

lithofacies within the Wilkins Peak Member.

The innermost of the cyclic lithofacies, which includes bedded evaporites, occupies the depositional center of the ancient lake basin and consists of repetitious ascending sequences of (1) dark-brown oil shale, (2) white to brown trona and halite, and (3) gray or green dolomitic mudstone. A second lithofacies that encircles the first, but does not contain bedded evaporites, shows in vertical section cyclic sequences of (1) gray siltstone, (2) dark-brown oil shale, (3) tan or light-brown oil shale, and (4) gray or green dolomitic mudstone. The oil shale and siltstone in these cycles were deposited as lake-bottom muds and along ephemeral shorelines during periods of lake expansion and water-freshening; the trona and halite and gray and green mudstone were deposited in salt pans and on mud flats during periods of lake contraction and water-salting. A third lithofacies is present at the outermost margins of the lake basin, but the cyclic sequences there, consisting mostly of gray and green mudstone and some thin interbedded tan and brown oil shale, are largely obscured by irregularly interbedded tan algal limestone, oolites, and thin beds of dolomite and sandstone. Flood-plain deposits of interbedded red and gray sandstone and mudstone are present nearly everywhere between the outer edges of the lake basin and surrounding mountains.

The number of major contractions of Lake Gosiute during deposition of the Wilkins Peak Member can be determined by counting the number of oil shale beds involved in cyclic sequences near the depocenter of the basin. Seventy-three oil shale beds, and hence 73 saline cycles, were counted in a hole cored in the Blacks Fork area by the U.S. Energy Research and Development Administration. Histograms of oil shale beds in drill holes and outcrops in other parts of the basin support 70 to 75 as the probable total number of saline cycles.

The time intervals of the saline cycles can be roughly estimated by using potassium-argon dating methods for biotites in tuff, and by counting oil-shale varves. From these data, the shortest cycle in which salines were deposited is believed to have lasted less than 1,500 years and the longest cycle more than 100,000 years.

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Geology and Mineralogy of Vogel Specialty Sand Deposit, Barstow, San Bernardino County, California

The Vogel specialty sand deposit contains on the order of 16 million tons of potentially economic dune sand. The immediate source is the fluvial deposits of the Mojave River adjacent to the site on the west. These fluvial sands are derived primarily from the Mesozoic granitic bedrock units of the San Bernardino Mountains near Silver Lake and the Jurassic to Triassic metavolcanic bedrock units of the Silver and Sidewinder Mountain areas.

The sands contain principally feldspar (oligoclase, 40%; K-spar, 17%), and quartz (35%), with minor amounts of hydrobiotite (5%) and hornblende, tourmaline, etc (2%). The sand is very well sorted with most grains about 0.3 mm in diameter and angular to subangular.

The deposit has many similarities to the once extensive specialty sand deposits mined along the California coast prior to the restrictive coastal zone ordinances of the 1960s and 1970s.

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Land Seismic Source Study

During the summer of 1980, faculty and students from the Colorado School of Mines Geophysics Department conducted an extensive series of seismic measurements in eastern Colorado, with the objective of characterizing and comparing land seismic sources under a variety of controlled conditions. This work was sponsored by 29 companies and one U.S. government agency, and results are reported in full in a series of Master of Science theses completed during the fall term, 1981, at Colorado School of Mines.

The test site for the measurement program was located near Brush, Colorado, on gently rolling range land. The site was selected on the basis of easy access, geology suitable for the program objectives (thick Pierre Shale section near the surface and good reflectors at depth), nearby petroleum production and well-log information, and a landowner willing to establish a permanent test site.

The seismic sources used in this study included: (1) vertical and horizontal vibrators, (2) land airgun, (3) weight drop, (4) conventional explosives in shot holes, (5) surface explosives, (6) suspended charges in air (Poulter method), (7) Marthor (registered trademark of IFP), and (8) Betsy (registered trademark of Mapco).

