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The Late Holocene Progradation of the Mixed Fluvial-Tidal Mahakam Delta, Imaged Using Very High-Resolution Shallow Seismics

R.A.F. Dalman*, T. Missiaen, D.A.S. Ranawijaya, S.B. Kroonenberg,
J.E.A. Storms, & J.B. Reinink

*Applied Geology, Geotechnology, Delft University of Technology, Delft, The Netherlands

Introduction

The late-Holocene Mahakam Delta, located along the tropical eastern shore of Kalimantan, Indonesia, prograded seaward about 60 km during the past 5000 years (Allen, 1979), under conditions of rising sea level. Simultaneously, the subaqueous rollover point prograded 100 kilometers. The Mahakam river supplied very large amounts of sediment during the progradation event, as the average water depth was 60 m (Roberts & Sydow, 2003) resulting in a significant delta volume. The Mahakam delta is a unique delta because of the strict separation of fluvial and tidal domains. Additionally the similarities to the hydrocarbon-producing Miocene delta make it a unique opportunity to study a recent reservoir analogue in a practically unchanged location and sedimentary setting (Allen et al, 1976; Allen and Chambers, 1998). The sedimentary architecture of fluvial channel sands and mouthbar amalgamations encased in marine and tidally deposited claystones make for a complex reservoir setting. By characterizing the recent analogues we hope to better understand the distribution of highly permeable zones in the ancient deposits. The sedimentary dynamics are studied using novel very high-resolution geophysical surveys, corings, and radiometric datings, in order to construct a 3-D conceptual sedimentary model describing the evolution of mixed tide-fluvial processes during Holocene sea-level rise.

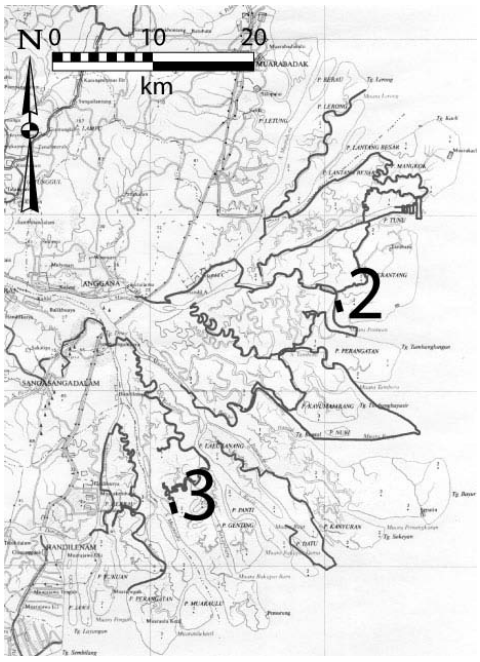

Figure 1; location of the echosounder profiles. The location of the examples are indicated; 2 (Figure 2) and 3 (Figure 3).

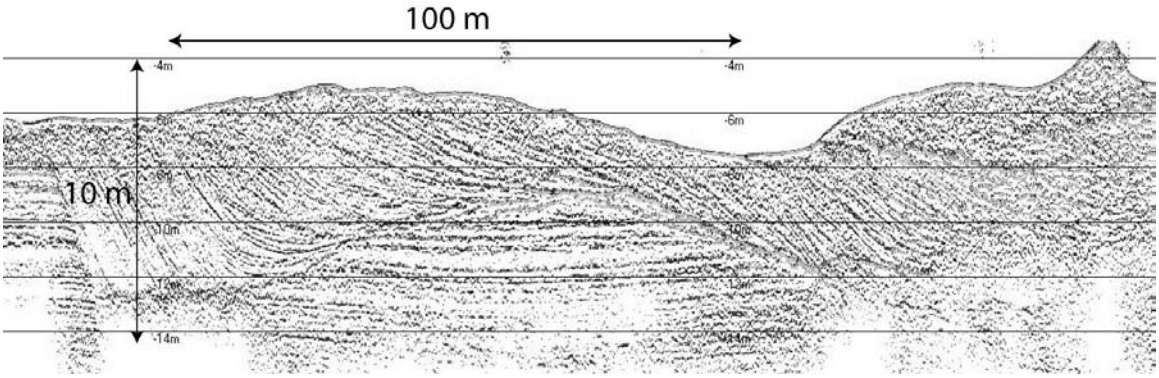

Figure 2; Cross-section profile of a channel fill in a meander bend of a tidal channel. Note the change in elevation of the paleo-channel floor. The channel is filled by lateral accretion; changes in angle are most likely caused by change in direction of accretion.

