UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SUREVY

PETROLEUM GEOLOGY OF ROCKS EXPOSED ON KODIAK ISLAND, ALASKA: A REPORT FOR THE FEDERAL LANDS ASSESSMENT PROGRAM (FLAP)

by

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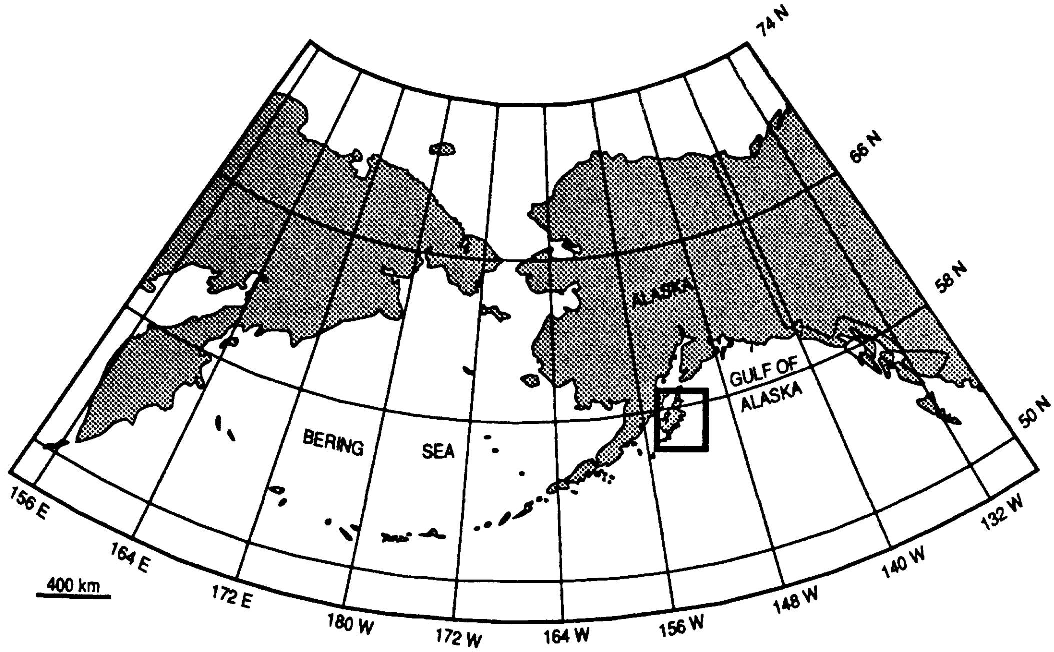

Figure 1. Index map of Kodiak islands and the Gulf of Alaska

INTRODUCTION

Geography and History of Petroleum Exploration

Kodiak Island forms part of the western rim of the Gulf of Alaska (Figure 1) This island, together with two other main and several lesser islands (Figure 2), cluster within an offshore area that was once explored intensively for petroleum This exploration entailed primarily collecting seismic reflection data, but also six Continental Offshore Stratigraphic Test (COST) wells were drilled in Federal waters through the continental shelf that borders these islands on the southeast. Despite initially high optimism for finding hydrocarbons within this offshore area, the petroleum industry's attention shifted elsewhere. After polling petroleum exploration companies in 1986, the Minerals Management Service of the Department of the Interior decided that the low level of interest did not warrant a sale of offshore leases.

Some of the six offshore COST wells bottomed in Eocene rocks that dip northwest and apparently correlate with rocks of the same age exposed extensively onshore (Turner et al., 1987). Although offshore seismic reflection data do not reveal the structure of the Eocene rocks, these data show that highly reflective Miocene and younger (McClellan et al, 1980; Keller et al., Turner et al., 1987) rocks unconformably overlie the Eocene units and fill three deep (about 5 km) basins under the continental shelf (Fisher and von Huene, 1980). This thick Neogene section is known from seismic reflection data to thin sharply toward the islands, so that rocks of this age outcrop onshore at only scattered, local sites, where they form a thin veneer that unconformably overlies the much more extensively exposed, highy deformed Cretaceous and Paleogene rocks. Hence, offshore well data contribute little to the petroleum assessment of the onshore rocks.