The measurement program consisted of three phases: (1) three-component downhole measurements from 400 to 1,000 ft (120 to 300 m) in 100-ft (30 m) intervals for each source type over a range of horizontal offsets from 50 to 1,000 ft (15 to 300 m); (2) three-component noise spread on the surface for each source covering an offset range of 120 to 8,730 ft (37 to 2,660 m); and (3) a conventional CDP line for each source covering 3 mi (4.8 km) of subsurface with a maximum of 24-fold coverage over the center 1 mi (1.6 km).

The primary test objectives consisted of: (1) quantitative comparison of source waveforms, amplitude and phase spectra, source repeatability, source directivity, and intensity levels from downhole measurements, (2) comparison of surface-wave noise-generation characteristics between different sources from noise spread data, and (3) quantitative comparison of reflection signal characteristics (e.g., bandwidth, S/N ratio, etc) from the CDP shooting.

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Buried Pleistocene Gold-Bearing Channels, Central Great Valley, California

Ancient gold-bearing channels have long been exploited in the Sierra Nevada foothills and in the eastern Great Valley of California. Many channels have been hydraulically mined, whereas others have been dredged. Yet there remains an extensive buried channel system, particularly associated with ancient courses of the lower American and Mokelumne Rivers. The channels are identified in water-well logs, in bridge borings, and locally in quarry exposures. Near the foothills, many channels are expressed geomorphologically by fluvial-filled terraces, many of which have been dredged, and some are even now exploited for gold and aggregate.

At least five now-buried channels were cut and filled by the lower American River. These channels emerge from the foothills near Folsom and are traced in the subsurface to depths of 115 ft (35 m) below present sea level. Some channels are over 25 mi (40 km) long, and 20 to 33 ft (6 to 10 m) thick. The channels are named Older Fair Oaks (oldest), Younger Fair Oaks, Older Riverbank, Younger Riverbank, and Modesto, respectively, after the formations in which they occur.

Five buried channels underlying the lower Mokelumne River are best defined between Clements on the east and Lodi on the

west. The oldest channel (Laguna age) is traced to almost 330 ft (100 m) below King Island in the western Sacramento–San Joaquin delta; the youngest channel (Modesto age) is about -33 ft (-10 m) at Lodi.

Because of their depth, these ancient channels are not presently exploitable. They are, however, a gold-bearing repository, and with newer technology may be potentially tappable in the not too distant future.

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Sedimentology and Paleolimnology of Miocene Peace Valley Formation, Ridge Basin, Central Transverse Range, California

The Peace Valley Formation of Miocene age occupies the axis of an asymmetrical trough in southern California known as the Ridge basin. Sandstone tongues of the Ridge Route Formation extend across the basin and separate the Peace Valley Formation into five members: the Paradise Ranch, Osito Canyon, Cereza Peak, and Posey Canyon Shale Members and the Alamos Canyon Siltstone Member.

The Paradise Ranch shale is a relatively deep freshwater facies, which was deposited in an anoxic lake that possibly was deeper than 65 to 80 ft (20 to 25 m). This unit consists of clay shale with interbedded turbidites, which form upward-thickening depositional lobes.

The Osito Canyon and Cereza Peak shales are shallow freshwater facies. Claystone is the dominant lithology in this extensively bioturbated facies. Deltaic distributary-channel and channel-levee deposits occur in this facies. Wave ripples, ostracodes, and bioturbation suggest deposition in an oxic lake. The sediment accumulation rate for this facies is from 11.1 to 11.7 ft/1,000 years (3.1 to 3.3 m/1,000 years), which is more than twice that of the deep freshwater facies 5.1 ft/1,000 years (1.4 m/1,000 years).

The Posey Canyon Shale and Alamos Canyon Siltstone are deep, brackish-water facies. The absence of insect burrows, mammal tracks, wave ripples, and mudcrack casts suggests that the lake was deeper than wave base or seasonal exposure, which may indicate depths from 65 to 80 ft (20 to 25 m). Dolostone, analcime-rich shale, clay shale, and claystone, as well as debris-flow and turbidite deposits, occur in this facies. Ridge Basin Lake was probably chemically stratified during accumulation of the deep brackish-water facies. The change from shallow freshwater to deep brackish-water deposition probably reflects a change from a hydrologically open to a closed basin.

