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.

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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-