environment. The associated foraminiferal assemblages are mixed and include shelf-edge and lower bathyal (> 6,500 ft or > 2,000 m) markers. Several foraminiferal species in this fauna are characteristic of low-oxygen conditions. An oxygen-minimum zone may also have been the source of pelletal phosphorite in these thin-bedded mudstones. The overall lithologic and paleontologic evidence suggests deposition of these rocks as distal-fringe turbidites immediately following rapid basin subsidence.

Recognition of the ostracode peak zone in uppermost Zemorrian strata 43 mi (70 km) to the west, at Arroyo Hondo, demonstrates its biostratigraphic continuity in this region.

FULTON, THOMAS K., and K. MICHELE DARR, Gulf Exploration and Production

Offset Panel Aids Processor and Interpreter

A novel display of common-offset profiles is found to be a powerful analytical tool for seismic data. The offset panel displays six sets of common-offset, single-channel data taken from a conventional marine seismic survey. The single-channel profiles are displayed below one another and arranged vertically by offset and horizontally by common depth point. This arrangement causes effects due to near-surface geologic changes to generate geometric patterns that are different from patterns due to changes in seismic source or receiver. Both reflection and refraction data are used in the display. Reflection data of the near trace or offset are at the top of the display and indicate the presence of acoustic boundaries. Refractions observed on distant traces are sensitive to changes in the near surface. They allow properties of acoustic layers to be determined through their alteration of transit times and amplitudes.

This display takes advantage of the exchangeability of seismic source and receiver to relate variations in refraction arrival time and amplitude at different offsets. Data commonly muted by the processor allow the detection of near-surface velocity anomalies from the simple geometric patterns they generate. The geometric patterns are symmetrical around the anomaly. A variation in refraction arrival due to change in source or receiver lacks symmetry and may be distinguished from a velocity anomaly.

Refraction arrivals penetrate to a depth of perhaps one-fifth the source to receiver distance, dependent on velocity distribution. A velocity anomaly anywhere in the path can be identified if one can compare refraction arrivals with and without the anomaly in the path. The offset panel arranges the data so that a comparison can be made.

The simple symmetry of the data in such a display renders it useful in many areas of analysis. For the data processor, the most important functions of the offset panel are to (1) verify field recording geometry, (2) monitor the seismic source, and (3) determine processing parameters. For the interpreter, the display serves to: (1) detect anomalous velocity zones in the near surface and allow for their correlation with deep structure, (2) locate and identify shallow, high-amplitude reflections, and (3) indicate shallow geologic changes.

Geotechnical and drilling engineers can use the display to: (1) locate zones of unstable sediments on the seafloor, and (2) locate and evaluate shallow drilling hazards.

Refraction data recorded by the conventional seismic spread are found to be very important in resolving problems associated with the near surface. They are most useful in the direct detection of shallow drilling hazards.

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Tectonic and Climate Controls on Sedimentation of Upper Miocene Nonmarine Strata East of San Francisco Bay, California

Upper Miocene nonmarine and shallow-marine strata exposed east of San Francisco Bay record a change from convergent-margin to transform-margin tectonics. During the late Miocene, the East Bay area occupied the oceanward side of a shelved fore-arc basin which was progressively incorporated in the evolving San Andreas strike-slip orogene. Patterns of deposition in the broad fore-arc basin were relatively simple: andesitic arc-derived detritus was transported the full width of the fore-arc basin from the Sierras to the East Bay area. In contrast, the wrench-tectonic regime produced complex patterns of sedimentation displaying greater local variability. Based on stratigraphic data from D. Wagner and our observations, we infer that the west-facing slope of the fore-arc basin in the East Bay area was reversed about 13 m.y. ago, with uplift of the area between the eventual traces of the San Andreas and Hayward faults. A fluvial clastic wedge was shed eastward into the East Bay area from this uplifted terrane of Mesozoic subduction-complex and fore-arc basin rocks. Initial rupturing along a "proto-Hayward fault zone" followed the uplift about 10 m.y. ago. Loci of basaltic volcanism (10 to 7 m.y.) along these fractures interfinger with the clastic wedge. A similar pattern of uplift and drainage reversal apparently heralded the onset of wrenching along the Calaveras trend 6 to 8 m.y. ago. Expansion of the strike-slip orogene segmented the outer fore-arc basin into local basins, some characterized by periodic lacustrine deposition and probable internal drainage. By the end of the Miocene, Sierran arc volcanism waned at the latitude of San Francisco Bay, and arc-derived volcaniclastics were fully supplanted by recycled Coast Range-derived detritus in the East Bay area. Certain of these Coast Range sediment sources, particularly blueschist-bearing Franciscan terranes, serve to constrain estimates of strike-slip on the Hayward fault.

