mation of the marginal ridge can account for nearly 40 percent of the theoretical crustal shortening between the Juan de Fuca and North American plates. Seismic profiles also indicate that accretion of Cascadia basin turbidites along the continental margin occurred during the Pliocene-Pleistocene and has continued to the present.

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PALEOCLIMATIC INTERPRETATIONS FOR LATE MIOCENE OF CALIFORNIA BASED ON MARINE DIATOMS

The diatom assemblages of a 1,600-ft section of diatomites in the Monterey and Sisquoc Formations near Lompoc, California, give evidence of a warming trend within the late Miocene. Frequency changes of individual warm and cold water species, ratios of different ecologic types, and variations in the overall assemblage indicate a general increase in temperature during the period of deposition. The lower third of the section (upper Mohnian Stage) contains a cool-temperate microflora, characterized by relatively high frequencies of *Denticula hustedtii* Simonsen and Kanaya. A mixed warm- and cold-temperate assemblage predominates through the overlying 1,000 ft of diatomites, and the highest 80 ft (Delmontian Stage?) contains a warm-temperate microflora, with *Coscinodiscus excentricus* Ehrenberg, *C. lineatus* Ehrenberg, *Thalassionema nitzschioides* Grunow, and *Thalassiosira* sp.

Diatom evidence for these temperature changes is further supported by that from the fossil fish and sparse Foraminifera of the Lompoc section. The changes may reflect a general climatic warming, but also may result from local variations in current distribution, such as the fluctuations in the cold-water California Current proposed for the late Miocene of southern California. Diatoms may provide valuable paleoecologic evidence for this extensive diatomite facies in California, which lacks the more commonly utilized foraminiferal and invertebrate paleoecologic indicators.

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CORRELATION OF MARINE AND CONTINENTAL PLIOCENE DEPOSITS IN NORTHERN CALIFORNIA BY TEPHROCHRONOLOGY

Recent reconnaissance of the Tertiary rocks of the Coast Ranges north of San Francisco Bay, together with trace-element studies and K-Ar dating of the associated tuffs, has necessitated revision of the age assignments and correlations of some units. Previous workers generally have held that the Merced(?) Formation of Sonoma County interfingers laterally with the Sonoma Volcanics, which in turn unconformably overlie the Petaluma Formation. Age assignments have varied, but most recent workers assign the Merced(?) Formation and the Sonoma Volcanics to the late Pliocene and the Petaluma Formation to the middle Pliocene. We have determined that most of the molluscan collections from the Merced(?) Formation are late Pliocene, but at least 2 are older (early Pliocene in terms of a twofold provincial division of the epoch). Hemphillian and Blancan vertebrates reported from 7 localities in the Petaluma Formation, indicate an early or middle Pliocene and late Pliocene age, respectively, for this formation, in terms of the nonmarine chronology. A pumiceous, vitric-crystal tuff in the Merced(?) Formation occurs stratigraphically between the early and late Pliocene molluscan localities. This tuff has been dated by the K-Ar method at 5.9 m.y., and has been correlated by trace-element "fingerprinting" (using X-ray fluorescence on the glass) with a petrologically similar tuff in the Petaluma Formation. This dating confirms the correlation of early and late Pliocene mollusks with Hemphillian and Blancan mammals, and suggests a provincial early Pliocene-late Pliocene boundary of about 6 m.y.

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SUBANDEAN BASIN OIL FIELDS, ECUADOR AND COLOMBIA

The Subandean basin of Colombia and Ecuador covers an area of approximately 50,000 sq mi, and is part of a foreland which extends from the Guyana shield to the Andes Mountains. The present structural basin is asymmetric and plunges toward the south. More than 30,000 ft of Paleozoic to Tertiary sedimentary rocks are present. During the Early Cretaceous, a marine transgression buried a basal sandstone member (Caballos in Colombia, Hollin in Ecuador). Later fluctuations in sea level resulted in deposition of marginal marine-fluvial sandstones of the Upper Cretaceous. Major petroleum reserves are trapped in large anticlines and faulted structures in these Cretaceous sandstones.

