Data compilation and preliminary summary of the 1977 Alaska Peninsula field project

Connelly, William, and Amoco Oil Co.

GMC DATA REPORT 461

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State of Alaska
Department of Natural Resources
Division of Geological & Geophysical Surveys
GEOLOGIC MATERIALS CENTER

Amoco Production Company

Denver Region

Frontier Division

AREA Alaska Peninsula

STATE Alaska

COUNTY

CF 79 047

SUBJECT Data Compiliation and Preliminary summary of the 1977 Alaska Peninsula Field project.

Geological Report **No.** FR-02-79

Date March 1, 1979

By William Connelly

NO.	ENCLOSURES	SCALE
1.	Geologic Map of the Alaska Peninsula } in report	1"=16,000'
2.	Location Map for radiometrically dated samples	1:1,000,000
3.	Measured Sections	
4.	Source Rock, Porosity, Permiability and Lithology Summaries.	
5.	Photographs	
6.	Miscellaneous	
	A. Sample Registers	
	B. Field Notes	
	C. Daily Log	
	D. Radiometric Dating Laboratory Reports	

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March 1, 1979

Re: Denver Region Geological Report No. FR-02-79
"Data Compilation and Preliminary Summary of
the 1977 Alaska Peninsula Field Project"

Mr. R. C. Brooke
BUILDING

Transmitted herewith is the referenced Geological Report by William Connelly. The report is a compilation and summary of all data pertaining to the 1977 field party. It includes updated geologic maps of the Alaska Peninsula (with all sample localities), measured sections, laboratory reports from the Research Center, photographs, sample registers, and field notes. The author presents many of his own impressions regarding the stratigraphy and tectonics of the Peninsula, but does not attempt to synthesize these subjects. Information in this report will be used to help assess the petroleum potential of Bristol Bay Native Corporation acreage.

Ronald H. Calvert
Frontier Division Geologist

WC:jz
Enclosure

APPROVED FOR TRANSMITTAL:

Denver Regional Geologist

February 28, 1979

Denver Region Geological
Report No. FR-02-79
Data Compilation and
Preliminary Summary of
the 1977 Alaska Peninsula
Field Project
Project No. 77-23

Author:

William Connelly

INTRODUCTION

Amoco conducted a surface geological investigation of the Alaska Peninsula during June, July, and August of 1977. A crew of 3 to 4 geologists with helicopter support measured stratigraphic sections and did reconnaissance work in several areas of interest (Enclosure 1). The primary objectives of this field investigation were:

1) Measure and describe several Tertiary composite sections across the Alaska Peninsula;
2) Collect samples for laboratory analyses to constrain reservoir character, source rock potential, and biostratigraphy;
3) Gain a better understanding of the Tertiary geologic history and paleoenvironments.

The field party consisted of Carlos Pierce (Party Chief, June 1 to July 16), William Connelly (Party Chief, July 17 to August 31), Leonid Smirnov (Geologist, June 1 to August 31), Steve Williams (Geologist, June 1 to July 12), Robert Scott (Paleontologist, July 12 to July 25), Earl Armstrong (Paleontologist, July 27 to August, 10), Greg Brown (Summer Employee, June 1 to August 24), and Eric Penttila (Helicopter Pilot, June 4 to August 31). Amoco chartered an Aleuet II helicopter from Evergreen Helicopters, Inc.; food and lodging were provided by local lodges, canneries, and motels.

CONCLUSIONS

The geologic record of the Alaska Peninsula indicates that episodes of widespread andesitic volcanism occurred in Late Triassic to Early Jurassic, Late Cretaceous, Late Eocene to Early Oligocene, and Late Miocene to Recent (Burk, 1965; Detterman and Hartsock, 1966). These episodes of arc volcanism apparently coincide with episodes of subduction and accretion along the Shumagin-Kodiak Shelf (Moore and Connelly, 1979; Connelly, 1978).

The exact location of the volcanic arc during Mesozoic time is not clear because plutons and coarse volcanic products of that age are not exposed on the Peninsula southwest of Becharof Lake (Reed and Lanphere, 1973; Burk, 1965; Moore and Connelly, 1979). However, magnetic data suggest that the Mesozoic batholiths (which are exposed northeast of Becharof Lake) continue southwest to the Bering Shelf beneath a cover of Tertiary volcanic and sedimentary rocks (Pratt and others, 1972). The transition of the volcanoplutonic arc from the Mesozoic trend (paralleling the Bering Shelf) to the Tertiary trend (along the Alaska Peninsula and Aleutian Islands) likely occurred in latest Cretaceous or earliest Tertiary time.

