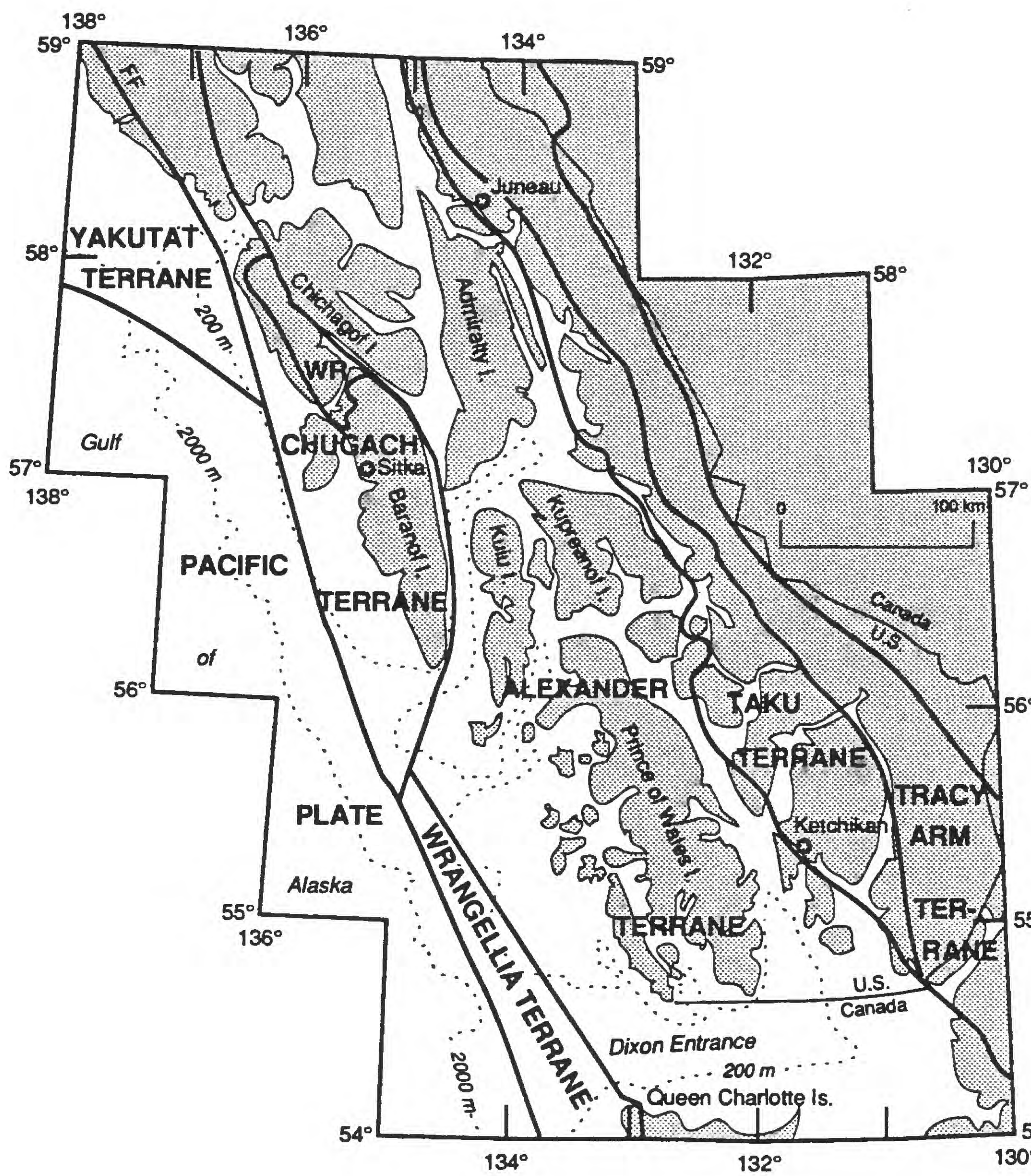

Figure 2. Terranes of southeast Alaska and northern British Columbia, from Monger and Berg (1985). WR - Wrangellia terrane.

