

Revisiting Willapa Bay:

Facies Templates for Estuary Deposits Modelled from Pleistocene Outcrops

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Summary

Willapa Bay is a mesotidal estuary situated near the southwest corner of Washington, USA. Outcropping Pleistocene terraces, which have been the focus of intense scientific scrutiny, rim the bay on its east and north margins. The Pleistocene deposits represent ancient bay accumulations that reflect similar, but not identical, depositional conditions. It is the similarity of the ancient strata to the modern bay sediments that has inspired much of the previous geological investigation (Clifton and Phillips, 1980; Smith, 1989; Gingras et al., 1999). At Willapa Bay the documentation of outcrop and modern occurrences of key sedimentary environments—i.e. tidal flat and point-bar deposits— aids in their characterization. This aids in identification of analogous deposits in other strata.

Intertidal Flat Deposits

Intertidal flat deposits at Willapa Bay are relatively common. Where present in complete vertical successions, intertidal sediments cap subtidal units, such as estuarine point bar or channel bar deposits. Pleistocene mud flats are reworked extensively and their bedding is massive to crudely defined by continuous horizons of silt- and sand-filled burrows. Meter-scale tidal-creek deposits cross-cut the bioturbated mud-flat sediments. In the ambient mudflat, primary sedimentary structures are rarely preserved, but may include planar bedding, graded laminae, ripple and starved ripple lamination. Organic detritus is locally abundant, including wood fragments and transported rhizomes. Ichnofossils display a broad range in size. Discrete burrows are locally discernible and are commonly limited to the ichnogenera *Skolithos*, *Arenicolites*, *Cylindrichnus*, *Planolites*, and *Palaeophycus*. *Thalassinoides* and *Psilonichnus* are locally common.

Ancient sandflat deposits are also common in the Pleistocene strata. These display massive to crudely bedded sand intercalated with rare mm-scale mud beds. The sandflat deposits are intensely cross cut by decimeter-scale silt- and sand-filled run-off channels. Bioturbation consists primarily of medium- to large sized bivalve traces (equilibrichnia and *Siphonichnus*), medium-sized *Thalassinoides*, passively-infilled crab domiciles, and diminutive *Planolites* and *Skolithos*. As a whole, smaller trace fossils are absent, probably due to extensive reworking of the deposit by larger burrowers and preservational bias in coarser-grained clastic deposits.

Point-bar Deposits

Point-bar deposits are common at Willapa Bay. Due to their association with fluvial tributaries, they exhibit notable ichnological and textural variability. As the major supply of coarser clastic detritus was delivered into the bay through its inlet, sandy deposits tend to be associated with outer estuary deposits. Inner estuary sediments are dominated by silt and mud.

Physical sedimentary structures include planar lamination, graded bedding, and starved ripple lamination arranged in cm-scale Inclined Heterolithic Stratification (IHS). The deposits can be rich in organic detritus; wood clasts are abundant throughout the point-bar deposit. The lower contacts are erosional and sharp. Point bar deposits may be unburrowed in the inner estuary. Middle estuary deposits contain a more diverse array of lebensspuren. These traces include *Skolithos*, *Cylindrichnus*, *Psilonichnus* and *Thalassinoides*. Passively-infilled, unlined burrows form tubular tidalites. Sedimentologically and ichnologically, ancient point-bar deposits at Willapa Bay are comparable to the modern deposits documented.

The point-bar units intensely cross-cut each other. They range in thickness from 50cm to 8m (for individual channel units). The point bars are commonly capped by intertidal sediments and may grade into supratidal deposits (i.e. rooted and alluviated). Several examples show that vertical aggradation of the channel fill is dominant over later migration. This is an important difference from fluvial point-bar deposits.

General Trends

At Willapa Bay, point bar and intertidal flat deposits are the exceedingly variable laterally, and are therefore useful paleogeographic indicators. Both of these depositional environments are characterized by striking changes (and fluctuations) in salinity and kinetic energy from the lower to the upper estuary. As such, textural changes can be linked to changes in the hydraulic energy and are generally evident in transects from the lower to upper estuary. Inner estuary pointbars and mudflats are mud-dominated, outer estuary accumulations are sandy. Trace assemblages present in the upper estuary are generally extremely stressed and are dominated by a low diversity suite of small (<2mm diameter) burrows attributable to worm-like animals. The middle to outer estuary is (additionally) characterized by large diameter ichnofossils attributed to crustaceans and bivalves.