Based on the distribution of Tertiary plutons and coarse volcanic deposits, it is likely that the axes of the Eocene/Oligocene arc and the Miocene/Pliocene arc were 15 to 25 miles southeast of (and parallel to) the present volcanic axis. Rapid facies changes in the Tertiary volcanogenic sections, both lateral and stratigraphical, suggest paleogeographical settings similar to the present Peninsula where active volcanoes supply sediment to nearby fluvial and shallow marine environments. It is likely that the Paleocene and the Late Oligocene to Middle Miocene were not times of active volcanism. Important unconformities occur in the mid-Cretaceous, Paleocene, and Middle to Late Oligocene (Figure 1).

Enclosure 3 contains all sections measured by this field party. The Milky River and Milky Ridge Sections (which actually form one continuous section) is the best Tertiary composite section. The micropaleontology of these and other sections have been studied by Dave Wall (1978) who did an excellent job of determining the Tertiary biostratigraphy for the Peninsula. The micropaleontology of "grab" samples had not been studied as of the time of writing.

Only 12 significant wells have been drilled on the Peninsula to date (Enclosure 2); these wells were all plugged and abandoned but have not adequately tested the petroleum potential of the region. Based on these wells, it is apparent that the Bristol Bay Lowlands are a very prospective petroleum province, and that the Alaska-Aleutian Range is non-prospective. A likely play in the Lowlands would have a Eocene/Oligocene source rock, a Miocene reservoir horizon, and an Upper Miocene or Pliocene capping formation.

REFERENCES

Brockway, R., and others, 1975, Bristol Bay region, "Stratigraphic correlation section" southwest Alaska: The Alaska Geological Society, P. O. Box 1288, Alaska 99510.

Burk, C. A., 1965, Geology of the Alaska Peninsula - Island arc and continental margin: Geol. Soc. America Memoir, v. 99, 250 p.

Carden, J. R., Connelly, Wm., Forbes, R. B., and Turner, D. L., 1977, Blueschists of the Kodiak Islands, Alaska: An extension of the Seldovia Schist terrane: Geology, v. 5, p. 529-533.

Connelly, Wm., 1978, Uyak Complex, Kodiak Islands, Alaska: A Cretaceous subduction complex: Geol. Soc. America Bull., v. 89, p. 755-769.

Conti, L. A., 1968, Preliminary investigation of the Mesozoic stratigraphy of the Alaska Peninsula: Denver Div. Geologic Memo No. 87-63 (SV 68-0221).

________, 1972, Geology of the Ugashik Lakes Area, Bristol Bay, Alaska: Denver Div. Geological Memo No. 154 (SV 72-1230).

________, 1973, Geology of the Nelson River Development Contract Area, Bristol Bay basin, Alaska: Denver Div. Geological Memo. No. 102 (SV 73-0430).

Conti, L. J., and Self, G. W., 1974, Geological maps of the Alaska Peninsula, Lower Cook Inlet, and northern Bristol Bay regions, Alaska: Denver Div. Rept. No. 139 (SV 74-0429).