Echosounder profiling

Most previous work on seismic and core data, focused beyond the sub-tidal zone, therefore the extension of the distribution of deltaic facies in relation to tidal- and fluvial dynamics remains unexplored. We made a detailed very high-resolution seismic/bathymetric survey of the delta platform in the tidal zone up into the fluvial and tidal channels using the Innomar Parametric Echosounder (**www.innomar.com**) in the delta channels and over the subaqueous delta front. This innovative instrument is capable of producing images of the subsurface with a resolution on dm scale; moreover data can be obtained at very shallow water depths (1 m). Unprecedented detail in the subsurface characterization was obtained, the locations of the profiles are provided in figure 1. Due to the widespread presence of shallow gas (most likely of biogenic origin, a result of decomposing plant and root fragments) the acoustic penetration was mostly limited to 10-12 m, but occasionally increasing up to 20 m or more. Figure 2 shows a profile of a composite channel-fill, shot in a tidal channel. Most seismic profiles were shot in the tidal channels, as the fluvially dominated channels are too sandy to allow penetration with an echosounder. Careful interpretation of the data is necessary as much of the profiles were shot in highly sinuous tidal channels, thus cross-cutting many subsurface features. Figure 3 illustrates prograding clinoforms that gradually change to a more aggradational stacking pattern.

Coring

Ten shallow corings (up to 25.5 m bsf) were carried out, which allow us to study a continuous sections of submerged deltaic sediments in high detail and tie sedimentary facies to the high resolution seismic profiles.

Future work/discussion

Dating and grainsize analysis of the shallow cores was performed to reconstruct the sealevel curve for East Kalimantan and to link the Holocene sea level to changes in the depositional pattern. In combination with 3D interpretation of the seismic data we obtain a static model of sedimentary architecture of the late Holocene delta and relate this to

autogenic or allogenic forcing mechanisms. The strong biogeomorphological influence on depositional pattern and sedimentary architecture will be further explored. The

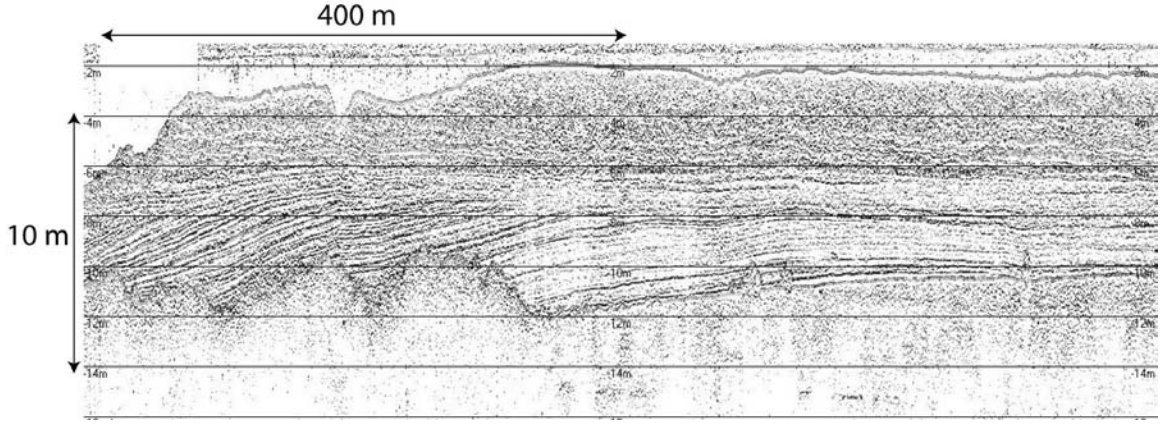

Figure 3; Prograding clinoforms overlain by aggrading parallel beds shot in a tidal channel. Note the irregular surface at 10-12 m bsf, most likely caused by the upward migration of shallow gas.

apparent robust segregation of fluvial and tidal channels will be analyzed, to determine whether the segregation fluctuates through time or is truly constant.

In order to better understand the Holocene development of the Mahakam Delta, the quantitative data generated by the echosounder profiles and corings will be used to calibrate a 3D numerical simulation. This will be done with a combination of high-resolution morphodynamical and basin-scale, stratigraphic models.