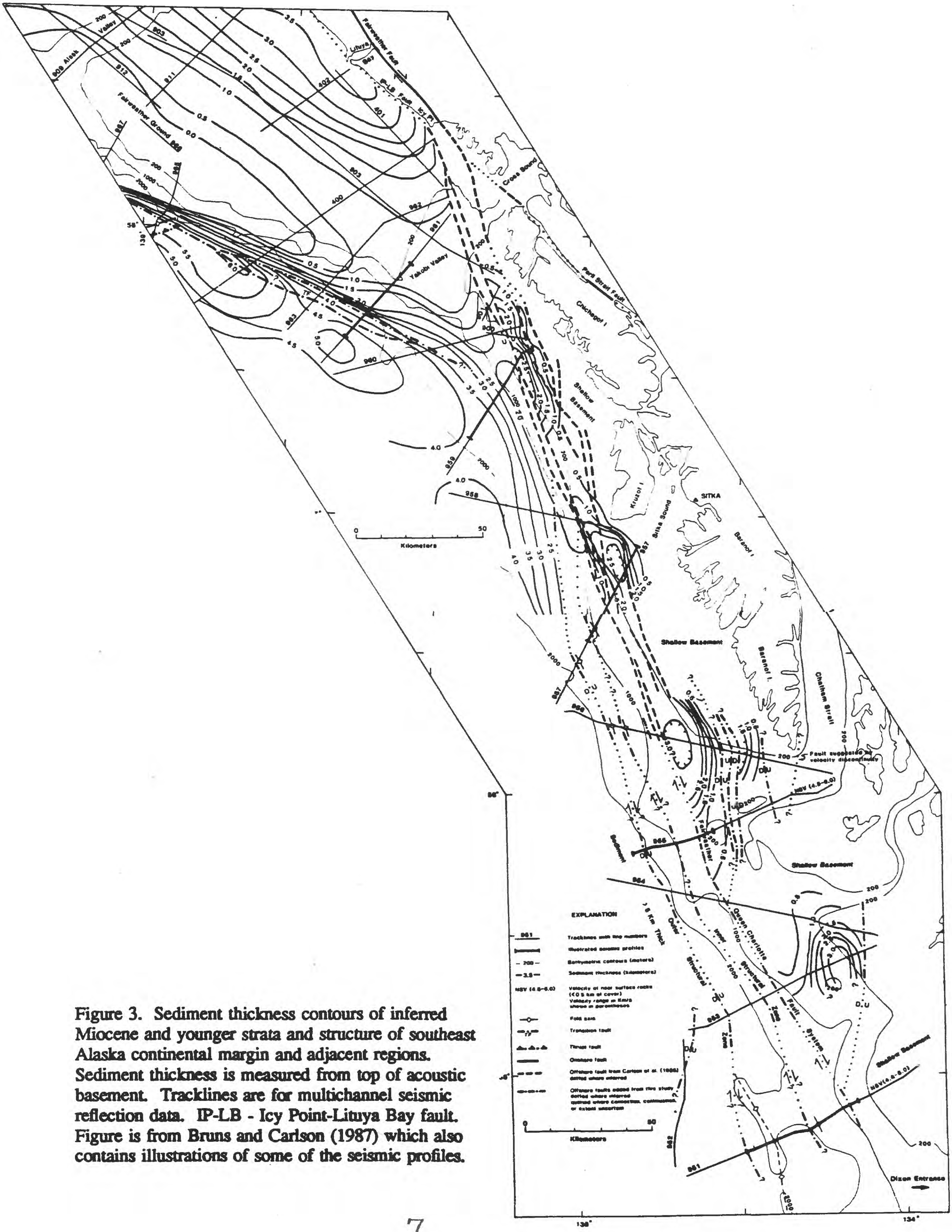

Figure 3. Sediment thickness contours of inferred Miocene and younger strata and structure of southeast Alaska continental margin and adjacent regions. Sediment thickness is measured from top of acoustic basement. Tracklines are for multichannel seismic reflection data. IP-LB - Icy Point-Lituya Bay fault. Figure is from Bruns and Carlson (1987) which also contains illustrations of some of the seismic profiles.