ALASKA PENINSULA NOMENCLATURE

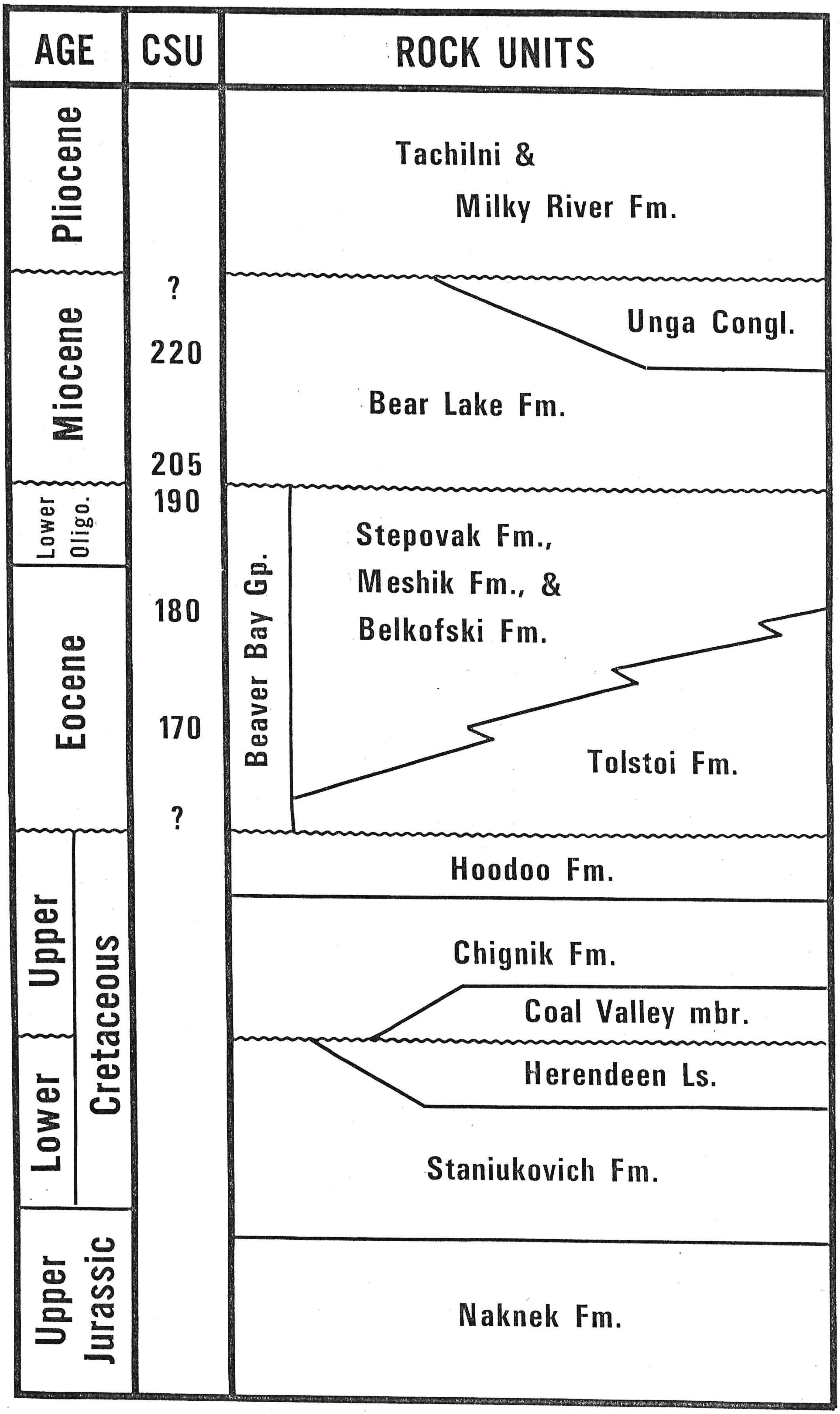

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Figure 1

from only three sections. He found that the one productive Tolstoi Formation section (Pavlov Bay Section) is Middle Eocene in age, and that the two productive Stepovak Formation sections (Coal Bay and McGinty Point Sections) ranged from Middle Eocene to Middle (and possibly Upper) Oligocene. Megafossils from these formations indicate slightly younger ages (Burk, 1965), but Amoco has had best results using microfossil ages for Tertiary rocks in southern Alaska (D. Englehardt, personal commun., 1977). Samples from the Meshik and Belkofski Formations were all barren; radiometric ages from the Meshik suggest a Late Eocene to Early Oligocene age (discussed below under Radiometric Dates). McLean (1978) reports the occurrence of marine mullusks of Oligocene age from a single bed at the base of the Belkofski section at the head of Belkofski Bay (Seaweed Cove Section).

The Tolstoi and Stepovak Formations are, in my opinion, lithologically indistinguishable. They consist mainly of dark gray siltstone with interbedded volcanic sandstone (commonly zeolitized), conglomerate, and local andesitic flows and breccia; dikes, sills, and small plutons locally are abundant. Burk suggests that the Tolstoi Formation is at least 5000 feet thick and the Stepovak is at least 15,000 feet thick; assuming no repeated section, our thickest "Tolstoi" section is 5800 feet (Ivanof Bay Section) and thickest "Stepovak" section is 9100 feet (American Bay).

The paleogeography in Tolstoi/Stepovak time probably was very similar to the present volcanic arc on the Peninsula. The rapid lateral and stratigraphical facies changes observed in the field reflect this complex paleogeography. Environments of deposition include lagoons, tidal flats, shallow shelf, deep bays, fluvial systems, and composite volcanoes. Most rocks were deposited in shallow marine to subareal conditions; there is no evidence for deep marine deposition by density currents.

The Belkofski Formation is restricted (by definition) to the Cold Bay and Belkofski Bay area. It is an extremely volcanogenic formation consisting dominantly of subareal andesitic ignembrites, flows, breccias, and volcanic sandstone; several hundred feet of feldspathic shelf sandstone occur at Belkofski Bay (Seaweed Cove Section). This formation was deposited very proximal to the Oligocene volcanic arc, likely along the flanks of composite volcanoes and in nearby fluvial and shallow marine environments.

The Meshik Formation occurs in the Kujulik Bay and Aniakchak Crater area (by definition). It consists mainly of andesitic lahar deposits and volcanic sandstones; occasional petrified forests (Enclosure 5, Photos 59-1, 2) and the lack of marine fossils indicate a dominantly subareal environment of deposition. Where sandstone and siltstone become abundant in the Meshik (e.g., the Aniakchak Crater area), I see no distinction between the Meshik and Stepovak or Tolstoi Formations. We had several samples of hornblende andesite from the Meshik Formation radiometrically dated (discussed below); these dates suggest a Late Eocene to Early Oligocene age of volcanism.