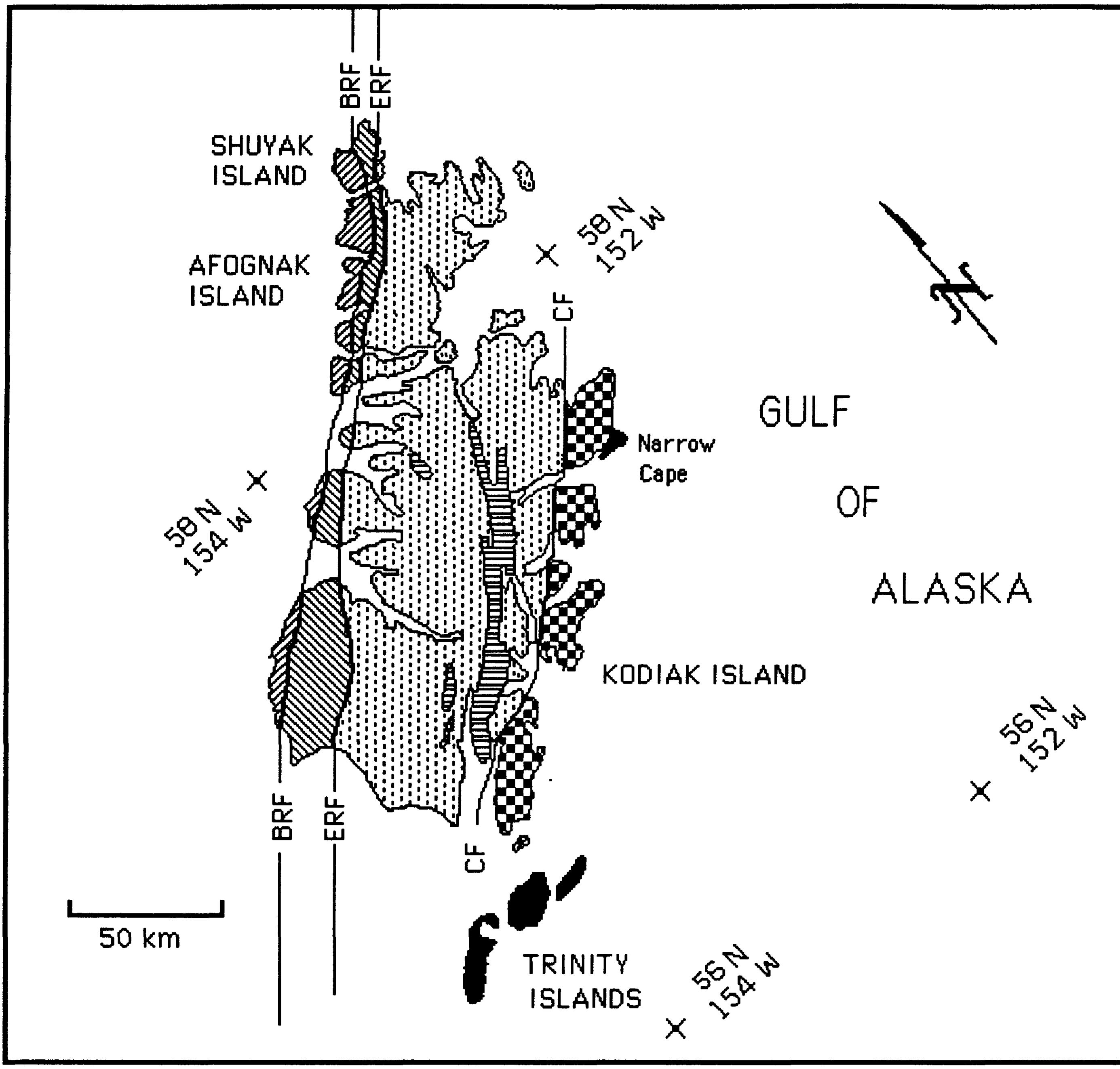

Figure 2. Generalized geologic map of Kodiak Island and adjacent islands. Patterns that show lithologic units are explained in Figure 3. BRF: Border ranges Fault; ERF Eagle River fault: CF Contact Fault.

