line camp on the Dalton Highway and went eastward over the 5,000-ft mountains separating the Dietrich and Mathews Rivers, then north to the headwaters of the Mathews River, and finally west to the Dietrich River drainage north of Snowden Mountain.

The geologists, who split off on traverses paralleling the pack-train route, mapped seven townships, located the bimodal Devonian Ambler volcanic belt, and traced it from near Dietrich Camp to Snowden Mountain. Farther west, this belt contains massive sulfide deposits valued in excess of $12 billion.

Although none had packing experience, all of the llamas were friendly and easy to handle. They carried 60-100 lbs each, depending on their age. Only blocky talus and very steep slopes were obstacles. The llamas easily traversed fine loose scree, making ascents and descents as steep as 1,000 ft/mi (190 m/km), bashed through alder scrub, slogged over muskeg, and forded rivers. Since they are avid foragers, minimal food was packed for the llamas. Bears were sighted during the trip, but none approached the group. Dall sheep and llamas puzzled at each other from a distance.

DILLON, JOHN T., Alaska Div. Geol. and Geoph. Surveys, Fairbanks, AK, and GEORGE R. TILTON, Univ. California, Santa Barbara, CA

Devonian Magmatism in Brooks Range, Alaska

Devonian bimodal metaplutonic and metavolcanic rocks lie in parallel, west-trending belts in the southern Brooks Range. Overlapping distribution of the plutonic and volcanic rocks occurs in volcanic centers found south of the Doonerak window in the Wiseman, Chandalar, and Colleen quadrangles, and near the Beaver Creek pluton in the Survey Pass quadrangle. The Devonian age is interpreted from isotopic analyses of U and Pb of over 55 zircon fractions from these felsic metaigneous units. Considering concordia plots and Pb-Pb ages from over 40 discordant zircon fractions and fossil ages derived from marbles intercalated in the volcanic sequences, we see an age range of 360-410 Ma. The age range is attributed to variation in crystallization ages, as well as the U-Pb systematics of the Brooks Range zircons. Their overlapping age and distribution provides evidence for cogenesis of the Devonian plutonic and volcanic rocks, and also for their correlation with Devonian magmatic rocks of the North American Cordilleran. Lower intercepts on U-Pb concordia diagrams for these zircons range from 105 to 150 Ma, bracketing the end of lead loss resulting from metamorphism. The age of this metamorphic event corresponds to the Late Jurassic and earliest Cretaceous emplacement of the Angayucham terrane.

U-Pb concordia plots of 15 zircon fractions from five samples of the Ernie Lake granitic gneiss bodies are explained as latest Proterozoic intrusion of granitic magma with entrained 2-Ga-old zircons, which subsequently lost lead during Mesozoic metamorphism.

DINTER, DAVID, U.S. Geol. Survey, Menlo Park, CA

Late Quaternary Depositional History of Alaskan Beaufort Shelf

Diverse nonmarine and shallow marine deposits blanketing the coastal plain and continental shelf of northern Alaska are known collectively as the Gubik Formation. In the Beaufort coastal region between Barrow and Prudhoe Bay and along the Chukchi coastline southwest of Barrow, five distinct marine subunits have been recognized within the Gubik, ranging in age from middle Pliocene to late Pleistocene. A sixth pre-Holocene transgressive marine subunit, about a meter thick and bearing abundant ice-striated dropstones that originated in the Canadian Arctic Islands, is present along much of the Alaskan Beaufort coast. The aggregate thickness of the Gubik Formation on the coastal plain is no more than a few tens of meters. Offshore beneath the Beaufort shelf, however, the Gubik Formation is locally thicker than 100 m and includes not only deposits that probably correlate with those mapped onshore but also subunits of intermediate and younger ages. These have been studied mainly through the interpretation of a network of high-resolution seismic reflection profiles that covers most of the Alaskan Beaufort shelf at 18 to 35-km intervals seaward of the 25-m isobath.