In my opinion, the Eocene/Oligocene formations described above cannot reliably be differentiated in the field because of the general lack of megafossils and because of lithologic similarities. If I were to re-map the Peninsula and redefine the stratigraphy, I would name all Eocene/Oligocene rocks the Beaver Bay Group (after Burk, 1965). Within this group, I would define useful descriptive members, but no formations. The paleogeographies of volcanic island-arcs or peninsula-arcs are far too complex to use subtle lithologic characteristics as bases for stratigraphic position.

Miocene: Bear Lake Formation: The Bear Lake Formation overlies the Eocene/Oligocene rocks with a slight angular discordance. The Bear Lake Formation generally consists of poorly consolidated sandstone and siltstone with less conglomerate and coal. The thickness of the formation at our Milky River Section is 3400 ft; it thickens to nearly 8000 ft in the Gulf Sandy River #1 well to the north in the Bristol Bay Lowlands. Wall (1978) studied the micropaleontology of the five Bear Lake sections measured during this project and determined that the formation ranges from Lower to Upper Miocene in age. The paleoenvironment of most of the formation is tidal flat to beach and shallow shelf; the local occurrences of coal beds indicates that some of the formation was deposited under subareal conditions. A likely analog for the formation is the Recent Bristol Bay Lowlands and shallow portions of Bristol Bay.

Unga Conglomerate: The Unga Conglomerate is a distinct volcanogenic member of the Bear Lake Formation which previously has been interpreted as the basal conglomerate for the formation. At the type-area (i.e., north Unga Island), the Unga Conglomerate consists of coarse andesitic breccia (lahar deposits) and volcanic sandstone with minor siltstone and coal. Local coal beds and petrified sequoia forests (engulfed by lahar deposits) indicate much of the section was deposited under subareal conditions, while local dinoflagellate horizons indicate some marine deposition. Micropaleontology of the Unga Conglomerate (North Unga Island and Zachary Bay Sections) indicates that it is Upper Miocene age and therefore not a basal conglomerate for the formation. It may be significant that the only strong evidence for active volcanism in Bear Lake time comes from the Upper Miocene portion of the formation (especially on the southeast side of the Peninsula); this episode of volcanism continued through Pliocene time.

Ugashik Conglomerate: The name "Ugashik Conglomerate" was coined by Conti (1972) for the thick section of fluvial conglomerate exposed in the Ugashik Mountain and Lower Ugashik Lake area. The section consists mainly of coarse granitic conglomerate with minor interbedded arkosic sandstone; x-ray diffraction analyses of the sandstone indicate the presence of abundant clinoptilotite (Enclosure 4). Burk (1965) mapped these conglomerates as Upper Jurassic Naknek Formation, while Conti (1972) and Conti and Self (1974) believed they were Oligocene/Eocene in age. Micropaleontology of samples collected from the Ugashik Conglomerate during this project (Lower Ugashik Lake Section) indicates that it was deposited in Upper Miocene or Lower Pliocene time, but that it includes reworked Jurassic dinoflagellates (D. Wall, personal commun., 1979). A granitic cobble from these conglomerates (Sample AP-2184G) yielded an Early Cretaceous K-Ar biotite age. As discussed below (under Radiometric Dating), this is considered a minimum age; most likely the real age is Early or Middle Jurassic and therefore the same as the Jurassic portion of the Alaska-Aleutian Range batholith.

Where exposed, the Alaska-Aleutian Range batholith is bound on the southeast by the Bruin Bay fault. This major up-to-the-northwest high-angle reverse fault is concealed southwest of the Becharof Lake, but projects along the northwest side of the Ugashik Lakes (Enclosure 1). Near to the Bruin Bay fault on the southeast side, the Naknek Formation often includes coarse granitic conglomerate which is referred to as the Chisik Conglomerate (Burk, 1965). The Chisik Conglomerate is not present in the Ugashik Lakes area and likely has been removed by erosion.

