Abstract

High Latitude Tidal Environments – Examples from Braganzavågen, Svalbard and their Implications for Facies Models and Stratigraphy

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Studies of modern processes and resulting sediments on a tidal flat in Svalbard in the high Arctic has revealed differences in processes, preservation and sequence stratigraphic setting relative to most facies models from low-mid latitude tidal environments. So far only few studies exist from cold climate tidal systems (e.g. Dionne, 1985; Greb et al., 2011) and a much better coverage of variations between different settings and systems at high latitudes is needed in order to provide generalized facies models, which can be useful also in an applied context.

Svalbard is an archipelago located in the north western Barents Sea between 74-81 degrees north. The present climate is arctic moderated by inflow of warm atlantic water from the North Atlantic Current. The main study area is the Braganzavågen tidal flat in the inner part of Van Mijenfjorden on the west side of the largest island, Spitsbergen. The tidal flat is formed at the seaward end of the glacial valley Kjellströmdalen and is prograding into a lagoon formed behind a moraine ridge and separated from the main fjord by a 1 km wide and 2 km long inlet. The barrier protects the tidal flat against significant wave influence and the dominant marine process is thus tidal currents with a tidal range between 1 – 2 m. The Kjellström River in the central part of the valley provides sediment supply to the tidal flat from an approximately 600 km^2 large catchment, of which 37% is covered by glaciers. The mean river runoff estimated to150 m^3/s (Lund, 2005). Additional sediment sources are large alluvial fans developed in front of side valley glaciers and colluvial fans developed on the steep mountain sides surrounding the embayment. The mountains consist of easily erodible sedimentary bedrock, mainly shales and sandstones strongly exposed for weathering due to permafrost and annual snow cover.

The rivers are flowing approximately from June – September. Sea ice forms between November and January and breaks up between the middle of June and the middle of July according to Høyland (2009), although this has been a couple of weeks earlier in the most recent years. Permafrost thickness in the area is at least 100 m at the shoreline and probably more than 500 m in the mountains (Humlum et al 2003). The active layer is generally about 2 m thick. The annual precipitation is low (266 mm/yr) (Caline 2010) and the ground is snow covered approximately from September to May/early June.

Investigations of the modern tidal flat have taken place annually since 2010. Focus have been on producing a facies model for a high Artic tidal flat, and methods have included geomorphological mapping of bar forms and channels, large-scale grain size distributions across the tidal flat, sedimentological descriptions from small cross sections in bars and short cores (typically 30-40 cm thick) through the most recent deposits. Analyses of aerial photographs from the past two decades provide information on the stability of geo-morphological elements. Longer cores (up to 15 m) provide new data on the stratigraphical framework for the infill.

AAPG Datapages/Search and Discovery Article #120178 © 2015 AAPG Hedberg Research Conference, Latitudinal Controls on Stratigraphic Models and Sedimentary Concepts, September 28-October 1, 2014 – Banff, AB, Canada

The sediments are characterized by laminated clay to silt in the subtidal part and laminated silt and fine sand to cross bedded sand and gravel layers in the most proximal intertidal part. The supratidal deposits are laminated and fine grained silt to sand with organic horizons formed by algae mats. Laminae in the supratidal sediments may be partly disrupted by freeze-thaw processes. Channel patterns vary from anastomosing to meandering in fine-grained supratidal areas to braided in the coarse-grained supratidal/alluvial area to meandering in the intertidal area. Channel orientation changes from valley-normal to valley parallel in the intertidal area. The position of tidal channels has been relatively stable over two decades, whereas the fluvial channels have migrated significantly.

The geological setting of the present tidal flat is comparable to a prograding delta/ bayhead delta in a flooded valley/fjord. The maximum transgression of the fjord system took place during ice retreat c 12.000 years BP when the relative sea level was up to 60 m above the present. All sedimentation since then has taken place during forced regression. Delta progradation has been interrupted at least once by formation of an ice-dammed lake during glacier surge from a side valley c 600 years ago. Up to 3 m of tidal sediments have accumulated since the drainage of the lake where the longest core is taken. This sedimentation rate may be higher in other parts of the embayment as photos showing large ships in the bay in the early 20th century, whereas even the subtidal zone is now so shallow, that it is difficult to navigate by rubber boat. Preservation of forced regressive tidal deposits is also known from other Quaternary tidal systems in similar settings (Jensen et al. 2006, Eilertsen et al. 2011) and is common in formerly glaciated areas (Jensen & Larsen, 2009).

The Braganzavågen tidal flat is an example of forced regressive tidal deposits in an inner fjord setting. Sedimentation is controlled by interplay between fluvial and tidal processes, with coarse clastic fluvial system and colluvial sediment supply playing an important role. This setting is common in high latitude areas. The present study is now being expanded to other coastal sites in the inner fjords on Svalbard.

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