ble, normal paraffins also have disappeared in the degraded zone. Biodegradation may be a plausible explanation for this additional phenomenon.

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Quaternary Paleoclimatic Variations

Ratios of Antarctic radiolarians, *Spongotrochus glacialis* and *Lithelius nautiloides,* to the subantarctic radiolarians, *Lithamphora furcaspiculata* and *Theocalyptra bicornis,* define at least 4 major cold intervals within the Brunhes Normal Magnetic Epoch, with a temperature range from less than 0 to about 5°C. In tropical areas, cooler temperatures of the Brunhes are suggested by the marked decline of *Sphaeroidinella dehiscens* and an increase in temperate species.

In the Antarctic area, temperate species of radiolarians such as *Eucyrtidium acuminatum, Lamprocyclas maritalis,* and *Saturnulus planetes* reflect generally somewhat warmer conditions in the Matuyama than during most of the Brunhes; variations in their abundances suggest perhaps 5 warmer cycles above the base of the Gilsa event with a range between about 5 and 15°C. In tropical areas, warmer temperatures are indicated by the common occurrences of *Sphaeroidinella dehiscens* and the absence or very uncommon occurrences of temperate species.

In temperate parts of the circum-Pacific area, the origin and development of *Globorotalia truncatulinoides* and the extinction of discoasters occurred long before the influx of polar populations of *Turborotalia pachyderma.* Thus, the base of the Pleistocene as defined by these events indicates that the Pliocene-Pleistocene boundary must be within the upper part of strata previously referred to as upper Pliocene in California. It is postulated that the subsequent major cooling indicated by the influx of sinistrally coiled populations of *Turborotalia pachyderma* is near the Brunhes-Matuyama boundary and may be near the base of the classic glacial Pleistocene.

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Depositional Environments of Muddy Reservoir Sandstones (Lower Cretaceous) in Powder River Basin, Montana and Wyoming

Lower Cretaceous Muddy Sandstone forms stratigraphic traps in the northeast Powder River basin. The most productive reservoirs are local concentrations of clean, quartzose sandstones deposited in linear bodies as marine bars. Sediment supply to the bars was accomplished by transverse sedimentation from associated fluviodeltaic environments.

Two distinct marine bar types may be recognized: (1) regressive, interdeltaic barrier bars, and (2) transgressive, delta-destructional bars. In regressive bars, grain size increases upward, and subenvironments which may be recognized include, in ascending order, lower shoreface, middle shoreface, upper shoreface-beach, and eolian. In transgressive bars, the vertical sequence of grain size and subenvironments is reversed with grain size decreasing upward, and subenvironments generally commencing with middle shoreface and succeeded upward by lower shoreface. Both bar varieties have prominent lagoonal or tidal-flat deposits as lateral equivalents. These fine-grained, back-bar sediments act as effective barriers to updip petroleum migration.

Transgressive bars are associated closely with typical fluviodeltaic deposits which they may succeed, laterally or vertically, in close succession. Therefore, they are interpreted as delta-destructional bars. Regressive bars, however, are laterally and vertically removed from the main sites of delta construction, and are interpreted to be typical coastal, interdeltaic deposits.

Although fluviodeltaic sandstones are local sources for bar sands, they are mineralogically quite distinct. Significant quantities of rock fragments and clay-rich matrix reduce the relative quartz content. Therefore, porosity and permeability values are low and, despite the fact that the fluviodeltaic sandstones are locally thick, they form less productive reservoirs.

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Expanded Need for Mineral Economics in Exploration for Metals

One of the most prominent manifestations of changing trends in exploration for metals is a more common participation by the geologist in mineral economics. There are at least three new aspects of exploration in which this involvement is expressed. 1. Increased competition and new entries in mineral exploration are challenging the traditional conservative approach to exploration by mining companies. A new philosophy introduced primarily by oil companies tends to increase costs and accelerate the tempo of exploration thereby changing the total economics of many programs of mineral exploitation. 2. The broadening commodity interests of many companies have utilized the varied backgrounds of exploration geologists in preparation of commodity evaluations and forecasts. Many geologists are now providing advice and background to guide corporate decisions regarding new commodity ventures. 3. The mining industry is confronted with a new set of costs that are now part of the economics of any operation. These may be considered to be environment-control factors and are related to restoration of mined-out areas and water- and air-pollution controls.

To function efficiently in mineral economics, the geologist must establish and maintain a flow of communication with all subdivisions of his company and with people in other professions and disciplines, such as engineering, accounting, sales, metallurgy, chemistry, and economics. It is also vital that he present his ideas and conclusions in a manner meaningful to management.

Finally, one of the major needs of the exploration geologist is the availability of educational facilities in mineral economics.

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Petrography and Origin of Krol Sandstones Around Solon, Northwestern Himalaya, India

The area around Solon (lat. 30° 55′; long. 77° 07′) in northwestern sub-Himalaya, India, is the type area of the Krol Group (Permo-Carboniferous?). Petrologically the Krol sandstones may be designated as coarse- to medium-grained sandstone: mature quartz and carbonate-cemented quartz arenite (Folk, 1966). Conspicuous presence of round grains of quartz led earlier workers to conceive of an eolian origin for these sandstones. Petrologic examination of the sandstone shows moderate amounts of different sedimentary rock fragments, no relation between size and roundness, and different degrees of roundness in the same size grade. All these features indicate the possibility of their derivation from preexisting rocks. To resolve the problem of origin of roundness, *i.e.*, "eolian" versus "inherited," size analyses of the rounded and well-rounded grains, assumed to represent the airborne fraction, yield a mean size of 0.466 ϕ. This value does not correspond to the size of the airborne load, as specified by Bagnold, nor does it correspond to the grain-size characteristics of the bimodal sands that are residuum in the eolian process. Thus the roundness of the Krol sandgrains is not from eolian action but is caused by the derivation of the sand grains from preexisting sandstone. In addition to the presence of glauconite, their close association with intraclastic, oolitic, and pelletiferous carbonate rocks indicates a shallow-marine origin for these sandstone beds.

