tal shelf. These units, defined on the basis of seismic reflection and sedimentologic data, are (1) Holocene glacial-marine sediments, (2) Holocene end morainal deposits, (3) Holocene (neoglacial) and Pleistocene glacial sediments, and (4) Pleistocene and older lithified sedimentary rocks. Each of these four units is divisible into facies on the basis of depositional environment. Each of the units was derived either totally or in part as a result of glaciation, hence each unit is a chronofacies or lithofacies of the overall glacial and glacial-marine depositional picture of the northeast Gulf of Alaska during the Quaternary.

The Holocene glacial-marine sedimentary unit contains sediment originally glacially eroded and transported that was (and is) deposited in the marine environment through glacial-fluvial, eolian, or ice-transported mechanisms. Facies in this unit vary from unimodal clayey silt to bimodal pebbly silt and clay with large percentages of ice-rafted components. The end moraine unit, which contains deposits representing the farthest penetration onto the shelf of fiord-filling piedmont and valley glaciers, contains facies ranging from massive boulder and cobble accumulations to fine-grained silt and clay that accumulated in basins within the lobes of the moraine. The Holocene (neoglacial) and Pleistocene sedimentary unit is the most variable of the four units as it contains sediment ranging from multi-modal ablation and lodgment tills, to recessional glacial-lacustrine and outwash facies, to marine pebbly mud. Post-depositional winnowing has further modified the textural and compositional nature of this unit.

The lithified sedimentary rock unit, typified by submarine outcrops of the Yakataga Formation, contains components of each of the three other units. The lithified unit, however, represents glacial and glacial marine events predating Holocene time. Stratigraphic and paleontological evidence suggests that the depositional environments producing the facies present in the Quaternary sedimentary units have changed little since middle Miocene time, and the influence of glaciation has been the primary controlling factor in the shaping of upper Tertiary and Quaternary depositional sequences.

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Lacustrine, Fluvial, and Fan Sedimentation—Quaternary Climate Change and Tectonism, Pine Valley, Nevada

Pine Valley, an intermontane graben in the Basin and Range province, has trapped a unique record of Quaternary volcaniclastic fluviolacustrine sediments, largely exposed by late Pleistocene tectonism and erosion. These are analogous to Great Basin sediments spanning the Tertiary and which produce oil in Railroad Valley, Nevada, and Rozel Point, Utah, and gas in Carson Sink, Nevada.

Three major facies in the 400+-m thick middle Pliocene to middle Pleistocene Hay Ranch formation are shallow lacustrine, fluviatile, and alluvial fan. Deposits from the fresh-water, quiet, alkaline, oxygeneated lakes include tuffaceous calcilutite interlayered with rhyolitic vitric tuff, zeolite, silt, and clay. Organic content varies widely. Grading laterally and in places vertically are fluviatile lithofacies of thickening wedges of silt and sandstone. Sedimentary structures indicate episodic transport by anastomosing stream channels and spreading sheetflood, which grade into sand to cobble-fanglomerates of valley-margin alluvial fan facies and include water-lain and debris-flow clasts.

Middle Pleistocene to Holocene sediments are of unconsolidated fluvial and alluvial fan facies, with minor landslide, talus, and thin carbonate lake and welded tuff facies.

The complexly interfingering facies and subfacies represent transgressing and regressing lake shorelines and variable fluvial input related to glacial climatic changes and are best illustrated with a series of time-sequential basin facies maps. Decreased evaporation and increased precipitation during glacial times, at least in winter, pulsed clastics to narrow basin-margin fans, and clay and silt to the lake center. Dry periods allowed thicker algal lime mud and ash to accumulate. Lack of paleosols, beaches, paludal facies, and lake shallowness preclude very wet conditions.

Tectonism had a steady control on sedimentation. Growing horst relief maintained local stream gradients. Pleistocene epeirogenic uplift and tilting northward of the region reversed the flow of and entrenched Pine Creek; the new external drainage dissected Hay Ranch pediments and inhibited playa evaporite and perhaps beach deposition and preservation. Continued extension and slight south and east tilting of the graben, however, roughly kept pace with warping during Hay Ranch time.

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Benthic Foraminifers From Eastern Gulf of Alaska

Grab samples, dart cores, and gravity cores from the Gulf of Alaska between Montague Island and Yakutat Bay were analyzed for benthic foraminifers. Robust specimens of *Cassidulina californica, C. limbata,* and *Cibicides lobatulus* are abundant in coarse sediment on Tarr Bank, Middleton Island platform, and along much of the outer shelf east of Kayak Island. This fauna may be relict, as it occurs in areas known from seismic profiles to be nearly devoid of the Holocene clayey silt which blankets much of the shelf. In several samples, glauconite associated with this fauna provides evidence for a low rate of sedimentation.

Another fauna, in which *Epistominella pacifica* occurs with *Elphidium clavatum* (typically a shallow-water, inner-shelf species), is found in Kayak Trough at depths ranging from 146 to 234 m and in Hinchinbrook Sea Valley at 205 m. Both of these depressions have topographic highs at their seaward terminations. In previous studies in other parts of the Gulf of Alaska, *Epistominella pacifica* is reported to be common above 300 m depth; however, farther south, off California, Oregon, and Washington, *E. pacifica* usually occurs at depths greater than 300 m. The association of *E. pacifica* and *Elphidium clavatum* might therefore be useful in determining paleoenvironments; their co-occurrence could indicate a depression, such as a trough or sea valley, somewhat restricted from open sea conditions.