Texaco began exploration for petroleum reserves in the trackless jungles of the Upper Amazon region of South America in 1941. During the early 1940s, the Orito anticline was discovered and mapped in detail by geologic field parties. In 1963, the decision to drill Orito was made, and Texaco acquired an aggressive partner, Gulf Oil, which earned one-half interest in the Texaco holdings by drilling the Orito No. 1 discovery well.

Following the Orito field discovery, exploration was accelerated and geophysical exploration began in 1965 with air magnetics and analogic seismic work. The helicopter gave support to portable geophysical crews, and later the helirig opened the entire area for exploratory drilling. The helicopter also figured prominently in the subsequent construction of two pipelines across the Andes Mountains.

Production began in Ecuador in August 1972, climaxing the long, arduous exploration and development of the Texaco-Gulf holdings in the Oriente.

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ANCIENT ANHYDRITE FACIES AND ENVIRONMENTS—THEIR ROLE IN RECONSTRUCTING GEOLOGIC HISTORY OF MIDDLE DEVONIAN ELK POINT BASIN, ALBERTA

The association of evaporites with a large percentage of the world's oil and gas reservoirs makes these rocks economically significant. Good core control for study of environments of deposition and diagenesis of these rocks is available in the Middle Devonian Elk Point basin, Alberta.

We have recognized 4 major types of anhydrite formation—supratidal, shallow-water, deep-water, and replacement. Supratidal anhydrite includes gypsum pseudomorphs and most of the nodular, nodular-mosaic, and mosaic types. These are identified by comparison with the anhydrite in the sabkha sequence of the Trucial Coast. Bedded anhydrite is interpreted to have been deposited in shallow water under conditions comparable with those in the Pekelmee of Bonaire Island. Tiny nodules and thin laminae of anhydrite, which are usually within or interbedded with laminated limestone, are interpreted as deep-water in origin, from their stratigraphic position in the deeper parts of the Elk Point basin. No modern analogues of these types are known. Some massive, nodular, nodular-mosaic, and mosaic anhydrites, considered to be postlithification replacement types, are located on the edges of shoals, banks, and reefs, and are characterized by their relatively greater thickness and by the inclusion of carbonate fragments of the host rock within the anhydrite.

By detailed core studies of the anhydrite environments and their order of occurrence in the subbasins, we have recognized 11 major sedimentary events. By correlation of these events

between subbasins, with the aid of additional core and density-log control, the history of the Middle Devonian basin has been reconstructed.

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ENVIRONMENTAL SIGNIFICANCE OF CERTAIN YELLOW-BROWN DOLOMITES, GREAT BASIN, CALIFORNIA AND NEVADA

Within the dominantly gray limestone and dolomite sequences of the Great Basin, sporadic yellow-brown dolomite is present as discrete beds, lentils, or wisps—the latter imparting a mottled or pseudobrecciated appearance. These distinct deposits, studied in Ordovician, Devonian, Pennsylvanian, and Triassic formations, are fine grained, are usually unfossiliferous, and possess a less than 5 percent terrigenous fraction of well-rounded quartz and sparse feldspar. Laminations, desiccation polygons, and possible relict bird's-eye structures also are apparent.

Stratigraphically, these deposits commonly overlie dolomite sequences several hundreds of feet thick and are in turn overlain by limestone sequences of varied thicknesses. The persistent occurrence of these yellow-brown dolomites at the top of dolomitized sequences possibly indicates that the yellow-brown lithology represents supratidal or penecontemporaneous dolomitization from which seepage-refluxion brines ultimately descend. The underlying rocks commonly are coarser grained, contain normal marine fossils, and reveal gravity-controlled dolomitization structures. In some cases where yellow-brown deposits are incorporated in a completely dolomitized interval, the beds below the lowest yellow-brown horizon reveal multiple dolomitization.

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COLOR PHOTOGRAPHY AND ITS APPLICATION TO NATURAL RESOURCE EXPLORATION

Color photography has added a new dimension to the field of remote sensing and its application to natural-resource exploration. The color differentiation allows the photogeologist to go much further in the details of his interpretation than he could with black-and-white photography. Additional structural implications also can be mapped. In the mineral field, color anomaly evaluations have proved valuable.