Structural Setting

No identifiable basin lies within the area of the Kodiak island group. Although Cretaceous and Paleogene rocks onshore are presumed to be thick (no accurate measurement of their total thickness has yet been made), this thickness results from folding and from structural repetition of stratigraphic units along thrust faults Onshore Cretaceous and Paleogene rocks lie within the forearc area of a convergent margin, and abundant evidence suggests that their present structural aspect results

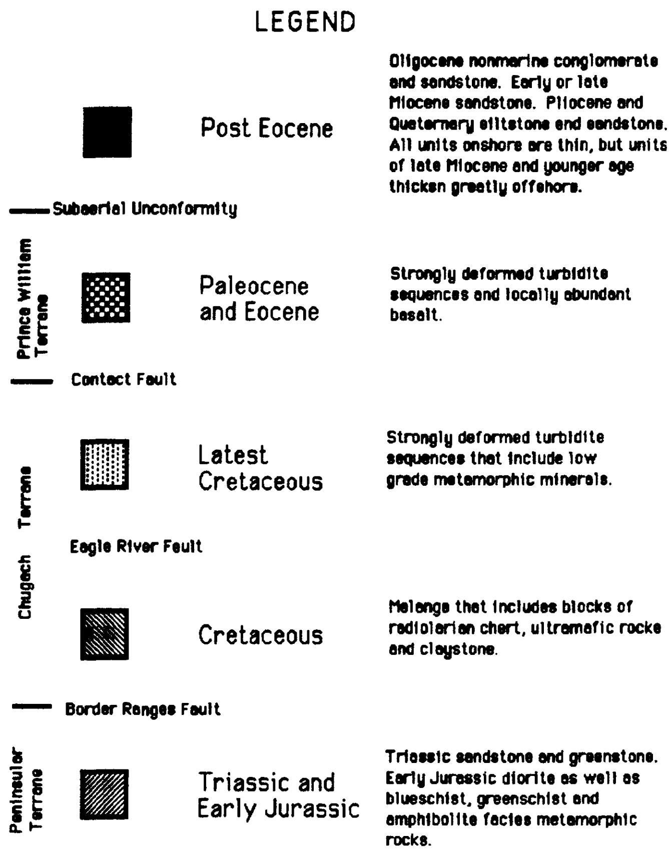

Figure 3. Explanation for Figure 2.

directly from a protracted history of convergent-margin tectonics. For example, paleomagnetic data obtained from Paleocene basalt and Eocene sedimentary rock exposed on Kodiak Island (Plumley et al., 1982, 1983; Moore et al., 1983) suggest that these rocks were deposited far south of their present position and migrated northward. The collision between the allochthonous rocks under Kodiak Island with what was then the continental margin of Alaska may have been responsible for the pervasive deformation of insular rocks by thrust faults and apressed folds. Microscopic examination of surface samples of the strongly deformed turbidite sequence indicates that the rocks apparently underwent ductile deformation at depths greater than about 10 km (Sample and Moore, 1987). Strong uplift and erosion have since exposed these rocks at the surface.

Three tectonostratigraphic terranes, the Peninsular, the Chugach and the Prince William, underlie the Kodiak group of islands. Along the northwest coasts of the Kodiak islands, two tectonostratigraphic terranes lie sutured along the Border Ranges fault (Jones, et al., 1981; Fisher and von Huene, 1984; Figure 2). The Peninsular terrane extends northwestward from this suture zone, and the Chugach terrane extends southeastward from this fault to the Contact fault. The Prince-William terrane is represented by Paleogene rocks exposed in a narrow band along the southeast coast of the Kodiak Islands, southeast of the Contact fault.

