The diverse topography and sediment types of the northern Bering shelf owe their origin to a combination of tectonic activity, subaerial processes during lowered sea level, and present marine processes. Late Cenozoic to recent tectonic expression is evident in nearshore regions, particularly (1) along southwestern Seward Peninsula, where faulting and folding affect sea-floor bedrock and relict gravel distribution and the major northward sea valley and subaerial drainage pathways and (2) off central St. Lawrence Island, where lava flows and plugs disrupt morphology of a structural seafloor depression.

During lowered sea levels of the Quaternary, Siberian glaciers pushing up to 150 km beyond the present shoreline deposited a series of morainal ridges now exposed as linear gravel bars that extend southward from Bering Strait and northward from St. Lawrence Island. Other early to middle Pleistocene local valley glaciers pushed debris a few kilometers off the coast of Seward Peninsula; subsequent reworking by shoreline transgressions and regressions has left these as nearshore patches of partly auriferous relict gravels. Shorelines of lower sea levels also formed beach ridges that are evident as linear topographic scarps, ridges, and constructional lenses of sorted, rounded, shelly, and oxidized coarse sands and gravels.

During the Holocene and other Quaternary periods of high sea levels strong currents affected the sea-floor shape and sediment distribution, particularly in the Bering and Anadyr Straits, where relict gravels and hummocky topography of apparent glacial origin remain exposed. On the lee side of such current-swept channels, slackening currents have deposited sediments forming shoals such as those north of Cape Prince of Wales and Northeast Cape. Except for the Siberian morainal ridges, nearshore areas, and straits regions, where current scour preserves surface relict gravels, most of the northern Bering sea floor has a thin cover of Holocene transgressive fine marine sands.

Holocene Yukon sediments are deposited as interlaminated fine sand and clayey silt, up to 60 km off the delta, and around Norton Sound where sediment has been ponded by the modern current regime. Ancient, buried depositional wedges of Yukon sediment apparently extended farther west and account for the smoother topography that is found within 200 km of the modern delta. Limited Holocene deposits, extensive subaerial topography, and common relict sediments suggest that during periods of high sea level, Yukon and other contemporaneous sediment are swept from most of northern Bering Sea by the strong northward currents. The great canyons of the Bering continental margin suggest a southward transport of Yukon sediment during low sea levels. This apparent past and present movement of Yukon sediment may explain the general lack of modern sediments in northern Bering Sea and presence of Holocene deposits on the epicontinental shelves in the north and south.