indicative of the extreme youth of large parts of the Arctic Ocean and of the formation of the ocean by oceanization of continental crust as a result of large vertical subsidence movements.

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MESOZOIC STRATIGRAPHY, SEDIMENTOLOGY, AND PALEOGEOGRAPHY OF NORTHERN YUKON, CANADA

Data derived from reconnaissance field work in 1962 and published data indicate that the Mesozoic succession is divided into 5 major cycles which reflect important events in the geologic history of the region: (1) Late Triassic transgression across a low shelf; (2) widespread Jurassic transgression and development of the Richardson trough; (3) earliest Cretaceous regression and basin filling that ended with local minor(?) uplift and erosion; (4) Albian transgression and development of the early Late Cretaceous regression; and (5) Late Cretaceous and early Tertiary nonmarine sedimentation in local tectonic basins. Within each of these major cycles several diastems and unconformities are present which increase in magnitude toward the basins' margins.

During Jurassic and earliest Cretaceous times, the Richardson basin was filled with marine shale and bordered on the east by a landmass (probably mountainous) which shed sand westward. The sands now form a series of Lower, Middle, and Upper Jurassic and Lower Cretaceous nearshore sandstone bodies. During the earliest Cretaceous some sand in the Babbage River region was derived from the underlying Mesozoic and upper Paleozoic clastic sediments in the western Brooks Range geanticline.

The earliest Cretaceous clastics filled the basin so that nonmarine conditions prevailed in the northernmost (Blow River) part. Moreover, slight uplift and erosion took place at that time. By the end of Aptian time, much of the eastern landmass had been peneplaned.

The tectonic and sedimentary patterns changed drastically during Albian to early Tertiary times. Sediments were derived from a rising cordillera which formed the western and southern margins of the new foreland basin and developed across the previous eastern Jurassic and Lower Cretaceous landmass. A thick succession of largely silty Albian shale was deposited in this basin. The thin Upper Cretaceous sedimentary sequence consists of nonmarine strata (Eagle Plain Formation) and marine shale. Much of the deformation and uplift of the Richardson Mountains took place during middle Late Cretaceous time. During the late stages of the cordillera deformation on the south and southwest, several small, partly fault-bounded basins developed in which thick sequences of coarse clastic materials were deposited.

A similar but thicker Mesozoic succession appears to extend beneath the Mackenzie delta. One of the best prospective hydrocarbon zones is the sequence of well-sorted sandstones near the base of the Lower Cretaceous, if these sandstones do not grade to shale on the north.

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SEDIMENTARY PROCESSES IN ARCTIC OCEAN

Two unusual Arctic Ocean sedimentary processes involve deposition of clay-size particles and deposition of glacial-marine erratics. The clay suite identified by X-ray diffraction in 50 cores from the Chukchi Rise and Alpha Cordillera consists mainly of illite with almost equal combined amounts of chlorite and kaolinite. Similar clays are present in atmospheric dust in permanent snow fields of northern Greenland. In addition, dust separated from snow samples of the Arctic ice pack contains these same clay minerals. This dust finds its way into leads during summer melting where it contributes an estimated 0.4 mm of sediment per 1,000 years. This is almost ½ of the total sedimentation rate for parts of the Arctic and up to 90% of the 2-μ size fraction sediment.

Pebbles have been found in 36 cores. Few striations have been noted but ice rafting is a believable mechanism to explain pebbles in the central Arctic Ocean. Twenty-three cores contain erratics at more than 1 level and as many as 7 are present in 300-cm cores; 38% are sandstone, 29% carbonate, 15% metamorphic, and 18% chert or unidentified clasts.

Distribution of the erratics shows no pattern that can be explained by known currents or events in time. Erratics are present in brown cores but no erratic has been found in gray cores. Turbidity structures characterized some of the gray cores. Probably, erratics were deposited randomly over most of the Arctic basin from melting glacial ice, but they appear to be less common in deeper parts of the ocean (Canada plain) where high sedimentation rates associated with turbidity flows mask their presence.

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TEXTURE, ORGANIC CARBON, AND CLAY MINERALOGY OF WESTERN BEAUFORT SEA SEDIMENTS

In the western Beaufort Sea the shelf sediments differ significantly from the slope and basin sediments in texture and in carbon and carbonate contents. The shelf is generally carpeted by positively skewed, platykurtic gravelly, sandy mud, whereas the slope and basin mostly have sandy or clean mud with symmetric and mesokurtic size-distribution curves. The predominance of muddy gravels on the shelf suggests that ice-rafting is important in transporting sediment to this region. Possibly the presence of the permanent pack ice across the slope and basin acts as an effective barrier for the movement of ice-rafted gravels to those regions. Probably the well-sorted and rounded sands associated with the slope and basin muds have been transported by turbidity currents from the shelf margin, where it is believed they were deposited originally under turbulent conditions during geologically recent lowered sea levels.

The shelf sediments have relatively lower organic carbon contents (average, 0.95%) than those of the slope and basin (average, 1.19%). However, the amount of carbonate in the shelf is higher (average, 4.8%) than in the slope and basin (average, 2.75%). The organic content is related to the clay percent whereas the carbonate content is related to the amount of calcareous shelly and lithogenous components.

Clay mineral composition of the less than 2- and 4-μ sediment sizes consists predominantly of illite with significant amounts of kaolinite and almost no chlorite. It is suggested that the use of clay minerals in the inference of paleoclimates must be made with great caution because the generally accepted view related to marine sediments is that kaolinite is a "low latitude" clay mineral and chlorite a "high latitude" one.

