No formations have been formally defined within the Cretaceous clastic deposits of the regionally extensive Kuskokwim Group of southwestern Alaska. Near Cairn Mountain, in its southeastern area of exposure, the Kuskokwim Group may be divided into two distinctive stratigraphic units. The widespread lower unit (Hook Creek unit) consists mainly of shale and siltstone with interbedded sandstone turbidites and is at least 5,000 m thick. The upper unit (Cairn Mountain unit) is characterized by poorly cyclical massive sandstone and granule to cobble conglomerate. This unit is at least 6,000 m thick at Cairn Mountain, but thins dramatically to the southwest to about 750 m.

Based on measured sections and other sedimentologic data, we interpret the Cairn Mountain area as part of a Cretaceous submarine-fan complex. The Hook Creek unit consists of mid-fan channel and levee deposits that thin and fine upward, whereas the coarser grained Cairn Mountain unit comprises inner-fan channel deposits. Paleocurrent and compositional evidence indicate that the submarine fan was shed southwestward, mainly from the Mystic terrane in the western Alaska Range.

MORROW, HYLAND B., Chevron U.S.A. Inc., Concord, CA

Seismic Subsequences in Foothills Foldbelt, National Petroleum Reserve in Alaska (NPRA), Alaska

The foothills foldbelt of the NPRA takes its name from its well-developed concentric folds involving Cretaceous rocks. These folds can extend over several townships, some being 40 mi (65 km) long and 10 mi (15 km) wide, and could contain significant amounts of oil. One fundamental problem in the foldbelt is to identify good quality reservoir rocks at optimum depths of burial.

The most widespread units containing potential reservoir rocks are the Torok Formation and the Nanushuk Group. The Torok Formation, of Aptian-Albian age, consists primarily of shale and siltstone with sands interbedded locally. It was deposited as a prograding delta sequence containing both marine and transitional marine clastics. The Nanushuk Group, of Albian to Cenomanian age, is typified by marine clastics grading upward into fluvial and nonmarine clastics. The Nanushuk Group contains many intervals with good reservoir potential, but they usually lie too near the surface to allow economical recovery of oil. The Torok lies at optimum depths, but it tends to be too fine grained or "dirty" to possess good porosities and permeabilities.

The Torok does contain certain intervals with better quality and more numerous sands. These sands were probably deposited as nearshore bars during periods of higher energy deposition. Seismic subsequences within the Torok are thought to represent large deltaic lobes. The tops of the subsequences are defined by zones of toplap or truncation and tie very well with the bases of sandier intervals near the transition from Torok to Nanushuk Group where the intervals are present in outcrop.

MULHERN, M. E., Schlumberger Well Services, Ventura, CA, J. E. LAING, Texaco, USA, Bakersfield, CA, J. E. SENECAL, Schlumberger Well Services, Ventura, CA, R. E. WIDDICOMBE, Schlumberger Well Services, Denver, CO, and C. ISSELHARDT and J. R. BOWERSOX, Texaco, USA, Bakersfield, CA

Electrofacies Identification of Lithology and Stratigraphic Trap, Southeast Lost Hills Fractured Shale Pool, Kern County, California

Subtle facies changes are traced vertically and laterally in the upper Monterey and Reef Ridge formations through application of the Multiwell Faciolog (mark of Schlumberger) technique. Electrofacies, representing intervals of similar log response, are identified in a key well by comparison with mud-log, conventional core, and x-ray diffraction analysis from sidewall cores and are retained in a data base. Five subsequent wells lacking detailed core or x-ray data but with similar log suites (bulk density, neutron porosity, gamma ray, and delta time) were compared to the data base and automatically assigned electrofacies. Twelve electrofacies—including diatomite, porcellanite, chert, dolomite, mudstone, and claystone, plus intermediate members—have been identified at the depth accuracy and resolution of petrophysical logs.

The lateral updip diagenetic facies changes from porous, hydrocarbon-productive diatomaceous mudstone to impermeable, low-porosity, nonproductive porcellanite are clearly illustrated by the Faciolog cross-sectional display. McGuire et al, documenting the change from mudstone to porcellanite, recognize it as a controlling factor in formation of a stratigraphic trap. Vertical electrofacies associations reflect cyclic paleoclimatic trends and provide sedimentary sequences that aid in well-to-well correlation, field studies, and mapping in otherwise nondescript shales. Lithologic characterization of fine-grained, compositionally variable reservoirs, such as the Monterey Formation and equivalent rocks, is critical in understanding diagenetically altered porosity and, therefore, production.