Seismic records show that the Holocene clayey silt, which is common on much of the shelf, is thin or absent on Pamplona Ridge and in the outer part of Bering Trough. Samples from these areas, in water depths ranging from 163 to 315 m, have abundances of *E. clavatum* of 10% or more, and *Buccella* is present. This fauna may indicate deposition at shallower depths during a Pleistocene lower stand of sea level.

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Depositional Environments Within High-Energy Tidally Dominated Embayments Along Pacific Margin, United States

Geophysical and sedimentological studies within lower Cook Inlet, Alaska, have revealed acoustic facies relations and sedimentologic depositional environments typical of large, tidally dominated estuarine systems along the Pacific margin of the United States. Since 1976, detailed high resolution seismic and sidescan sonar surveys, bottom underwater television, and bottom photography, together with sediment sampling, in lower Cook Inlet, have delineated six major depositional environments: high-energy tidal flat; trough-edge platform; trough slope; tidal trough (channel); channel-mouth plateau; and seaward progradational ramp. Within these environments are found lithofacies ranging from sand patches, sand ribbons, and mixed cobble-sand "hard bottom" to sand-wave bodies of both large- and small-scale and to sand-wave and shell-lag complexes. These facies appear to be primarily controlled by the modern hydrodynamic regime and the availability of sediment within lower Cook Inlet.

In lower Cook Inlet at present, sands and gravels are being deposited while older glacial sediments are being winnowed. Marine transgression since glaciation has resulted in a more energetic tidal environment in the present than existed in the past. Geophysical (evidence shows that deposition has occurred over a preexisting glacial topography consisting of an irregular surface cut by numerous shallow channels. In other areas, banks of till lightly covered by recent sediments appear to nearly crop out on the seafloor. Throughout lower Cook Inlet, however, modern sediments average approximately 30 to 40 m in thickness.

Four primary acoustic depositional facies are recognized in the shallow subsurface sediments. The upper two acoustic facies can be correlated with the modern lithofacies within lower Cook Inlet. Facies A, considered to represent unsorted tills, overlies the eroded glacial surface and is up to 75 m thick. It has a characteristically nearly transparent acoustic appearance on high resolution geophysical records. Overlying Facies A is Facies B which is characterized by a strong acoustic reflection. This facies is very thin and is thought to represent glacially derived outwash gravels and cobbles. Facies C overlies Facies B and it is acoustically identified by its pattern of multiple horizontal reflectors which is thought to represent a succession of alternating layers of silt and sand. Facies C is considered to have been deposited when lower Cook Inlet was a quiet bay. The uppermost acoustic facies, Facies D, appears limited to trough, plateau, or ramp environments and is composed of large-scale sand-wave complexes. Modern analogous sand-wave complexes can be presently found in parts of lower Cook Inlet.

Willipa Bay, Oregon, and San Francisco Bay, California, exhibit modern sediment facies which are similar in some ways to those described for lower Cook Inlet. Comparison of these Pacific margin embayments in terms of hydrodynamics, sediments, constructional history, and topography has led to a general facies model for high-energy tidally dominated estuarine systems.

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Foraminifera of Sangamon(?) Estuary, Central San Francisco Bay

Up to 30 m of muds deposited in a Sangamon(?) estuary are found in boreholes drilled for the proposed Southern Crossing of central San Francisco Bay. Microfossils and plant fragments in the core samples represent deposits of shallow estuarine and deeper marine environments.

The most abundant species is *Elphidium excavatum* (including its variants *E. selseyense, E. lidoense*, and *E. clavatum*). It occurs with *Elphidiella hannai* to comprise over 70% of the total population in all samples. *Bucella frigida, Elphidium gunteri*, and *Ammonia beccari* comprise at least 15-25% of the taxa in many samples. All other species occur with frequencies of less than 2%.

Two associations are defined: (a) one in which *E. excavatum* comprises over 50% of the total population, and *A. beccari* and *E. gunteri* are also abundant; and (b) one in which *E. excavatum* is common but less abundant, and *Elphidiella hannai* and *B. frigida* are also common. The *Elphidium excavatum* association is found in the lower samples in each core, the *Elphidiella hannai* association in the upper samples.

In the present bay, *E. hannai* is most abundant at depths greater than about 12 m, whereas *Elphidium excavatum* and associated species are the most common species at shallower depths, which suggests that the Sangamon(?) estuary was of moderate depth and gradually became deeper. The presence of *B. frigida*, a species not found in the present bay but common in inner netritic environments of the West Coast, suggests that the later Sangamon(?) bay may have had a more open-marine aspect. Foraminifera common to shallow-bay environments are apparently not preserved in the cores.

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Geological Assessment of Petroleum Potential of Tertiary Basin, Western Oregon and Washington

Recent drilling and the subsequent discovery of gas near Mist, Oregon, have stirred new interest in the large Tertiary basin of western Oregon and Washington. Developments in the understanding of the regional tectonic framework of the western North America continental margin over the last 10 years has clarified some aspects of the geology of this area. Our new-found insight into the mobile nature of the crust provides little new indication, however, of the possible volumes of hydrocarbons in the basin.

Our current work in the area indicates little that is