Color photography has been used successfully in exploration for uranium, coal, and base metals, as well as oil and gas. It has become an important detection tool in the fields of ecology and environment. Maximum use has been in the mineral field, although I feel there is more use to be made by the oil and gas industry if color photography is properly applied, and it certainly will be applied more to detect ecologic problems.

Color photography has not had widespread use outside the United States; however, I feel that this will be remedied in the near future. Part of the problem is lack of first-class processing and printing facilities in many countries. Regardless of all the other more exotic remote-sensing methods, I believe the future will see a tremendous increase in the use of color photography in many fields.

BIRD, W. E.

"VIBROSEIS" EVOLUTION IN CALIFORNIA

The "Vibroseis" system of exploration received extensive use during its early development in the Los Angeles basin. Later CDP efforts were hampered by increased urbanization. "Vibroseis" CDP examples demonstrate some of the results of an exploration program over a large part of the San Joaquin Valley. One partial solution is demonstrated for weathering control for surface source data. Examples of higher effort "Vibroseis" data in more complicated areas conclude the 15-year evolution.

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TECTONIC CONTROL OF LATE PALEOZOIC AND EARLY MESOZOIC SEDIMENTATION NEAR HINGE LINE OF CORDILLERAN MIOGEOCLINE

Pennsylvanian, Permian, and Lower Triassic strata in the eastern Great Basin aggregate about 35,000 ft of dominantly marine clastic and carbonate rocks that accumulated in the eastern part of the Cordilleran miogeocline. Subsidence and hypersubsidence created the Sublett, Oquirrh, Arcturus, Park City, Bird Springs, and other sedimentary basins within this major downwarp of the earth's crust. Late Paleozoic and early Mesozoic tectonism within and adjacent to the miogeocline controlled contrasting realms of clastic and carbonate sedimentation. Highlands in western and northwestern Utah, in eastern and northeastern Nevada, and in southern Nevada, certain orogenic belts (*e.g.*, Sonoma) were stripped, in places to their Precambrian cores, and provided abnormal thicknesses of sediment to adjacent mobile negative depocenters. The craton east of the tectonic hinge line provided additional sediment.

The Cordilleran miogeocline did not close its doors in chaotic orogenic spasms at the end of the Paleozoic. Contrarily, the changeover from Permian to Early Triassic was not a major diastrophic event. A paraconformity typifies the boundary at many places, with disconformities elsewhere. Up to 4,000 ft of Early Triassic sediments accumulated; by Middle Triassic time, a major reversal occurred: what had been a major negative mobile belt since late Precambrian time was now uplifted, although the region east of the hinge line became negative, and the hinge line was a fulcrum. The Cordilleran miogeocline was destroyed, and some of its sediments were stripped away, only to be recycled and deposited in the Rocky Mountain geosyncline on the east.

BORGESE, E. M.

WHAT IS THE ENVIRONMENT?

No abstract available.

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MARINE GEOLOGIC ASPECTS OF AMERICAN MEDITERRANEAN

The Gulf of Mexico and the Caribbean Sea, also known as the American Mediterranean, contain examples representative of most of the types of geologic phenomena present in the world's oceans.

Although these water bodies are relatively small and accessible to many research vessels, major geologic problems are still unanswered, in spite of the many data that have been collected. The tectonic complexity of the region apparently does not fit seafloor-spreading ideas. The major tectonic trends and the present position of Cuba, partly sandwiched between the carbonate areas of Florida and Yucatan, strongly influence the different genetic interpretations of the American Mediterranean. The extensive salt diapirism and its influence on the history of a major part of the Gulf of Mexico continental margin, as well as on the knolls and ridges, have resulted in many opinions on the origin of salt and the various mechanisms.

Sedimentologically, major observations can be undertaken, ranging from coastal and sea-level variations, aspects of carbonate deposition and pelagic sedimentation, to origin and structure of submarine canyons and the processes of basin filling by turbidity currents. The part of each basin covered by fan deposits is large, and Holocene deposition is still impressive.

Combination of geologic and geophysical studies in these natural laboratories should be promoted by the various government agencies which have jurisdiction over ocean research.