Comparison of average log values for each electrofacies with equivalent Miocene-age coastal basin rocks reveals decreased dolomite and increased terrigenous clay content in the Lost Hills strata. Using the Faciolog technique, combined with x-ray diffraction analysis, allows identification of average log values associated with specific lithologies.

MULL, CHARLES G., Alaska Div. Geol. and Geoph. Surveys, Anchorage, AK, KAREN E. ADAMS, Univ. Alaska, Fairbanks, AK, DIRK A. BODNAR, Sohio Petroleum Co., Houston, TX, and JEROME P. SIOK, Univ. Alaska, Fairbanks, AK

Stratigraphy of Endicott Mountains and Picnic Creek Allochthons, Killik River and Chandler Lake Quadrangles, North-Central Brooks Range, Alaska

Geologic mapping in the Killik River and Chandler Lake quadrangles has delineated rocks of at least three of the major allochthons found in the De Long Mountains of the western Brooks Range: the Brooks Range (Endicott Mountains), Picnic Creek, and Copter Peak allochthons. Rocks characteristic of parts of the Tpnavik River and Nuka Ridge allochthons are also present.

The Endicott Mountains allochthon forms the main crest and mountain front of the central Brooks Range. It is the structurally lowest of the allochthons in the region. Major rock units on the allochthon are: Upper Devonian Hunt Fork Shale and Noatak Sandstone, Upper Devonian–Lower Mississippian Kanayut Conglomerate, and Mississippian Kayak Shale of the Endicott Group; Alapah Limestone and Kuna formation of the Lisburne Group; and Permian Siksikpuk Formation and Triassic Otuk formation of the Etivluk group. Lower Cretaceous coquinoid limestone and, in some places, orogenic sediments of the Okpikruak Formation cap the allochthon. Total stratigraphic thickness of the Endicott Mountains allochthon is over 2,000 m (6,500 ft).

Rocks of the Picnic Creek allochthon are widespread in the "disturbed belt" of the Brooks Range foothills, and structurally overlie the Endicott Mountains (Brooks Range) allochthon in the Killik River quadrangle and quadrangles to the west. The allochthon is not recognized with certainty east of the Killik River quadrangle. Major rock units on the Picnic Creek allochthon are: Upper Devonian(?) Hunt Fork Shale, Lower Mississippian Kurupa sandstone tongue (new name) of the Noatak Sandstone, and Mississippian Kayak Shale of the Endicott Group; Carboniferous Akmalik chert (new name) of the Lisburne Group; and Pennsylvanian Imnaitchiak chert (new name) and Otuk formation of the Etivluk group. Orogenic sediments of the Lower Cretaceous Okpikruak Formation form the top of the Picnic Creek allochthon. Total stratigraphic thickness of these rock units is not over 1,000 m (3,200 ft).

Plant fossils from a number of localities in the Kurupa sandstone are dated as Early Mississippian (Tournaisian-Visean) by B. A. Thomas and R. A. Spicer and have close affinities to material from eastern USSR. Palinspastic restoration of the Picnic Creek allochthon southward to a position south of the Endicott Mountains allochthon restores the Kurupa sandstone, the Akmalik chert, and the Imnaitchiak chert to their proper basin position. In the reconstructed basin, the Kurupa sandstone appears to represent the distal, southern end of the Kanayut-Noatak coarse-clastic wedge. The Akmalik chert and Imnaitchiak chert represent basinal equivalents of the Alapah Limestone–Kuna formation of the Lisburne Group and Siksikpuk Formation of the Etivluk group.

Detailed stratigraphic and paleontologic studies of the Mississippian through Triassic rocks on both allochthons are in progress.

