grain pores in grainstones; most muddy marine rocks interbedded with tidal-flat dolomites were dolomitized. Both the grainstones and dolomites are very porous (up to 35 and 42%, respectively) and permeable (up to 160 and 1,430 md, respectively) because of widespread leaching of cements.

The grainstone-dolomite complex forms a large, tabular body of rock which now is continuously permeable to water and which is enclosed above, below, and along one side by impermeable rocks. The linear carbonate-sand body and associated reefs controlled the distribution of original porosity, and it now marks the northeastern boundary of permeable rocks.

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Late Ordovician–Early Silurian Strata in Mid-Continent Area

Late Ordovician–Early Silurian strata extend from the Texas Panhandle across Oklahoma and Arkansas into eastern Missouri and Illinois. The sequence consists of upper and lower sections of organic-detrital limestone separated by calcareous shales (Sylvan, Cason, Maquoketa Shales); the limestones directly above the shales are commonly oolitic (Keel, Noix Formations). The carbonate rocks have a rich megafauna and microfauna, and the shales yield graptolites and chitinozoans. The Ordovician-Silurian boundary, as here defined, usually falls just above the oolite, but locally it occurs in the shale. The faunal and stratigraphic relations suggest continuous deposition through the oolitic beds, although there is substantial lateral gradation between shale and limestone. At most places, Late Ordovician (late Ashgillian) strata are overlain by Late Silurian (late Llandoverian) strata; earliest Silurian beds are poorly represented or absent. Physical evidence for an unconformity at this horizon is common, pointing to interruption in deposition accompanied, at least locally, by erosion. Late Ordovician glaciation reported from Africa and South America was possibly of sufficient magnitude to have caused an appreciable lowering of sea level; this could explain the absence of earliest Silurian strata. The Late Ordovician shales are almost devoid of benthic fossils, a condition that might have been caused by various factors including colder water; however, these shales are closely associated with organic-detrital limestones and oolites which bear a large, sessile and vagrant benthos, suggesting temperate to tropical waters.

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Antarctic Continental Margin

The positions of Paleozoic depositional basins in Antarctica are determined by examining the paleogeographies of other Gondwana continents. However, because of its ice cover, Antarctica's post-Paleozoic paleogeographic settings are more uncertain. Most of the Antarctic continental margin has remained passive since initial rifting. The only exception is the Bellingshausen-Amundsen margin along which the Aluk Ridge was subducted between 53 and 21 m.y.B.P.

The initial breakup of Gondwanaland resulted in a network of narrow ocean basins in which euxinic claystones were deposited. As spreading continued, enhanced circulation resulted in the deposition of biogenic sediments, mostly carbonate beds, in the juvenile ocean basins bordering Antarctica. At the time of separation of Antarctica and South America approximately 23 m.y.B.P., the Circum-Antarctic Current was initiated. The continent was then thermally isolated and the stage was set for a continental ice sheet to develop. By late Miocene time the ice sheet had advanced onto the continental margin and has dominated marginal sedimentation since that time. The importance of glacial erosion and sedimentation on the continental margin has been profound. In the Ross Sea, the only area where the continental margin has been drilled, the waxing and waning Ross Ice Shelf has eroded hundreds of meters into the continental shelf to within a few tens of meters of basement rock. In its retreat, the ice deposited almost 400 m of glacial-marine sediments. Seismic profiles from the Weddell Sea continental shelf reflect similar deep erosion. Hence, although paleogeographic reconstructions suggest that parts of the Antarctic continental margin may contain rich oil and gas reserves, the combined influence of isostasy and glacial erosion may have reshaped the Antarctic continental margin significantly.

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Glacial-Marine Sediments of West Antarctica and Puget Sound

The ice-covered parts of the world oceans are among the most complex and poorly understood sedimentary environments. Studies of sediments from the Antarctic continental margin and the Pleistocene glacial-marine deposits of the Puget Lowlands are under way, and models for glacial-marine deposition are being developed. These depositional models account for the interrelations among glacial, climatic, oceanographic, isostatic, and sedimentary processes. In particular, glacio-isostatic adjustment and subglacial processes appear to have pronounced effects on sedimentation. Several cruises to the Antarctic continental margin have been conducted and most of the West Antarctic margin has been surveyed.

Piston cores from the West Antarctic margin contain a variety of sediment types ranging from nonstratified, nonsorted marine tills to well-sorted, quartz-rich sands and laminated silts. Debris flows, turbidites, biogenic oozes, and other marine sediments are interbedded with glaciogenic deposits. Lateral and vertical variability of sediments and faunas, well-illustrated by stratigraphic sections from the Puget Sound region, suggests that major shifts in depositional boundaries and environments occur frequently.

Understanding the complexities of the glacial-marine environment is essential for reconstructing past glacial histories. The origin of glacial-marine sediments cannot be understood by considering processes unique to the marine or glacial environments, but must be evaluated in terms of interactions between the two.

