part of the Iditarod quadrangle. The ultramafic rocks are poorly exposed on rounded tops of the low rolling hills in the area, and they form a northeast-southwest belt at least 8 mi long and as much as 3 mi wide. Although these rocks are associated with Mississippian to Jurassic(?) chert, tuff, argillite, and basalt of the Innoko terrane, the contact relations are uncertain.

The ultramafic rocks consist of harzburgite, lherzolite, pyroxenite, and pods of altered dunite; disseminated chrome spinel is a common but minor constituent. Serpentinization is ubiquitous, all samples showing at least some effects and many being entirely serpentinized. Discontinuous pods of former serpentinized dunite(?) within lherzolite are entirely altered to a magnesite + talc + chrome spinel assemblage, indicative of low-grade metamorphism in the presence of water and carbon dioxide.

The ultramafic rocks of Iditarod quadrangle are similar to and on trend with those of the Mount Hurst area, 25 mi to the northeast in the Ophir quadrangle. The Mount Hurst rocks represent part of a dismembered ophiolite, probably related to the Yukon-Koyukuk ophiolite belt. Although several of the classic ophiolite components are missing from the ultramafic sequence in Iditarod quadrangle, an ophiolite origin is strongly suggested by correlation with the Mount Hurst rocks and is supported by the presence of a structural slice of hypersthene gabbro in close proximity to the ultramafic sequence.

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Late Cretaceous Coccolith Biostratigraphy of San Miguel Island, California

Coccoliths recovered at 69 localities from the northwest coast of San Miguel Island provide definitive biostratigraphic criteria for subdivision of more than 1,425 m of submarine fan strata of the Mirounga formation of Late Cretaceous age. The seven coccolith zones recognized from the stratigraphic distribution of 38 species suggest that San Miguel Island has one of the most complete sequences of Upper Cretaceous strata in southern California. The zones are, from oldest to youngest: *Quadrum gartneri, Eiffellithus eximius, Marthasterites furcatus, Micula staurophora, Broinsonia parca, Quadrum trifidum,* and *Arkhangelskiella cymbiformis* zones. These coccolith zones are known elsewhere in the world. They appear to represent a time interval from the early Turonian to the middle Maestrichtian, although coccolith criteria for the Santonian stage interval were not observed, possibly because of ecological restrictions.

Coccolith localities along the northwest coast of San Miguel Island indicate Upper Cretaceous strata where the Paleogene Pozo-Canada Formations and South Point sandstone had been mapped previously. These new data may add more than 500 m of rock to the previously recognized Late Cretaceous stratigraphic column. On the basis of coccolith criteria, various parts of the Mirounga formation correlate with Upper Cretaceous rocks of the southern California mainland such as: the Jalama Formation (western Santa Ynez Mountains), the Chatsworth Formation (Simi Hills), the Holz Shale Member of the Ladd Formation (Santa Ana Mountains), and the Point Loma Formation of the Rosario Group (San Diego area). Correlations are possible also with the Valle Formation of Mexico (Vizcaino Peninsula).

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Depositional History and Seismic Stratigraphy of Lower Cretaceous Rocks, National Petroleum Reserve, Alaska and Adjacent Areas

Knowledge of depositional history of Lower Cretaceous rocks in the National Petroleum Reserve in Alaska is necessary for predicting the occurrence of potential sandstone reservoirs. These rocks range in thickness from 7,000+ m along the Colville basin axis to about 1,200 m on the Barrow arch. Lower Neocomian strata on the north flank of the basin consist of southward-prograding marine shelf and slope deposits of shale and minor sandstone units. Uplift, erosion, and subsequent transgression on the northernmost flank of the basin resulted in deposition of the pebble shale unit in late Neocomian time and termination of the northern provenance. Following this, the basin was downwarped, and little deposition occurred on the north flank until distal, deep-water deposits of the Torok Formation onlapped and downlapped the south-dipping flank of the basin in middle or late Albian time.

On the south flank of the basin, southern-source turbidites of the Okpikruak Formation (early Neocomian) accumulated in a subsiding foredeep and were subsequently thrust northward in late Neocomian or Aptian time. The Fortress Mountain Formation (early Albian), which consists of as much as 3,000 m of mainly deep-water deposits, unconformably overlies the Okpikruak and older rocks on the southernmost flank of the basin. Filling of the Colville basin occurred in middle to late Albian time as thick prodeltaic and deltaic deposits of the Torok Formation and Nanushuk Group, respectively, prograded across the basin from the south on the south side of the basin, but prograded principally from the west-southwest over most of the basin.

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Significant Outcrops of Cretaceous and Tertiary Rocks in Northeastern Alaska

Cretaceous and Tertiary rocks in northeastern Alaska comprise the Neocomian part of the northerly derived Ellesmerian depositional sequence and the overlying Brookian sequence, which was derived from the ancestral Brooks Range to the south and southwest. The Ellesmerian part is less than a few hundred meters thick and consists of the upper part of the Kingak Shale and the overlying transgressive part of the pebble-shale unit and associated Kemik Sandstone Member of the Kongakut Formation. The Brookian sequence is more than 4,000 m thick and consists of, in ascending order: (1) a deep-water condensed section of organic-rich shale and bentonite with a discrete 30 to 60-m thick radioactive zone at the base; (2) a slope-and-shelf shale section with turbidites at the base; (3) a fluvial-dominated deltaic sequence that, except for one major and several minor transgressions, prograded from southwest to northeast during Albian to Eocene time; and (4) a shallow marine and nonmarine post-Eocene section.

Rocks of the four facies, which represent a wide range of depositional environments, are discontinuously exposed along the coastal plain and foothills of the Brooks Range in northeastern Alaska. Certain outcrops are significant because they show critical facies relationships. Recognition of vertical and lateral facies sequences and key lithologic units, in conjunction with available paleontologic data, facilitates correlation of the Cretaceous and Tertiary rocks both across the outcrop belt and into the subsurface to the north.

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Pre-Mississippian Accreted Terranes of Northeastern Brooks Range, Alaska

Low-grade metamorphic rocks (Neruokpuk Formation, sensu lato) underlying a regional angular unconformity in the northeastern Brooks Range have been interpreted as a conformable Precambrian to Devonian stratigraphic succession. The pre-Mississippian rocks include not only "miogeoclinal" quartzites and carbonates but also a variety of "eugeoclinal" lithologies such as radiolarian cherts, argillites, and graptolitic shales; mafic to intermediate volcanic rocks; and volcanogenic graywackes. Fossils of Cambrian, Ordovician, and Silurian age have been identified in these lithologies. Many of these units are fault-bounded and may be interpreted as pre-Mississippian tectono-stratigraphic terranes. Several of the terranes are depositionally overlapped by Middle(?) Devonian clastic rocks and intruded by plutonic rocks depositionally overlain by Mississippian and younger rocks, but which yield equivocal middle Paleozoic age dates. Similar relationships are exposed in the Doonersk anticlinorium in the central Brooks Range. These features are interpreted to indicate that the lower Paleozoic rocks of the eastern Brooks Range were tectonically assembled by accretionary processes along an active continental margin prior to Middle Devonian time. Subsequent uplift and erosion occurred prior to deposition of the Mississippian to Neocomian (Ellesmerian) passive margin sequence.

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Stratigraphy and Sedimentology of Kuskokwim Group in Vicinity of Cairn Mountain, Southwestern Alaska

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.

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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.

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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.

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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.

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Geological Mapping in Doonerak Fenster, Central Brooks Range, Alaska