MULL, CHARLES C., Alaska Div. Geol. and Geoph. Surveys, Anchorage, AK, KAREN E. ADAMS, Univ. Alaska, Fairbanks, AK, and JOHN T. DILLON, Alaska Div. Geol. and Geoph. Surveys, Fairbanks, AK

Geological Mapping in Doonerak Fenster, Central Brooks Range, Alaska

Mapping of the north flank of the Doonerak fenster has traced the Amawk thrust, the sole fault of the Endicott Mountains allochthon, from the North Fork of the Koyukuk River–Mount Doonerak area eastward for more than 40 km (25 mi) to the east plunge of the Doonerak anticline at Koyuktuvuk Creek near the Dietrich River. Mapping has concentrated on the structural style of the area and on the autochthonous or parautochthonous Carboniferous Lisburne Group, Kayak Shale, and Kekiktuk Conglomerate—which are present along most of the anticline—and Triassic Karen Creek Sandstone, Triassic Shublik Formation, and Permian-Triassic Sadlerochit Group—which are present only in the west. This Triassic to Mississippian section closely resembles the coeval autochthonous to parautochthonous Ellesmerian section of the subsurface to the north and in the Brooks Range to the northeast.

The north-dipping Amawk thrust is mapped between outcrops of lower Paleozoic metasedimentary rocks and this subjacent Triassic to Mississippian section. On the west, an unbroken stratigraphic sequence underlies the Amawk thrust; a complete section of Karen Creek, Shublik, Sadlerochit, Lisburne, Kayak, and Kekiktuk is exposed in the canyon of Bombardment Creek. The Kekiktuk Conglomerate unconformably overlies weathered Ordovician-Cambrian mafic volcanic rocks. Well-developed slaty cleavage in Sadlerochit and Lisburne rocks is compatible with northward-thrust transport of the overlying Endicott Mountains allochthon. East of Bombardment Creek, structural complexity increases markedly, and multiple slivers of Kekiktuk, Kayak, Lisburne, and Sadlerochit are mapped below the Amawk thrust. At Falsoola Mountain, near the east end of the fenster, the Lisburne is isoclinally folded. Near Koyuktuvuk Creek, this parautochthonous section can be described as a broken formation. Movement has occurred along incompetent horizons, particularly within the Kayak Shale, resulting in imbrication of the competent beds. This movement can be interpreted as drag resulting from emplacement of the overlying Endicott Mountains allochthon and not from a regionally significant thrust fault.

Along most of the north side of the fenster, from Mount Doonerak eastward to Falsoola Mountain, east-trending high-angle longitudinal faults uplift the core of the fenster. These vertical to steeply south-dipping faults have vertical separations of a few meters to over 500 m (1,600 ft), and postdate the Early Cretaceous (probably Neocomian) emplacement of the Endicott Mountains allochthon. This uplift was probably related to the Albian and Late Cretaceous tectonic events interpreted elsewhere in the Brookian orogen. Alternatively, the high-angle faults can be interpreted as part of the floor of a duplex. However, there is no evidence of any large amount of horizontal translation along these faults.

MULL, CHARLES G., Alaska Div. Geol. and Geoph. Surveys, Anchorage, AK, CHESTER PARIS, ARCO Alaska, Inc., Anchorage, AK, and KAREN E. ADAMS, Univ. Alaska, Fairbanks, AK

Kemik Sandstones, Arctic National Wildlife Refuge (ANWR), Alaska

In the Sadlerochit Mountains area of ANWR, the Kemik Sandstone of Hauterivian-Barremian age ranges to at least 35 m (120 ft) of very well sorted, fine-grained quartzose sandstone with minor pebble conglomerate. It is an elongate body traceable for over 160 km (100 mi) from the eastern Sadlerochit Mountains into the subsurface near the Sagavanirktok River to the west. In the northeast, it crops out in a belt about 16 km (10 mi) wide; to the southwest in the subsurface, it expands to about 65 km (40 mi) wide. It is a potential petroleum reservoir in the subsurface of ANWR, but its distribution north and east of the Sadlerochit Mountains is unknown.

The Kemik overlies a regional angular unconformity with increasing depth of truncation northward; it is overlain by and intertongues with an unnamed "pebble-shale" unit. Data suggest that the Kemik was derived from erosion of Lisburne Group carbonate rocks and a terrain of mature sedimentary rocks north and east of the outcrop belt. Conglomerate clasts consist dominantly of white leached spicular and foraminiferal chert, silicified carbonate, and quartzite. Although the sand has a nearly uniform grain size from east to west, conglomerate clasts are most abundant to the northeast and become smaller and less abundant westward; few are noted west of the Canning River. This distribution is suggestive of longshore drift from the northeast.

A shoreface depositional environment, possibly a barrier island along a coast with low tidal flux, seems to be represented in the Kemik. Beds up to 2 m (6 ft) thick with sweeping low-angle cross stratification are interbedded with parallel laminated units and scattered, thin, maroon siltstone-mudstone beds. Vertical burrows up to 0.5 m (20 in.) long and truncated by overlying beds are conspicuous in some areas. A sparse pelecypod fauna is present, usually in the maroon silty horizons.