A likely model for the origin of the Ugashik Conglomerate is as follows. In the Late Miocene when a new phase of subduction and arc volcanism began (following the Late Oligocene to Middle Miocene hiatus), a prominent down-to-the-northwest fault became active and provided a boundary between the magmatic arc (Aleutian Range) and the backarc basin (Bristol Bay Lowlands and Bristol Bay). This important boundary fault projects through and to the southeast of the Ugashik Lakes (Enclosure 1). Rapid uplift on the southeast side of the fault in the Ugashik Lakes area caused erosion of the Upper Jurassic Chisik Conglomerate from the highlands. This conglomerate was redeposited directly northwest of the fault as alluvial fans. These deposits included Jurassic granitic cobbles and Jurassic dinoflagellates as well as Upper Miocene or Lower Pliocene palynomorphs which were added during redeposition. No paleocurrent data is presently available from the Ugashik Conglomerate, but this model predicts that transport was mainly to the northwest. An alternate hypothesis is that the Ugashik Conglomerate was derived directly from the Alaska-Aleutian Range batholith to the northwest by up-to-the-northwest movement along the Bruin Bay fault. The fault and batholith are not exposed southwest of Becharof Lake, but for reasons discussed below (under Radiometric Dating), they almost surely continue in the subsurface in this area. The hypothesis would call for Late Miocene uplift of the batholith along the Bruin Bay fault and the shedding of granitic conglomerates to the southeast to form the Ugashik Conglomerate. The problem with this model is that the General Petroleum Great Basins #1 and #2 wells penetrated both Miocene and Eocene strata overlying Jurassic granite. This indicates that the Jurassic batholith in this area was not exposed to erosion during Tertiary time.

Conti (1972) describes a possible petroleum play in the area between the Ugashik Conglomerate and the Great Basins wells to the northwest. He postulates that a fining-to-the-northwest facies change occurs between the coarse Ugashik Conglomerate and the time-equivalent fine-grained "Eocene-Oligocene" strata in the wells. Within this region there may exist a sandstone "fairway" which would provide an attractive reservoir horizon. Our work indicates that the Ugashik Conglomerate is Upper Miocene or Lower Pliocene in age rather than Eocene-Oligocene as Conti had believed. However this does not seriously change Conti's model, it simply changes the stratigraphic position of the sandstone "fairway" from the Eocene-Oligocene to the Upper Miocene or Lower Pliocene.

Pliocene: The contact between the Pliocene Tachilni Formation and the underlying Bear Lake Formation was studied only at the Milky River/Milky Ridge Section (see Photos 27-1, 2 in Enclosure 5). We interpret this complex contact as an unconformity with pronounced erosional relief and local slumping, but with little angular discordance. Four of the five sections measured in the Tachilni Formation (Cape Tachilni, Milky Ridge, Sandy Lake, and NE Veniaminof) yielded palynomorphs which indicate that the formation ranges in age from Lower to Upper Pliocene (Wall, 1978). The formation is poorly consolidated and volcanogenic, consisting of volcanic sandstone, pebble to cobble conglomerate, andesitic breccias and flows, and minor siltstone. The environment of deposition was largely continental, but horizons with burrows and pelecypods indicate some shallow marine deposition. Our thickest section of Tachilni Formation (Milky Ridge Section) is 4300 ft thick.

The Sandy Lake and NE Veniaminof Sections were interpreted as Bear Lake Formation in the field. However, Wall's (1978) palynologic studies of these sections indicate they are Pliocene and therefore Tachilni Formation. The Upper Miocene portion of the Bear Lake Formation commonly is very volcanogenic and therefore resembles the Tachilni Formation.

Radiometric Dating

Ten samples collected during this field project were radiometrically dated by the Potassium/Argon technique. Locations of dated samples are shown on Enclosures 1 and 2, analytical results are included in Enclosure 6-D, and a brief summary of the results (Tertiary only) is given in Tables 3 and 4. Enclosures 1 and 2 and Tables 3 and 4 also include radiometric ages from previous Amoco field projects on the Peninsula. This section of the report is an interpretative discussion concerning reliability of individual radiometric ages and how these ages suggest periods of volcanic activity on the Alaska Peninsula.

Ugashik Conglomerate: Sample AP-2184G is a biotite granodiorite cobble collected from the granitic conglomerates of the Lower Ugashik Lake Section. As discussed above, these conglomerates were deposited in Late Miocene time and apparently are composed of reworked Jurassic sediments. Sample AP-2184G yielded an Early Cretaceous biotite age (120 ± 5 myBP); the biotite was chloritized so the age is considered a minimum age. Most likely the real age of the cobble is Early to Middle Jurassic and therefore the same age as the Jurassic portion of the Alaska-Aleutian Range batholith which is exposed northeast of Becharof Lake (Reed and Lanphere, 1973). This batholith is not exposed southwest of Becharof Lake, but apparently continues to the southwest beneath the Bristol Bay Lowlands and Bristol Bay along the prominent magnetic lineament described by Pratt and others (1972). The General Petroleum Great Basins #1 and #2 wells (which were drilled northwest of the Ugashik Lakes in the Bristol Bay Lowlands) bottomed in Jurassic granitic rock, indicating the batholith extends at least that far southwest.