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Glacial Origin of Megachannels of Upper Yakataga Formation (Pliocene-Pleistocene), Robinson Mountains, Gulf of Alaska

A tidewater glaciomarine depositional model is proposed for the upper Yakataga Formation in the Robinson Mountains, eastern Gulf of Alaska. The upper 2,000 to 3,000 m of the Yakataga Formation is characterized by major channels (depth >90 m) cut into and filled with both fluvial and/or marine rocks. The channels are elongate and steep walled, and appear to be confined within or parallel with paleotopographically low areas. Detailed studies of five channels show maximum dimensions of 430 m in depth and about 3 km in width. Channel length was not determinable.

Channel margins are in places grooved and striated. Channel-base conglomerates exhibit foreset bedding inclining down the channel axis, and are interpreted to be subglacial melt-water deposits. The channel fill is dominated by interbedded siltstones and pebbly siltstones (diamictites). The siltstones contain abundant in-situ marine fossils, commonly encrusting the tops of dropstones. These deposits are interpreted to be proglacial marine sediments and ice-rafted glacial erratics. Thin sandstones interbedded within the siltstones are graded and exhibit traction features. These are believed to originate as gravity-flow units from oversteepened clastic wedges deposited by subglacial melt-water discharge at the grounded terminus of a glacier. Diamictites are of two major types: (1) poorly sorted sandy siltstone units with patchy distribution of angular clasts (nonmarine tillite); and (2) moderately sorted, muddy siltstone units with in-situ fossils and evenly dispersed, slightly rounded clasts (marine tillite). Some of the diamictites are highly contorted, particularly those underlying younger channel bases. The contorted character is probably the result of loading sediments by an advancing ice lobe.

Nonmarine sandstones and conglomerates are present as interbedded lenticular packages, and are interpreted as fluvial units deposited within a braided glacial-stream complex. These units occur both within channels and as clastic wedges within marine-shelf sequences. The channels are interpreted as fiords, and the modern fiords of the Yakataga area (Icy and Yakutat Bays) serve as modern depositional analogs.

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Glacial-Marine Trace- and Body-Fossil Associations, Upper Yakataga Formation (Pliocene-Pleistocene), Gulf of Alaska

Glacial-marine deposits of the Yakataga Formation are characterized by six associations of trace and body fossils. These associations can be directly compared to modern associations within the tidewater-fiord and marine-shelf environments in the Gulf of Alaska, and allow definition of specific paleoecologic conditions.

Inner-shelf sandstones are extensively bioturbated by a community characterized by the infaunal pelecypods *Siliqua* and *Spisula* and the epifaunal gastropod *Neptunea*. Distinct trace fossils are absent.

Open-shelf siltstones are also extensively bioturbated. Epifaunal body fossils of the gastropod *Colus* and small ophiuroids are abundant. The infaunal pelecypods *Mya* and *Panomya* are locally common. Trace fossils include rare small vertical burrows and large pelecypod burrows parallel with and oblique to bedding planes.

Major channel systems within the upper Yakataga Formation are interpreted as fiord deposits. The fiord deposits have three rock-fossil associations. Rhythmically bedded siltstones and sandy siltstones have an infaunal community of the pelecypods *Acila* and *Macoma*. Distinct trace fossils are absent. "Massive" siltstones are extensively bioturbated, have locally abundant large burrow networks, and typically have locally abundant body fossils of the epifaunal gastropods *Beringius*, *Colus*, and *Musashia*, as well as small ophiuroids. Within the siltstone sequences of fiord deposits are thin, graded sandstones. These thin sandstones have an associated body-fossil community of shallow-burrowing *Nuculana* and *Clinocardium* and trace fossils of small vertical escape burrows, bed-top pelecypod resting impressions, and pelecypod foot-push trails.

A sixth faunal association consists of epifaunal organisms such as serpulid worms and barnacles that are attached to the upper surface of glacially derived dropstones.

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Pleistocene Submarine Canyons of Northwest Gulf of Mexico—Study in Seismic Stratigraphy

Parts of six submarine canyons and canyon complexes on the shelf of the northwest Gulf of Mexico were studied using seismic stratigraphic techniques. These canyons were eroded during the late Pleistocene, probably by subaqueous processes acting on channels formed subaerially during a low stand of sea level. They have since been infilled and are now buried beneath as much as 6,000 ft (1,830 m) of sediment. The reflection patterns produced by the sediments infilling the channels range from parallel to mildly chaotic, and the reflections are variable in intensity. The sediments appear to have undergone considerable modification by slumping or flowage. They are mostly shale with some silt and lesser amounts of sand nearshore. The sediments that were deposited at the mouths of the canyons are mostly shale and, where undisturbed, display subparallel reflections. Individual canyons ranged in size from 2 to 20 mi (3.2 to 32 km) wide and were as much as 3,500 ft (1,068 m) deep before being infilled.

Oil or gas accumulations may be associated with these canyons in two ways. First, there may be hydrocarbon accumulations within the sediments deposited in deeper water at the mouths of the canyons. Second, the