Vitrinite reflectance indicates that, although the vertical composite thickness of the Peace Valley Formation exceeds 5 mi (8 km), the vertical thickness never exceeded 2.5 mi (4 km) at any given location.

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Nonmarine Trace Fossils in Miocene-Pliocene Ridge Basin, Central Transverse Range, California

The trace fossils *Palaeophycus*, *?Scoyenia*, *?Scolicia*, and *?Chondrites* occur in lacustrine and fluvial deposits of the Miocene-Pliocene Ridge basin of southern California. *Palaeophycus* is the most common ichnofossil in the sequence. *Palaeophycus* is a curved, cylindrical burrow that rarely branches. This ichnofossil is divided by diameter into two types: type A and type B. Type A averages 2 to 6 mm and type B

averages 8 to 18 mm in diameter. Subaerial burrowing by insects probably formed these traces, hence they possibly can be used as evidence of subaerial exposure of the sediment. *?Scoyenia* is morphologically similar to *Palaeophycus* except *?Scoyenia* contains meniscate packing indicating active filling of the burrow, whereas *Palaeophycus* was passively filled. *?Scoyenia* was probably formed by deposit-feeding insects. Both *Palaeophycus* and *?Scoyenia* occur in fluvial and shallow freshwater lacustrine facies.

*?Scolicia* was formed by grazing gastropods. These ichnofossils are ribbonlike depressions which occur both as simple, sinuous furrows and as intertwined paths. *?Scolicia* is found in delta-front and shallow nearshore lacustrine environments in the Ridge basin. The presence of this trace fossil indicates that water depths were less than a few tens of meters.

*?Chondrites* is found in prodelta, delta-front, and deep brackish-water lacustrine deposits. It appears as small (averaging 1.75 mm), curved, commonly branching burrows which locally are replaced by pyrite. Aquatic worms constructed this trace fossil. In the deep, brackish-water deposits, zones of unbioturbated sediment are interbedded with zones of sediment which are partially or totally bioturbated by *?Chondrites*. This probably is the result of alternating oxic and anoxic conditions in the lake's bottom waters.

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Sedimentary Facies of Nonmarine Lower Miocene Diligencia Formation, Canyon Spring Area, Orocopia Mountains, Southern California

The Diligencia Formation in the Canyon Spring area consists of a 2,950-ft (800m) section of interbedded sedimentary and volcanic rocks that accumulated in an east-west-trending intermontane valley. Sedimentary facies are alluvial fan-braided fluvial, shoreline with interfingering basalt flows, fluvial-deltaic, and lacustrine. The alluvial fan-braided fluvial facies occurs in the basal part of the formation in the Canyon Spring area. Alluvial-fan processes predominated in the lower part of this facies where coarse debris was derived from an uplifted Precambrian schistose gneiss-augen gneiss basement complex on the south. Braided-fluvial processes predominated in the upper part of the facies where alternating sequences of sand and mudcracked mud accumulated.

Basin subsidence occurred with syntectonic outpourings of basalt. Some of the flows are pillow basalts that interfingered with rippled, well-sorted, fine-grained sand of the shoreline facies. Fossils are sparse in the shoreline facies and include ostracodes, land-mammal remains, and horizontal burrows. Spring-tufa deposits are present in a laterally persistent bed. As infilling of the lake occurred, deltas formed where gravel-bearing, sandy fluvial sediments of the fluvial-deltaic facies entered the lake. These deposits interfinger with the shoreline facies, and some of the boulders are anorthosite and Lowe-type granodiorite. Offshore, thin-bedded mud and silt of the lacustrine facies interfingered with the delta deposits. Evaporite lagoon conditions and volcanic activity (ash deposits) were intermittent.

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Late Miocene Activity on San Gabriel Fault as Indicated by Paleoenvironment of Castaic Formation