Meshik Formation: Three grab samples of Meshik andesite from the Kujulik Bay/Aniakchak Crater area were dated for this project. Sample AP-2224G was run as a "whole rock" and dated 33.1 ± 1.8 myBP; because whole rock ages tend to be too young (because of loss of radiogenic argon) this is considered a minimum age. Sample AP-2227G was run both as a whole rock and as a hornblende separate and dated 34.2 ± 1.7 myBP and 50.1 ± 4.2 myBP, respectively. The hornblende separate contained about 40% pyroxene (which contains excess argon) so the hornblende age may be slightly

TABLE 3: PALEOGENE RADIOMETRIC AGES

Age (myBP)	Number	General Location	Formation	Lithology	Quad	Township & Range	Latitude/ Longitude	Mineral Dated	Reference[†]
59.4 ± 8.7	C-1325	Cape Douglas	West Foreland(?)	felsic volc.	Afognak	14S-25W	58°58'N,153°25'W	WR	REN
53.8	Core #1 5913-38'	Pan Am Big Lake #1	West Foreland	welded tuff	Anchorage	1-15N- 4W		(?)	E-LOG
52.8 ± 6.5	C-1329	Cape Douglas	West Foreland(?)	intermed. volc.	Afognak	15S-24W	58°51'N,153°15'W	PL	REN
46.2 ± 2.4	CL70-274	King Salmon	TV or Meshik (?)	rhyolite (?)	Naknek	14-16S-43W	58°42'N,156°42'W	WR	COT
46.1 ± 3.1	CL70-285	Btwn Naknek & Becharof Lakes	TV or Meshik (?)	rhyolite	Naknek	2-21S-43W	58°23'N,156°17'W	PL	COT
42.9 ± 2.4	6200'	Union Fish Ck. #1	West Foreland	rhyolite	Anchorage	8-16N- 3W	61°33'N,150°20'W	(?)	STA
*42.2 ± 3.0	AP2227G	Cape Kumliun	Meshik	andesite	Sutwick IS	17-42S-54W	56°32'N,158°08'W	HO/WR	CON
42 ± 4	Core #1 11,832-11,856'	Gulf Port Heiden #1	Meshik	volcanic	Chignik	20-37S-59W	56°57'N,158°10'W	WR(?)	AGS
39.4 ± 3.1	CL70-279	N. Naknek Lake	TV or Meshik (?)	basalt	Naknek	36-14S-41W	58°55'N,156°03'W	WR	COT
39 ± 7	Core #2 8083-8095'	Great Basins Ugashik #1	Meshik	volcanic	Ugashik	8-32S-52W	57°27'N,157°44'W	WR(?)	AGS
37.2 ± 2.1	CL70-222	Pinnacle Mt., near Meshik Lake	-	stock	Sutwick IS	7-39W-54W	56°46'N, 57°50'W	WR	COT
36 ± 8	14,000'	Gulf Port Heiden #1	Meshik	volcanic	Chignik	20-37S-59W	56°57'N,158°10'W	WR(?)	AGS
35.9 ± 2.3	P2035G	E. Pavlof Bay	dike	mafic volc.	Port Moller	6-55S-78W	55°30'N,161°20'W	WR	MAC
*35.0 ± 2.8	AP2248G	SW Aniakchak	Meshik	tuff	Chignik	25-39S-58W	56°47'N,158°26'W	HO	CON
34.1 ± 1.8	P2091G	E. Herendeen Bay	-	basaltic sill intruding Stepovak(?)	Port Moller	21-50S-74W	55°45'N,160°45'W	WR	MAC
*33.1 ± 1.8	AP2224G	Kujulik Bay	Meshik	andesite	Chignik	9-42S-56W	56°34'N,158°07'W	WR	CON
33 ± 3	Core #1 3239-52'	Union Knik Arm #1	West Foreland	volcanic	Anchorage	1-14N- 4W		(?)	E-LOG
33 ± 1.5	Core #1 5364-5391'	Great Basins Ugashik #1	Meshik	volcanic	Ugashik	8-32S-52W	57°27'N,157°44'W	WR(?)	AGS
28.8 ± 1.9	CL70-253	Old Creek	Meshik	basic volc.	Ugashik	19-35S-51W	57°10'N,157°33'W	WR	COT
26.8 ± 2.6	B68-318	Cinder Creek	Meshik	basic volc.	Ugashik	11-36W-53W	57°07'N,157°50'W	WR	COT
25.7 ± 2.8	C-2231	Cape Douglas	West Foreland(?)	basalt	Afognak	15S-24W	58°54'N,153°21'W	WR	REN

*Samples dated for this project.

[†] See Robinson (1976) for explanation of references; "CON" refers to ages first described in this report; "AGS" refers to ages published in Brockway and others, 1975; "E-LOG" refers to ages indicated on Electric Logs in Amoco files.