Concentrations of uranium in the sediments range from 0.75 to 5.0 ppm and their variations seem to have no relation to the texture, organic carbon content, or clay mineralogy of the sediments.

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LATE CENOZOIC HISTORY OF DEPOSITION OF NORTHERN BERING SHELF

The diverse topography and sediment types of the northern Bering shelf owe their origin to a combination of tectonic activity, subaerial processes during lowered sea level, and present marine processes. Late Cenozoic to recent tectonic expression is evident in nearshore regions, particularly (1) along southwestern Seward Peninsula, where faulting and folding affect sea-floor bedrock and relict gravel distribution and the major northward sea valley and subaerial drainage pathways and (2) off central St. Lawrence Island, where lava flows and plugs disrupt morphology of a structural seafloor depression.

During lowered sea levels of the Quaternary, Siberian glaciers pushing up to 150 km beyond the present shoreline deposited a series of morainal ridges now exposed as linear gravel bars that extend southward from Bering Strait and northward from St. Lawrence Island. Other early to middle Pleistocene local valley glaciers pushed debris a few kilometers off the coast of Seward Peninsula; subsequent reworking by shoreline transgressions and regressions has left these as nearshore patches of partly auriferous relict gravels. Shorelines of lower sea levels also formed beach ridges that are evident as linear topographic scarps, ridges, and constructional lenses of sorted, rounded, shelly, and oxidized coarse sands and gravels.

During the Holocene and other Quaternary periods of high sea levels strong currents affected the sea-floor shape and sediment distribution, particularly in the Bering and Anadyr Straits, where relict gravels and hummocky topography of apparent glacial origin remain exposed. On the lee side of such current-swept channels, slackening currents have deposited sediments forming shoals such as those north of Cape Prince of Wales and Northeast Cape. Except for the Siberian morainal ridges, nearshore areas, and straits regions, where current scour preserves surface relict gravels, most of the northern Bering sea floor has a thin cover of Holocene transgressive fine marine sands.

Holocene Yukon sediments are deposited as interlaminated fine sand and clayey silt, up to 60 km off the delta, and around Norton Sound where sediment has been ponded by the modern current regime. Ancient, buried depositional wedges of Yukon sediment apparently extended farther west and account for the smoother topography that is found within 200 km of the modern delta. Limited Holocene deposits, extensive subaerial topography, and common relict sediments suggest that during periods of high sea level, Yukon and other contemporaneous sediment are swept from most of northern Bering Sea by the strong northward currents. The great canyons of the Bering continental margin suggest a southward transport of Yukon sediment during low sea levels. This apparent past and present movement of Yukon sediment may explain the general lack of modern sediments in northern Bering Sea and presence of Holocene deposits on the epicontinental shelves in the north and south.

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APPLICATION OF ACOUSTICS TO DETERMINATION OF PERMAFROST DISTRIBUTION

During the past several years, interest in the Arctic region as a source of petroleum has developed, spurred by the discovery of the North Slope petroleum deposits. A major problem involves the engineering properties and stability of frozen ground subjected to load-bearing stresses and the addition of heat from structures and heated pipelines.

Acoustic data-acquisition systems, coupled with sophisticated processing, reduction, and analysis techniques, are used to determine the permafrost and/or seasonal ice distribution in the subsurface. Oceans International has evolved techniques for the acquisition of valid data.

Sophisticated data-analysis techniques, which have been proved in other disciplines, such as aerospace telemetry and communications theory, are being applied to both the more general geophysical problem, and the specific permafrost-ground-ice problem.

The reduced, analyzed data which have been developed, can be used to determine, measure, and evaluate those parameters which are most important in delineating permafrost. It is important that the analyzed data be displayed in both gross and detailed formats for proper understanding.

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DEVONIAN (OLD RED SANDSTONE) SEDIMENTATION AND TECTONICS OF NORWAY

Lower and Middle Devonian continental redbeds in Norway record the deposition of coarse clastic fluvial sediments in a series of separate intramontane basins. Contemporaneous uplifting of surrounding provenance areas resulted in the deposition of breccias, conglomerates, and sandstones as thick coalescing alluvial fans and stream deposits in E-W-trending grabens and half-grabens. The largest of the structurally formed basins covers an area of approximately 2,000 sq km and has a maximum preserved continuous Devonian section of approximately 5,000 m.

Devonian rocks crop out in four parts of Norway: (1) 6 basins along the west coast north of Bergen thought to contain Middle Devonian sediments; (2) several isolated areas west of Trondheim thought to be primarily Early Devonian; (3) a small outlier of very coarse Lower Devonian sediments in eastern Norway near Røragen; and (4) redbeds of probable Early Devonian age near Oslo. Fossils are scarce and include plants, crustaceans, and Crossopterygian vertebrates.

The Devonian basins in western Norway developed in the former eugeosynclinal part of the Caledonian geosyncline, which underwent major orogeny and uplift during the Late Silurian and Early Devonian. This uplift resulted in the formation of a major NE-SE-SW-trending mountain system, which supplied abundant and varied detritus to the Devonian intramontane basins, including eugeosynclinal metasediments and metavolcanics, high-grade metamorphic schists, gneisses and amphibolites, and diverse mafic and felsic intrusive igneous rocks.

Postdepositional folding and faulting have obscured the original basin margins; the Devonian sediments presently form a series of E-W-trending anticlines and synclines that have locally been thrust over surround-