Although tectonics provide the principal control on patterns and composition of Neogene sedimentation in the East Bay area, late Miocene climatic fluctuations left a marked overprint. Red beds, typical of the lower upper Miocene and suggestive of seasonal aridity, correlate with a relatively cold period along the northeast margin of the Pacific Ocean. In contrast, overlying middle upper Miocene fluvial-lacustrine beds are gray brown and contain abundant carbonaceous debris and faunas indicative of a marked decrease in aridity. These strata correspond to a period of warming in the later Miocene prior to latest Miocene refrigeration (Messinian).

GILBERT, JOHN R., Gulf Oil Exploration and Production Co.

Stratigraphy and Sedimentology of Upper Miocene Williams Sand, San Joaquin Valley, California

The upper Miocene, late Mohnian age, Williams Sand crops out in the southeastern Temblor Range along the southwest margin of the southern San Joaquin Valley, California. The Williams is composed of lenses of generally coarse material within the siliceous Antelope Shale Member of the Monterey Formation and is stratigraphically equivalent to the Stevens Sand. The sands and shales were deposited in paleontologically defined waters as much as 4,000 ft (1,219 m) deep. Based on field and laboratory studies, the Williams is interpreted as a

submarine fan deposit.

Continuous grain-size plots of the outcropping sands were drafted and distinct turbidite facies were identified using Mutti and Ricci-Lucchi's classification. At the surface, the Williams dips northeast into the valley and contains many rather thin-bedded, usually graded, sandstones and conglomerates, with high porosity and permeability, which are interbedded with siltstone and shale. Thick deposits of shale, commonly cherty, separate large bundles of turbidites that pinch out along strike. The sandstone bundles often form coarsening- and thickening-upward sequences typical of deposition on the smooth suprafan lobes of the midfan. Other sandstones form fining- and thinning-upward sequences diagnostic of deposition on the channelized suprafan, although lack coarse pebbly material. Apparently, the Williams fan continued to prograde until at least midway through its depositional history, when significant lateral shifting of coarse-grained sandstone bodies occurred.

According to petrographic modal analyses, the sands are arkosic, having a clay matrix and occasional carbonate and opal cements. Lithologic descriptions plus petrographic and paleocurrent data suggest the source terrane was only a few miles west-southwest, and most likely was the northern Gabilan Range. The northern Gabilan Range is composed of granitic and metamorphic rock, and is now located 150 mi (240 km) northwest of the outcropping Williams owing to Miocene and post-Miocene strike-slip displacement along the San Andreas fault.

In the subsurface, the Williams is composed primarily of fine to medium-grained sands, which are rather thinly bedded, poorly sorted, and interbedded with thick shales and siltstones characteristic of a lower fan facies. Oil is produced from Williams sands less than 2 mi (3.2 km) north of the study area from the Spellacy and Midway anticlines of the Midway Sunset field. Shales, and occasionally bentonites, separate the producing Williams into different reservoirs.