TABLE 4: NEOGENE RADIOMETRIC AGES

Age (myBP)	Number	General Location	Formation	Lithology	Quad	Township & Range	Latitude/ Longitude	Mineral Dated	Reference†
20.2 ± 1.6	CL70-44	S. Mother Goose Lake	-	pluton	Ugashik	7-35S-50W	57°10'N,157°33'W	WR	REN
18.2 + .6	CL70-289	N. Becharof Lake	-	granite	Naknek	23-24S-42W	58°07'N,156°05'W	BI	COT
*15.9 ± 1.8	AP2235G	NE Veniaminof	Tachilni	tuff	Chignik	6-45S-63W	56°19'N,159°10'W	HO	CON
*22.0 ± 2.4	AP2249G	Windy Mtn. Section	Tachilni	andesite aggl.	Chignik	31-41S-59W	56°33'N,150°35'W	HO	CON
*14.9 ± 2.6	AP2250G	Windy Mtn. Section	Tachilni	andesite aggl.	Chignik	31-41S-59W	56°33'N,150°35'W	HO	CON
13.2 ± 2	CL70-12	Btwn Mother Goose Lake & Dog Salmon River	Tachilni (?)	basalt	Ugashik	26-33S-50W	57°20'N,157°20'W	WR	COT
11.0 ± 0.9	C-1338	Cape Douglas	Tyonek, Hemlock, or West Foreland(?)	volcanic	Afognak	14S-25W(?)	58°55'N,153°23'W	HO	REN
*10.4 ± 1.1	AP3128G	Milky River Milky Ridge Section	Talchilni	andesite	Port Moller	27-48S-69W	56°01'N,160°02'W	HO	CON
*8.7 ± 0.4	AP2228G	Devils Bay	-	bio-hnbld granodiorite	Chignik	2-48S-59W	56°03'N,158°25'W	BI	CON
*7.6 ± 0.3	AP2230G	Devils Bay	-	bio-hnbld granodiorite	Chignik	2-48S-59W	56°03'N,158°25'W	BI	CON
4.7 ± 0.2	P3072G	Portage Bay	-	hornfels	Ugashik	22-31S-42W	57°30'N,156°10'W	BI	MAC
3.8 ± 1.0	C-1339	Cape Douglas	QV (?)	dacite	Afognak	14S-25W	58°55'N,153°25'W	WR	REN

*Samples dated for this project.

†See Robinson (1976) for explanation of references; "CON" refers to ages first described in this report; "AGS" refers to ages published in Brockway and others, 1975.

anomalously old; an average of the whole rock and hornblende ages is 42.2 ± 3 myBP. Sample AP-2248G was run as a hornblende separate and dated 35.0 ± 2.8 myBP; this probably is a reliable age.

Table 3 lists nine other Meshik samples that range in age from 26.8 to 46.2 myBP. The ages 26.8, 28.8, and 33 myBP are whole rock ages and likely are anomalously young. I believe that the most reliable ages for the Meshik range from about 42.2 to 33.1 myBP. A stock south of Aniakchak Crater (Pinnacle Mtn.) dated at 37.2 myBP (whole rock) and likely represents one of many nearby vents of Meshik volcanoes.

In conclusion, the Meshik Formation volcanics apparently range in age from Late Eocene to Early Oligocene. As discussed above, they consist mainly of subareal andesitic flows, lahar deposits, and volcanic sandstones that accumulated along the flanks of composite volcanoes and in nearby fluvial and shallow marine environments. I believe the Meshik Formation is in part coeval with the Belkofski, Stepovak, and Tolstoi Formations: the greater abundance of flows and coarse volcanic debris in the Meshik Formation simply indicates a more proximal location to the Eocene/Oligocene volcanic arc.

Bear Lake and Tachilni Formations: As discussed above, the distinction between the upper Bear Lake Formation and the Tachilni Formation often is not clear, and several of our field-calls were incorrect. Moreover, there are serious discrepencies between the palynologic ages given to those formations and the ages based on radiometric dating.

Sample AP-2235G is a hornblende tuff of primary origin (i.e., not reworked) collected from the NE Veniaminof Section; a hornblende separate from this rock dated at 15.9 ± 1.8 myBP. This date clearly is too old because the palynologic age determined from samples stratigraphically above and below the dated sample (Wall, 1978) is Lower Pliocene (ca. 4-6 myBP). (When we measured this section, we thought it was Bear Lake Formation; palynology indicates it is Tachilni Formation.) I have discussed this discrepancy with Mr. H. Krueger of Geochron Laboratories and he pointed out four problems with the dated sample. First, the radiogenic argon to total argon ratio averages 0.027. This ratio is a measure of the reliability of the quantity of radiogenic argon present in the sample; if the ratio is below 0.10, the reliability is low, and, consequently, the radiometric age is not reliable. Second, the two radiogenic argon analyses (0.000223 and 0.000449 ppm) disagree by a factor of two which is unacceptable replicability. Third, the potassium content of the sample is quite low, thus allowing greater analytical error. And finally, the sample is very young and at the limit of Potassium/Argon technique for determining an accurate age, especially with the low potassium content.