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Geomorphology of Reef Complexes

Quaternary reef complexes are primarily Darwinian oceanic or shelf reefs on slowly subsiding foundations. "Glacial control" of reef morphology has been important, but not in the sense that Daly visualized. Corals dated by the uranium-series method prove that many, perhaps most, reefs were not truncated at the low sea levels of the last glacial age. Dates from such scattered and classic reef localities as Western Australia, the Tuamotu Archipelago, Eniwetok Atoll, the Florida Keys, the Bahamas, and Barbados demonstrate that reef limestones and eolianites can be emerged for 100,000 years or more, several hundred feet above the glacially lowered sea, without being dissolved away. The permeability of reef frameworks is the major reason for their durability under subaerial tropical weathering. Although Pleistocene and older reefs were not eroded to sea level during glacial ages, the extensive drowned karst topography on them, as identified from Florida, Bermuda, the Bahamas, and the Marshall Islands, probably has been a primary control in the postglacial evolution of modern reef complexes.

Reef growth probably was not suppressed, in the tropical Pacific at least, during glacial low sea levels. Recent calculations of the change in O^{18} isotopic composition of seawater by continental ice sheets minimize the effect attributable to cooling of the sea surface. The central Pacific was neither too cold nor too turbid for coral-reef development even during a full glacial age. Pelagic carbonate productivity in the equatorial Pacific actually increased during glacial ages, and it is likely that reefs flourished on the exposed flanks of emerged atolls. The steep flanks of reef-rimmed Pacific islands and atolls may provide evidence by which we can measure the true Pleistocene fluctuations of sea level, and thereby infer the amount of Quaternary warping of continental shelves.

The concept that postglacial sea level higher than the present is necessary to cause modern reef morphology needs to be rigorously reexamined. Rather than being relict from a "10-ft stand of the sea" a few thousand years ago, modern reefs show every indication of being in dynamic equilibrium with the forces that now act on them. Modern reef-building organisms have reoccupied the weathered surfaces of reef limestones that have been exposed for nearly 100,000 years and have veneered the tops of ancient atolls or eolianite dune fields. As the postglacial rise of sea level has approached its present level, upward growth has slowed and reefs have expanded laterally to resharpen the precipitous upper slopes of eroded ancient platforms. Primary productivity by reef builders is generally adequate to keep pace with rising sea level but, at several localities, atolls were "drowned" and have not reached present sea level and may be in the process of being preserved.

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Recent Braided-Stream Sedimentation, South-Central, Alaska

The Scott Glacier outwash fan, in the Copper River delta area, Alaska, shows a progressive decrease in grain-size and slope away from the glacier terminus. Bar and channel morphology change systematically from proximal to distal areas.

Detailed study along a 12-km tract shows that average clast size on bar surfaces decreases downfan from 30 to 3 cm, and slope decreases from a maximum of 15.5 m/km to 2.0 m/km. Upstream, bars are present between channels in sheetlike deposits; downstream, bars are present largely in mid-channel. Bars are composed of poorly sorted, well-imbricated coarse to fine gravel and plane-bedded, better sorted sand. Plane-bedded sand is more abundant in distal areas and may be capped by small-scale cross-bedding.

Cobble and pebble imbrications are the most persistent and reliable indicators of flow direction. Modal dip direction is upstream with long axes transverse to current flow. Other directional features measured included lineations, ripples, bar slipfaces, and logs. Linear stripes of large pebbles, which are oriented transverse to flow direction (determined from pebble imbrication) and occur in groups on bar surfaces, are interpreted as relict antidune bedforms.

Most deposition, which occurs during high-water stages, takes place on bar surfaces under upper flow-regime conditions. Flow separation along bar edges allows avalanche slipfaces to form. During low-water stages, when flow is mostly confined to channels, lateral erosion removes bar deposits and some channel deposition occurs under lower flow-regime conditions.

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Triassic Carbonate Buildups of The Dolomites, Northern Italy

In the Middle Triassic of the Dolomites of northern Italy thick carbonate bodies (1,000 m) of relatively restricted extension are surrounded, and in places covered, by volcanic rocks and clastic sediments. These bodies, characterized at the periphery by inclined beds dipping basinward (15-35°), are formed by massive carbonates, mostly crystalline dolomite (Schlern Dolomite); in many places the massive facies is replaced laterally by stratified carbonate rocks. Organisms in the massive dolomite are uncommon (some corals, a few pelecypods and crinoidal plates) and poorly preserved; in the massive limestones and in the bedded carbonate rocks, calcareous algae, crinoids, mollusks, rare corals, foraminifers, and ostracods are present. The central part of the buildups lies directly on a biostromal blanket dolomite (Serla Dolomite) which extends throughout the region. A sequence of cherty micritic limestone (Livinallongo Formation) in places nodular or bitumi-