changes within the Madera and Sangre de Cristo Formations, overlap of the Crestone Conglomerate onto Precambrian rocks, and the presence of unconformities within the late Paleozoic section indicate that several faults in the Crestone (Sangre de Cristo Range) and southern Wet Mountain areas were displaced significantly in the late Paleozoic.

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DISPLACEMENTS ACROSS, AND STRAIN IN, OROGENIC BELTS

The production of accurate palinspastic maps demands knowledge of displacements across orogenic belts. Traditionally this has involved attempts to measure linear crustal strains (ϵ) across orogenic belts by fabric studies, unraveling folds, unscrambling thrusted superposed facies, *etc.* The inherent problems of this approach (*e.g.*, distinguishing between stratal and crustal shortening) and the consequent difficulties of making meaningful strain measurements are minor compared with the complexities imposed by relating orogenic strain to displacements across consuming plate boundaries. It is possible in a general way to convert relative plate displacements (D) and displacement rates ($\dot{D}$) directly into gross shortening and shortening rate values across a particular Mesozoic-Tertiary orogen (*e.g.*, Mediterranean fold belt). This has little meaning, however, for ϵ and $\dot{\epsilon}$ values in orogens for the following reasons. 1. Relative plate displacement vectors change with time. 2. Most of D is not converted into orogenic crustal strain, but is lost by subduction. Only where continental collision has occurred is there a chance that ϵ and $\dot{\epsilon}$ are direct functions of D and $\dot{D}$. 3. ϵ and $\dot{\epsilon}$ may be related to second-order consequences of plate motion; for example, high-level spreading and gliding of marginal nappes. 4. Mechanically significant rates depend upon determining instantaneous $\dot{\epsilon}$ and this in turn depends on the width of a zone deforming homogeneously at an instant of time. Using Le Pichon's $\dot{D}$ values across the Alpine Himalayan fold belt, $\dot{\epsilon}$ values vary from 1.27 × 10[illegible] (ϵ concentrated in Indus suture) to 1.59 × 10[illegible] (ϵ across 900 km wide seismic belt from the Zagros crush zone to the Caspian Sea). These rates are far slower than rates (5 × 10[illegible] —10[illegible]) at which ductile strains have been achieved in laboratory experiments. Brittle and semi-brittle structural behavior is common in orogenic belts and suggests that natural instantaneous $\dot{\epsilon}$ values are much higher than those calculated from $\dot{D}$. This may be a function of ϵ being concentrated instantaneously in narrow fault zones or, by incremental strain propagation, across a particular zone. Even these factors, though, do not seem to modify $\dot{\epsilon}$ enough (*e.g.*, in a 1-cm wide thrust zone in the Himalayas where $\dot{D}$ = 5.6 cm/yr., $\dot{\epsilon}$ = 1.8 × 10[illegible]). Yet, brittle deformation is evidenced by shallow earthquakes suggesting either that ϵ is concentrated along hairline fractures or that large strain accumulations precede rupture. Orogenic strains, however, are small compared with displacements across orogenic belts. The displacements can only be calculated from oceanic magnetic anomaly fitting and, less accurately, from paleomagnetic data from stable forelands and cratons.

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INJECTION WELLS AND OPERATIONS TODAY

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CONICAL-COLUMNAR STROMATOLITES AND SUBTIDAL ENVIRONMENT

Several distinct varieties of stromatolites are present in dolostones of the Proterozoic Dismal Lakes Group, Great Bear Lake region, Northwest Territories. Comparison of the stromatolite types with respect to abundance of associated sedimentary structures (cross-laminations, ripple marks, oolites, desiccation cracks, evaporite casts, intraformational conglomerates) supports the concept that stromatolite morphology is closely related to environment. As in modern analogues, water turbulence appears to be a particularly significant determinant of morphology.

On the basis of textures, associated sedimentary structures, and comparison with modern algal stromatolites, most stromatolites of the Dismal Lakes Group appear to have formed in either supratidal or intertidal environments. However, conical-columnar stromatolites ("Conophyton"), for which a modern analogue is lacking, are confined largely to a prominent dolostone unit in which sedimentary structures indicative of turbulence are almost totally absent. The paucity of such structures, coupled with consideration of the stromatolite morphology during growth, suggests that conical-columnar stromatolites may be characteristic of a subtidal environment. Maintenance of a vast field of conical surfaces in an intertidal or supratidal environment without reduction or fragmentation of the apices seems unlikely.

The relation of the conical-columnar stromatolites to flat-bedded subjacent strata renders interpretation of origin by deformation untenable, and continuity of lamination within and between the columns refutes a diagenetic origin. The Dismal Lakes dolostone unit consisting mainly of conical-columnar stromatolites is interpreted as a Proterozoic subtidal algal reef of unusual persistence in space and time.

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MODEL OF CRETACEOUS PALEOGEOGRAPHY AND ITS CONSEQUENCES

Growing acceptance of continental drift as expressed in the plate tectonics model leads to consideration of its use as a basis for investigating certain aspects of paleogeography and paleobiogeography. As a first step the geophysical, stratigraphic, and paleontologic data for the Cretaceous, with particular reference to mid-Cretaceous events were examined.

The final separation of South America and South Africa dates from about Aptian Albian time, which implies that the Mid-Atlantic Ridge as a relief feature dates from about that time. Unless there was compensating downwarping a change in the volume of the oceanic basins would occur. The stratigraphic records of Africa, North America, and Western Europe show that the major transgressive and regressive movements are synchronous and that a major transgression began about that time, perhaps reflecting the ridge activity.