In general, the Gubik Formation offshore appears to be a stack of wedge-shaped transgressive marine units that thicken toward the shelf break, beyond which they are disrupted by active slumps and landslides. This idealized geometry is altered in the area east of Canning River, where active faulting and folding have created persistent local highs and depocenters, and in the area between Smith and eastern Harrison Bays, where a complicated Quaternary drainage history has resulted in extensive local erosion of the marine wedges and in the deposition of relatively large deltaic sequences.

Accumulation of the marine wedges must have occurred during periods when depositional rates were considerably higher than at present, perhaps during deglaciations of the Canadian Arctic Islands, when great volumes of sediment-bearing ice are likely to have been debouched into the Arctic Ocean.

DOVER, J. H., U.S. Geol. Survey, Anchorage, AK

Tectonic Framework of Interior Alaska—A Model of Continental Margin Extension, Collapse, and Dispersion

Preliminary results of geologic mapping and structural studies raise questions about terrane accretion models as presently applied to interior Alaska and suggest an alternative model of tectonic development. Among the regional geologic patterns and problems pertinent to any model for interior Alaska are (a) the present Z-shaped configuration of the northern Cordilleran fold-and-thrust belt (CFTB), (b) the means by which 450 km of dextral strike-slip is dispersed on splays of the Tintina fault system, (c) the original continuity of the crystalline terranes of interior Alaska and their pre-Tintina Z-shaped distribution paralleling that of CFTB, and (d) the origins of two belts of deep-water deposits with mafic-igneous and locally ophiolitic associations—one outboard and the other inboard of the crystalline belt. The proposed model features (1) a relatively straight and passive North American margin with a Proterozoic to Middle Devonian sedimentary prism that underwent intermittent extension and volcanism in its distal part, (2) a Devonian-Mississippian continental arc at the outer edge of (1) and flanked cratonward by (3), an extending and rapidly subsiding basin also developed on (1) but containing Mississippian to Triassic deep-water sediments and abundant mafic-igneous material. Collapse and structural telescoping of the margin and intense reactivation of the continental arc occurred in Jurassic through Early Cretaceous time as oceanic crust converged with North America, and exotic terranes were accreted to the outboard side of arc. Oroclinal Z-bending of Cordilleran trends probably accompanied Late Cretaceous and earliest Tertiary strike-slip movement on the Tintina and other fault systems based and rearranged.

DUMOULIN, J. A., U.S. Geol. Survey, Anchorage, AK, and ANITA G. HARRIS, U.S. Geol. Survey, Washington, D.C.

Lower Paleozoic Carbonate Rocks of Baird Mountains Quadrangle, Alaska

Lower Paleozoic carbonate rocks in the Baird Mountains quadrangle form a relatively thin (about 550 m), chiefly shallow-water succession that has been imbricately thrust and metamorphosed to lower greenschist facies. Middle and Upper Cambrian rocks—the first reported from the western Brooks Range—occur in the northeastern quarter of the quadrangle, south of Angayukaqsraq (formerly Hub) Mountain. They consist of marble grading upward into thin-bedded marble/dolostone couplets and contain pelagiellid mollusks, acotretid brachiopods, and agnostid trilobites. Sedimentologic features and the Pelagiellas indicate a shallow-water depositional environment. Overlying these rocks are Lower and Middle Ordovician marble and phyllite containing graptolites and conodonts of midshelf to basinal aspect. Upper Ordovician rocks in this area are bioturbated to laminated dolostone containing warm, shallow-water conodonts.

In the Omar and Squirrel Rivers areas to the west, the Lower Ordovician carbonate rocks show striking differences in lithofacies, biofacies, and thickness. Here they are mainly dolostone with locally well-developed fenestral fabric and evaporite molds, and bioturbated to laminated orange- and gray-weathering dolomitic marble.

Upper Silurian dolostone, found near Angayukaqsraq Mountain and on the central Squirrel River, contains locally abundant corals and stromatoporoids. Devonian carbonate rocks are widely distributed in the Baird Mountains quadrangle; at least two distinct sequences have been identified. In the Omar area, Lower and Middle Devonian dolostone and marble are locally cherty and rich in megafossils. In the north-central (Nakolik River) area, Middle and Upper Devonian marble is interlayered with planar to cross-laminated quartz-carbonate metasandstone and phyllite.