Lithology and Age of Rock Units

This brief description of the lithologies and ages of rocks exposed on the islands is derived from Moore (1967), Connelly and Moore (1979), Moore et al. (1983 and references therein) and Byrne (1984) as well as from other reports and maps listed in the bibliography. The geographic distribution of lithologic units exposed on the Kodiak islands (Figure 2) is controlled mainly by major thrust faults, which confine these units to four main belts. The first belt lies along the northwest coasts of the islands, northwest of the Border Ranges fault, and includes rocks of the Peninsular terrane, which are Triassic sandstone and greenstone as well as Early Jurassic plutonic rocks. This belt also contains metamorphic rocks that range from blueschist to amphibolite facies (Figure 2). The Chugach terrane includes the second and third fault-bounded lithologic belts. The second belt lies between the Border Ranges and Eagle River (or Uganik) thrust faults, and includes the Cretaceous melange of the Uyak Complex, which contains blocks of Paleozoic limestone, chert and greenstone that are encased within a foliated claystone matrix. The youngest fossils recovered from the matrix of this melange indicate a middle Cretaceous age. The third fault-bounded belt lies between the Eagle River and Contact faults and includes strongly deformed, uppermost Cretaceous turbidite sequences (Kodiak Formation) that are rich in silty sandstone and siltstone. The fourth fault-bounded belt encompasses the Prince William terrane and lies southeast of the Contact fault. This belt includes strongly deformed turbidite sequences, melange and locally exposed basalt that are assigned to the Paleocene and Eocene Ghost Rocks Formation. The fourth belt also includes deformed turbidites assigned to the Eocene and Oligocene Sitkalidak Formation. Paleocene plutonic rocks intrude the Kodiak and Ghost Rocks Formations and show that the Chugach and Prince William terranes were together at the beginning of the Cenozoic.

Post-Eocene rocks outcrop in scattered patches, primarily on the small islands that lie south of Kodiak Island (Figure 2). These rocks unconformably overlie the Oligocene and older turbidite sequences and include upper Oligocene nonmarine and early Miocene marine sandstone as well as upper Miocene sandstone and conglomerate (T. Byrne, oral commun., 1987). In addition, one small outcrop of rocks of middle (macrofossils) or late (microfossils) Miocene age crops out on northern Kodiak Island.

Petroleum Geology

Most rocks exposed on the Kodiak islands are so strongly deformed and highly indurated that few traps or reservoir rocks for hydrocarbons are present. This bleak assessment, however, does not pertain to Miocene and younger rocks, whose limited onshore exposure means that they could contain significant hydrocarbons only in offshore areas.

Values of vitrinite reflectance and thermal alteration index (TAI) from surface samples suggest that Eocene and Oligocene rocks of the Sitkalidak Formation as well as Neogene rocks are either immature or just barely mature for generating hydrocarbons (Lyle et al., 1977, Fisher, 1980; Moore et al., 1983). These rocks generally contain less than 0.4% of organic carbon that is contained in woody and herbaceous kerogen. In contrast, Eocene and Paleocene rocks that are included within the Ghost Rocks Formation are overmature for hydrocarbons. Petrographic analysis of thin sections made from Upper Cretaceous rocks (Kodiak Formation) reveals prehnite, suggesting that these rocks have been thermally altered far beyond the thermal zone of hydrocarbon generation (Sample and Moore, 1987).

Scattered measurements of porosity and permeability indicate that, despite their generally low level of thermal alteration, post-Eocene rocks would make poor reservoirs for hydrocarbons. Maleable grains within these rocks have been deformed so that they occlude pore space. The pores in rocks of Paleocene and older age have been filled completely by diagenetic minerals. This diagenesis may have resulted from a high flux of fluids through the convergent margin where the rocks were deformed (Vrolijk, 1987).

Principle Plays for Petroleum

The foregoing discussion should have made clear that no conventional plays for petroleum exploration exist within rocks exposed on Kodiak Island or adjacent islands. In my opinion, onshore rocks make unpromising candidates for hydrocarbon exploration. Furthermore, rocks of Miocene and younger age that fill offshore basins thin markedly toward the islands, so that within three miles of the shoreline, these rocks are thin and unlikely to contain hydrocarbons in economic quantities.

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