Major changes can be seen in the biogeography of mollusks, forams, and other groups between the Early and Late Cretaceous. Pre-Albian marine faunas in the Pacific regions are linked by a large number of taxa with faunas in the Atlantic-Mediterranean region. After the mid-Cretaceous there is a reduction in the cosmopolitan aspect and more intense provincialism. The biogeographic changes appear related to changing ocean basin configuration and initiation of the break-up of the circum-equatorial Tethys.

In the present preliminary phase of investigation firm conclusions cannot be drawn, but the convergence of such diverse approaches encourages the interpretation that ridge activity caused mid-Cretaceous biogeographic changes.

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APPLICATION OF OIL CORRELATION AND SOURCE-ROCK DATA TO EXPLORATION IN WILLISTON BASIN

Most Williston basin oils belong to one of two basic types: (1) a lower Paleozoic type believed to have originated in Winnipeg shales and found predominantly in Ordovician and Silurian reservoirs, and (2) a Mississippian type expelled primarily from Bakken shales and produced mostly from Madison reservoirs. The two types are isolated vertically by evaporites but commonly are mixed beyond the evaporite limits in basin margin areas.

Both oil types can be related to their source facies. Lithofacies maps of these source sequences, when combined with diagenesis determinations, provide source-area definition. The time of expulsion and volume of expelled oil from each source can be calculated. Paleostructure maps and carrier-bed isopachs indicate the direction and extent of secondary migration, both horizontally and vertically from the source area. Ultimately, the subsurface distribution of each oil type is predicted, to define high-grade areas in which to concentrate exploration activity.

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DISCRIMINATION FUNCTION ANALYSIS AND BAYESIAN CLASSIFICATION APPROACH TO MUDDY SANDSTONE EXPLORATION, WYOMING

Stratigraphically trapped petroleum deposits occurring in the Muddy Formation of Campbell County, Wyoming, were studied by using discriminant function analysis followed by Bayesian classification analysis. The data used in this study were obtained from over 600 productive and nonproductive wells in a 720-sq mi area.

A total of 15 quantitative measures (variables) of lithology, porosity, and salinity were computed from the S.P., gamma ray, and density logs from each well. Discriminant and Bayesian classification analyses were used to compute discriminant and probability maps. Discriminant-scores maps were made by two methods: (1) using the total data set of both productive and nonproductive wells, and (2) using only the nonproductive wells. The second type of map more closely simulates the exploration situation.

A map showing probability of oil occurrence was constructed by first partitioning the study area into 64 cells of 9 sq mi each, and then establishing a control area and a test area. In the control area the cells were divided into productive and nonproductive subsets; a discriminant function then was computed. The discriminant function derived from the control area was used as the input for a Bayesian classification procedure to compute probabilities of petroleum occurrence in the test area. The predictions made by the statistical analyses are compared to the actual production in the test area.

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NORTH SEA BASINAL AREA, EUROPE—IMPORTANT OIL AND GAS PROVINCE

The North Sea covers the offshore part of a major sedimentary basin which extends from Norway, Scotland, and Denmark across northern Germany and the Netherlands into eastern England.

Information gained from exploration efforts over the last 10 years shows that the North Sea covers several smaller sedimentary and structural basins of different geologic ages, but for descriptive purposes these can be divided into southern and northern areas. The rocks range in age from Paleozoic to Tertiary and consist of sandstone, shale, carbonate rock, and evaporite. The most important reservoir rocks are the Lower Permian sandstones of the Rotliegendes Formation, the Upper Permian dolomites of the Zechstein Formation, the Triassic sandstone of the Bunter Formation, the Maestrichtian-Danian chalk, and Paleocene and Eocene sandstones. Significant shows of hydrocarbons have been found in 9 formations. The main source rocks are Carboniferous coal measures, Mesozoic shale and carbonates, and Tertiary shale and carbonates. The significant traps are folds and fault blocks associated with salt movement and basement faulting.

Exploration activity received its initial impetus in 1959 from the discovery of a major gas field, Schlochteren, onshore in northern Netherlands. In the early 1960s the passing of legislation favorable for the acquisition of exploration acreage offshore added further stimulus to the exploration pace. The majority of this activity was concentrated initially in the southern area, and resulted in the discovery of the first offshore commercial gas field at West Sole in 1965. This discovery was followed rapidly by other gas discoveries in the United Kingdom and the Netherlands culminating in the Leman Bank field, a major gas field by world standards. Interest and activity lagged, however, in the northern area despite reported small oil and gas discoveries in Denmark, and the discovery in 1968 of the Cod gas-condensate field in Norway. In late 1969, oil production was established at the Ekofisk field in Norway. With this discovery and subsequent confirmation as a major field, exploratory interest has shifted to the north.

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BIOMERIZATION: ECOLOGIC THEORY OF PROVINCIAL DIFFERENTIATION WITH EXAMPLES FROM MODERN AND FOSSIL BIOTAS

Modern biotic provinces are centers of endemism surrounded by zones of coincidence of broad-ranged species. Provinces form coherent units of association above the community level. Superimposed ranges are used to construct a surface contoured for provincial diversity. Provincial boundaries overlap. Frequencies of provincial components along boundaries vary from season to season. Relict provinces survive in these zones.

Biomeres, as chronologic provincial units, are transgressive and regressive, and exhibit complex intertonguing in boundary regions. Faunal and floral zonal sequences are replicable within the biomere, but are complicated by inversion and recurrence along boundaries. These anomalies are useful in locating boundary zones.

Provinciality is due to homeostasis of the ecosystem and is proportional to diversity. Terrestrial biota is more provincial than marine biota.

A biomere appears as a pioneer biota under new conditions. It differentiates about centers of habitat di-