DUSEL-BACON, CYNTHIA, E. F. O'ROURKE, K. E. READING, M. R. FITCH, and M. A. KLUTE, U.S. Geol. Survey, Menlo Park, CA

Metamorphic Facies Map of Alaska

A metamorphic-facies map of Alaska has been compiled, following the facies-determination scheme of the Working Group for the Cartography of the Metamorphic Belts of the World. Regionally metamorphosed rocks are divided into facies series where P/T gradients are known and into facies groups where only T is known. Metamorphic rock units also are defined by known or bracketed age(s) of metamorphism. Five regional maps have been prepared at a scale of 1:1,000,000; these maps will provide the basis for a final colored version of the map at a scale of 1:2,500,000. The maps are being prepared by the U.S. Geological Survey in cooperation with the Alaska Division of Geological and Geophysical Surveys.

Precambrian metamorphism has been documented on the Seward Peninsula, in the Baird Mountains and the northeastern Kuskokwim Mountains, and in southwestern Alaska. Pre-Ordovician metamorphism affected the rocks in central Alaska and on southern Prince of Wales Island. Mid-Paleozoic metamorphism probably affected the rocks in east-central Alaska. Most of the metamorphic belts in Alaska developed during Mesozoic or early Tertiary time in conjunction with accretion of many terranes. Examples are Jurassic metamorphism in east-central Alaska, Early Cretaceous metamorphism in the southern Brooks Range and along the rim of the Yukon-Koyukuk basin, and Late Cretaceous to early Tertiary metamorphism in the central Alaska Range. Regional thermal metamorphism was associated with multiple episodes of Cretaceous plutonism in southeastern Alaska and with early Tertiary plutonism in the Chugach Mountains. Where possible, metamorphism is related to tectonism. Meeting participants are encouraged to comment on the present version of the metamorphic facies map.

DUTRO, J. THOMAS, JR., U.S. Geol. Survey, Washington, D.C.

Revised Megafossil Biostratigraphic Zonation for Carboniferous of Northern Alaska

Carboniferous megafossils are widely distributed in the Kayak Shale and Lisburne Group throughout the northern Brooks Range. Diverse assemblages of brachiopods, corals, and mollusks, with subordinate echinoderms and bryozoans, were collected from 40 measured sections. The combined stratigraphic ranges and abundances of more than 300 species were assessed to construct a biostratigraphic zonation that can be applied regionally for correlation. Preliminary zonations, used for more than a quarter century, were revised to account for the rapidly accumulating data. The 18 assemblage zones, from youngest to oldest, are: *Umboanctus?* sp., *Corwenia jagoensis, Choristites?* sp., *Delepinoceras* sp., *Siphonodendron ignekensis, Gigantoproductus striatosulcatus-Stelechophyllum?* aff. *S.? mclareni, Goniatites americanus-Siphonodendron lisburnensis, Sciophyllum lambarti, Eumetria costata, Stelechophyllum? mclareni, Naticopsis suturicompta-Lithostrotion reiseri, Skelidorygma subcardiiformis, Spirifer tenuicostatus-Siphonodendron dutroi, Sychnoelasma konincki* s.l.-*Actinocrinites* sp., *Brachythyris choteauensis, Cryptoblastus-Pentremites, Leptagonia analoga,* and *Scalarituba-Lepidodendropsis.*

In the central and western Brooks Range, the deeper water Kuna formation contains a low-diversity fauna of mollusks and brachiopods. Goniatites are found at several levels but never more than two zones in any partial section. Regionally, these goniatite zones, from youngest to oldest, are: *Delepinoceras* (late Chesterian), *Goniatites americanus* (late Meramecian–early Chesterian), *Beyrichoceras* (early to middle Meramecian), *Ammonellipsites* (Osagean) and *Muensteroceras-Protocanites* (late Kinderhookian?).

Correlations of megafossil zones with the foraminiferal zones of Mamet are discussed. The 15 Mississippian zones have an average age-resolution of about 2 m.y. By themselves, the goniatite zones give an age-resolution of about 6 m.y. zone.