The Kemik and other coeval sandstone and conglomerate horizons in the subsurface, such as the Put River sands and the Point Thomson sands, are probably separate bodies of sediment derived from uplifted blocks along the rifted Arctic Alaska plate margin.

MURPHY, J. M., Univ. Alaska, Fairbanks, AK, and JOHN DECKER, Alaska Div. Geol. and Geoph. Surveys, Fairbanks, AK

Goodnews Terrane and Kuskokwim Group, Eek Mountains, Southwest Alaska: Open Marine to Trench-Slope Transition

In the Eek Mountains, southwest Alaska, four depositional settings record Permian to mid-Cretaceous marine sedimentation and post-Valanginian crustal shortening. Sequence 1: pillowed basalt flows (SiO_2 = 44%) and volcaniclastic sediments intercalated with Permian Atomodesma-bearing sandy limestones grade upward through volcanic debris flow deposits and tuffaceous argillites into sequence 2: thin-bedded chert with argillite partings. Sequence 3 rests conformably(?) on sequence 2 and consists of undated argillite grading upward into Early Cretaceous (Valanginian) thin-bedded Tcde/Tde turbidites and thick-bedded conglomeratic grain flow deposits. Sequence 4 consists of late Early Cretaceous (Albian) thick-bedded conglomeratic grain flow deposits and minor Tcde/Tde and Ta/Tab turbidites. Sequence 4 (Kuskokwim Group) overlies sequences 1, 2, and 3 (Goodnews terrane) with an angular unconformity preserving submarine canyon cut-and-fill.

Sequence 1 requires an ocean island(?), and sequence 2 an open marine origin. Sequences 3 and 4 are inner-fan turbidite deposits; conglomerate and sandstone compositions indicate recycled orogen, arc orogen, and collision orogen provenances. This suggests preaccretion Valanginian clastic input from the now-adjacent Kilbuck terrane.

All four sequences record southeast over northwest imbrication along southeast-dipping thrusts. Deformation and metamorphic intensity increases with age/depth; a maximum is recorded in pervasively foliated Permian greenstone crosscut by prehnite and pumpellyite veins. Sequences 1 and 2 are highly disrupted, with local blocks-in-matrix fabric. Sequence 3 shows a similar, less pervasive style. Sequence 4 is locally disrupted and overturned along faults but lacks penetrative deformation. Deformation began between Valanginian and Albian times, and either progressively penetrated upsection with time or was multiphased with consistent recurring structural style.

NEWBERRY, R. J., Univ. Alaska, Fairbanks, AK

Overview of Gold-Bearing Skarns of Southern Alaska

Although skarn deposits occur throughout Alaska, skarns with appreciable gold production/reserves are largely limited to an arcuate belt that stretches through southeastern and southern Alaska to the Alaska Peninsula. Within this belt are nearly 100 known gold-bearing skarn prospects and deposits. They occur in a variety of tectono-stratigraphic terranes, with no consistent age or character of the host carbonate unit. These skarns are, however, characterized by specific geologic associations, including intrusives, alteration, ore and gangue mineralogy, and trace metals.

Intrusions associated with gold skarns are typically medium-grained, equigranular to slightly porphyritic members of gabbro-diorite-tonalite or diorite-quartz monzodiorite suites. Intrusive alteration, if present, consists predominantly of secondary albite, actinolite, and epidote, with little secondary quartz and sulfide and very rare secondary K-feldspar and muscovite. Typical "identifying" mineralogies include an abundance of epidote, chalcopyrite, and chlorite; the presence of pyrrhotite, "specular magnetite," idocrase, scapolite, hornblende, and albite; and the general absence of bornite, sphalerite, and galena. Generally, only minor amounts of sulfides and magnetite in gold skarns are present in the skarns per se or the associated plutons; most of the (gold-bearing) sulfide and magnetite is present at the marble front. Trace elements found at anomalous levels in gold skarns include Ni, Co, As, V, Mo, Sb, and Bi. Elements that are inevitably low in gold skarns include Zn, Pb, F, Sn, Be, W, and Ba. These elemental characteristics contrast strongly with those of gold-poor skarns and with metamorphosed volcanogenic massive sulfide deposits.