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Mineral-Kerogen Interactions in Laboratory Experiments—Significance for Petroleum Genesis

Kerogen from lagoonal mats and from a coastal marine sediment was extracted, mixed with known minerals, and heated in sealed pyrex tubes for periods extending from 1 to 100 hours over a temperature range of 50 to 500°C. The minerals used were calcite, kaolinite, illite, and two different montmorillonites. Methane and carbon dioxide were separated, quantitatively determined, and their $^{13}C/^{12}C$ isotope ratio measured. Rock Eval was used on the bulk residual material after pyrolysis to determine amount of hydrocarbon formed and the thermal changes in the kerogen. These results were compared with data obtained from bitumen extraction by organic solvents.

The results suggest that minerals can have either catalytic or inhibitory effects. These effects are displayed at lower temperatures only. At higher temperatures, thermal effects dominate. Calcite and montmorillonite C were found to be inhibitory to production of bitumen, whereas kaolinite, illite, and montmorillonite B were found to be catalytic. The inhibitory effects were interpreted as being due in part to direct interaction between mineral and kerogen, but also to entrapment of bitumen within interlayer spacing and prevention of its escape due to mineral-organic molecular configuration.

HARNETT, TOM, Ventura, CA

Late Pliocene Turbidites, Adams Canyon, California

Late Pliocene deep-water 990 ft (330 m), turbidites of the upper Pico Formation form a well-exposed, nearly complete vertical section in Adams Canyon, California. Approximately 213 ft (700 m) of section were examined in detail, revealing five sectionss of channel-fill sediments up to 386 ft (117 m) thick, dominated by thick-bedded, coarse to fine-grained sandstones, pebbly sandstones, and conglomerates. A thinning of beds upward was found in all five section, along with an associated decrease in grain size. The channel-fill sediments are separated by tens to hundreds of feet (meters) of finer grained plane-parallel interchannel turbidites. The associations of facies types, along with the cyclic nature of the bed thicknesses, indicate that the entire sequence represents a midfan environment of deposition. A comparison with equivalent age midfan channel sediments exposed in Santa Paula Creek, 1.2 mi (2 km) to the east, indicates more frequent deposition for the midfan sediments of Adams Canyon. This is interpreted to be the result of a decrease in the midfan gradient from east to west causing increased deposition of sediment gravity flows in the Adams Canyon area. Paleoecologic studies have indicated an infilling sedimentary basin from early Pliocene time to the beginning of the Pleistocene.

Pebbles and other clast composition indicate the source terrane was Eocene and Miocene sedimentary rocks to the northeast and crystalline basement toward the east. A submarine canyon trending west to southwest is indicated by the paleocurrent data. Flow mechanisms indicated by structures within the section show that sediment was transported by debris, grain, fluidized, and turbulent flows. A rate of 1 mm/year has been estimated as the overall sedimentation rate for the Pliocene sediments in the area.

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Marine Geophysical Measurements in Central Puget Sound, Washington

Marine seismic refraction (sonobuoy and OBS) and gravity data obtained from the Puget Sound main basin and Lake Washington show a major discontinuity in both seismic velocities and rock densities across a steep (15 mgal/km) gravity gradient striking generally westward through Seattle from the Cascade Range foothills to Hood Canal. North of this gradient is a -129 mgal Bouguer gravity minimum centered over Lake Washington. A least squares inversion analysis of the residual Bouguer gravity field was combined with the refraction velocities to model the subsurface density distribution beneath the central Puget Sound lowland.

The data suggest the existence of a 7 to 8-km deep sedimentary basin beneath the gravity minimum north of the steep gradient. The basin is filled with probable Tertiary and Quaternary rocks having densities ranging from 2.0 to 2.6 g/cc. Modeled rock densities beneath the basin (2.7 to 2.8 g/cc) may indicate the presence of volcanic basement rocks. South of the gravity gradient, Tertiary volcanic and intrusive rocks are overlain by Tertiary and Quaternary sedimentary rocks up to 2 km thick.

The gravity gradient appears to mark a steep fault or faulted flexure forming the southern boundary of the Tertiary basin lying beneath Lake Washington and Seattle. The gravity model suggests that much of the steepness in the gradient across this feature is due to a near-surface density contrast between a west-