EAKINS, G. R., and J. G. CLOUGH, Alaska Div. Geol. and Geophy. Surveys, Fairbanks, AK, and J. E. CALLAHAN, M. M. MENGE, and A. C. BANET, JR., U.S. Bur. Land Management, Anchorage, AK

Coal Resources of Northwest Alaska

Rural areas in Alaska depend almost entirely on expensive imported fuel oil for heat and power generation. Following the drastic price increase in petroleum a few years ago, local governments and state agencies have shown considerable interest in determining the potential for northwest Alaska as an alternative energy source. A compilation of earlier work by the U.S. Geological Survey, Bureau of Mines, and industry located over 50 separate coal occurrences within the 50,000 mi^2 Cape Beaufort, Kobuk Valley, Seward Peninsula, and Norton Sound areas. The most promising localities were examined in the field by DGGS and BLM geologists, and six of these were selected for drilling and geophysical surveys by contractors.

Two of the areas drilled were found to have coal of sufficient quantities and quality to justify additional drilling and feasibility studies. The Cape Beaufort–Kukpowruk River area contains Cretaceous-age coal beds up to 20 ft thick and extends from the coast to about 20 mi inland. Drilling under the DGGS-USGS/MMS/BLM–administrated program indicated approximately 20 million tons in the Deadfall syncline alone, where four moderately dipping beds have a 1 to 5 stripping ratio. One 320-acre tract may contain eight million tons of bituminous coal having a 13,000 to over 14,000 Btu value as received.

The other site where work continues is the old Chicago Creek coal mine near Candle on the Seward Peninsula. The coal bed here has been traced by drilling and geophysics for 3,500 ft along strike and found to average 35 ft in thickness. While the deposit is up to 80 ft thick in one drill hole, the coal is lignite and typical of the Tertiary coals in this region, being erratic in character and averaging about 6,900 Btu/lb. Three and one-half million tons of lignite are indicated and another million tons inferred.

EDRICH, STEVEN P., BP Alaska Explor., Inc., San Francisco, CA

Geological Setting of North Slope Oil Fields, Alaska

The North Slope is a prolific hydrocarbon province in which discoveries to date amount to some 60 billion bbl of oil in place and 50 tcf of gas in place.

Reservoirs and prolific source rocks occur throughout the stratigraphic column, which consists of a lower (or Ellesmerian) megasequence of Carboniferous to Jurassic age and an upper (or Brookian) megasequence of Early Cretaceous to Recent age. Discovered oil is almost equally divided between Ellesmerian and Brookian reservoirs.

Patterns of hydrocarbon generation and migration have been controlled by deposition of clastic sedimentary wedges derived from the Brooks Range orogen. In the Late Jurassic to Early Cretaceous, the main oil kitchen was located in the Western Colville trough. Clastic depocenters and associated kitchen areas migrated progressively eastward with time and are now located in the East Beaufort offshore. Important source rocks include the Jurassic Kingak and Late Triassic Shublik Formations of the Ellesmerian megasequence, and the Aptian-Cenomanian "HRZ" and Turonian-Paleocene Shale Wall formations of the Brookian megasequence.

In the Ellesmerian megasequence, productive reservoirs are known at several stratigraphic levels, with best reservoir properties associated with secondary porosity development in subcrop beneath a mid-Hauterivian unconformity.

The Kekiktuk Formation (Mississippian), oil- and gas-bearing in the Endicott field (ca. 1 billion STBOIP), is a fluvially dominated unit, locally deposited in fault-controlled basins. The Lisburne Group (Mississippian to Early Permian) contains oil in the Lisburne pool of the Prudhoe area (?2-3 billion STBOIP). The reservoir is primarily early diagenetic dolomites within a thick platform carbonate sequence.

The major reservoir on the North Slope is the Early Triassic Ivishak Formation, reservoir to the Prudhoe field (22 STBOIP), the Seal Island discovery (?1 billion STBOIP), and target in the recent Mukluk well. Sands and conglomerates were deposited by a series of alluvial fan deltas shed from a nearby northern landmass.

Arctic Ocean rift events culminated in mid-Hauterivian continental breakup, which generated the subcrop unconformity of the rift margin uplift. Post-unconformity sands associated with local erosion of Elles-