Samples AP-2249G and AP-2250G were collected from the Windy Mountain Section which directly overlies the Bear Lake Formation of the Windy Ridge Section. The Windy Mountain Section consists of coarse volcanic agglomerate and minor volcanic sandstone; no rocks suitable for palynologic study are present. The upper portion of the Windy Ridge Section is Upper Miocene in age, so the Windy Mountain Section must be Upper Miocene or younger; we interpreted it to be Tachilni Formation in the field.

Sample AP-2249G is a hornblende andesite; a hornblende separate from this rock dated at 22.0 ± 2.4 myBP. This date is considered unreliable because of the same reasons mentioned above (Sample AP-2235G). Especially bad here is the lack of replicability of the radiogenic argon analyses (0.000451, 0.00724, and 0.000326 ppm). Because of this lack of replicability, I had another sample of hornblende andesite from the same outcrop dated: Sample AP-2250G. This sample had the same analytical problems as AP-2249G except that the replicability of radiogenic argon was much better (0.000397 and 0.000272 ppm). The sample dated at 14.9 ± 2.6 myBP, but is still anomalously old: it should date less than about 10 myBP based on palynology in the Windy Mountain Section.

Sample AP-3128G is a hornblende andesite collected from the Tachilni Formation in the Milky Ridge Section. A hornblende separate from this sample dated at 10.4 ± 1.1 myBP. Again, because of the low ratio of radiogenic argon to total argon, the low potassium analyses, and the young age, this date probably is unreliable. The palynology of samples collected stratigraphically above this dated sample indicate that the andesite has a likely Lower Pliocene age (ca. 4 to 6 myBP).

Samples AP-2228G and AP-2230G are biotite-hornblende granodiorite collected as grab samples from the Devil's Bay pluton; biotite separates from these samples dated 8.7 ± 0.4 and 7.6 ± 0.3 myBP, respectively. These appear to be reliable dates even though they are at the young limit of the Potassium/Argon technique.

In conclusion, most radiometric dates presently available for Neogene rocks are unreliable and anomalously old. Our constraints on the age of Neogene volcanism must therefore be based on palynologic control. As discussed above (under Tertiary Stratigraphy), it appears that primary volcanic products became important constituents in Late Miocene time and remained important through all of Pliocene time. The Devil's Bay pluton may belong to a belt of Upper Miocene to Pliocene plutons which trends northeast from Unga Island through Devil's Bay to the Chiginagak Bay pluton; most of this supposed plutonic belt is underwater. The belt may represent the core of a Late Miocene to Pliocene volcanic arc.

Petroleum Potential

The petroleum potential of the Alaska Peninsula and Bristol Bay region will be discussed at length in a future report by Leonid Smirnov, so it is only briefly mentioned here. Twelve significant wells have been drilled on the Peninsula and oil and gas shows occurred in the Pan Am David River #1, Pan Am Hoodoo Lake #2, and Gulf Sandy River #1 wells, mainly in the Lower Miocene and Eocene formations (Brockway and others, 1975; Conti, 1968, 1972, 1973). Most of the twelve wells were not drilled in the best possible locations. Based on these wells and on analogies with other convergent plate margins where hydrocarbons have been discovered, it is apparent that the backarc region (i.e., Bristol Bay Lowlands and Bristol Bay) is the most likely region to contain commercial hydrocarbons.

Source rock analyses of surface samples collected during this project (Enclosure 4) indicate that Eocene/Oligocene strata are the most prospective source rocks for a Bristol Bay play. Most analyzed rocks of this age are gas sources in peak gas stage of generation; only three potential oil source rocks were analyzed. Miocene and Pliocene rocks analyzed are gas sources, generally in pregeneration to early gas stage.

Porosity and permeability analyses of surface samples (Enclosure 4) indicate that Miocene sandstones may provide a very good reservoir horizon. Porosities range from 16.2% to 33.3% while permeabilities range from 17.7 to 599 md. Eocene/Oligocene sandstones generally are tight and commonly contain zeolites (Enclosure 4); these rocks are not likely to provide an effective reservoir horizon.

Volcanogenic Upper Miocene and Pliocene strata are likely to provide a capping formation over the Miocene reservoir. Hydrocarbons might also be trapped within the Miocene strata as "stacked" accumulations since porous sandstones are interbedded with siltstones and claystones. "Stacked" reservoirs are common in Miocene strata of the Upper Cook Inlet.