Sand-Rich, Tide-Dominated Deltaic Systems of the Lower Miocene, Central Sumatran Basin, Indonesia*

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Introduction

The Central Sumatran Basin is a Neogene foreland basin that hosts over 100 known hydrocarbon fields. Most are in the Miocene Sihapas Group, which consists of sand-rich, tide-dominated deltaic systems and updip fluvial equivalents. Operations such as the Duri steamflood, with nearly 8000 wells within an area of 200 km^2, provide a unique opportunity to study the stratigraphic architecture of tropical tidal deltas in a low accommodation-space setting. The preserved depositional systems tracts extend from updip deposits dominated by fluviotidal channels, into downdip delta-front deposits dominated by inclined tidal-marine sands and muds. These in turn transition into shelf systems, in which delta front deposits intertongue with open marine mudstones, sandy foraminiferal grainstones, and cross-bedded glauconitic sands. Individual sequences record deltaic progradation followed by delta abandonment, but the entire interval is grossly transgressive and capped by marine shales of Middle Miocene age. Geometries and facies proportions vary laterally and vertically, reflecting complex relationships between sediment supply, fluviotidal energy, accommodation space generation, sea-level change, and location in the systems tracts.

Progradational Deltaic Model

Tide-dominated deltas have complex morphologies, with single or multiple distributary channels and complex tidal-creek networks. The map view cartoon (Figure 1) distills the major components into one conceptual system.

Parasequence architecture reflects fluctuations between two idealized end-member geomorphic profiles. When fluvial sediment supply was abundant, the system aggraded towards the profile of a fluvial-dominated distributary and mouth bar complex (red profile, Figure 2). Conversely, when sediment supply waned, tidal currents re-sculpted the mouth bar into subtidal bars and channels, and the subaqueous delta platform prograded seaward. Meandering tidal channels simultaneously robbed saltation load from the channels of the lower delta plain and transported a significant portion of it seaward (blue profile, Figure 2). Mangroves stabilized mud on the lower delta plain.

Two-Tiered Model

A two-tiered architecture is proposed for the most complete and expanded progradational delta-front sequences. The lower tier consists of gently inclined marine bar sands and muds, and the upper tier contains proximal mouth bar and fluviotidal distributary channel deposits (Figure 3). In fully expanded sequences, the two tiers are separated by a pronounced surface of shallow marine erosion and sediment bypass or a thin zone containing an amalgamation of these surfaces. This ravinement surface is inferred to be grossly regressive, not transgressive, in nature. It is inferred to be the stratal record of the subaqueous delta platform. The relative proportion of fluviotidal channels to proximal mouth-bar deposits in the upper tier is variable, probably reflecting variations in the balance between sediment supply, tidal energy, and rate of accommodation. In settings with less accommodation space, the fluviotidal channels of the upper tier scour deeply into the lower tier and remove most or all of it.

Figure 4 is a depositional-dip correlation panel of wireline logs from a field with dense well control. The brown shading in each track is shale volume (Vsh), from 0 to 100%. Rose spikes are portions of the porosity curve with values between 0 and 30% total porosity; most rose spikes are thin carbonate-cemented lags. The green-filled curve is oil saturation (1-Sw), from 0 to 100%. The display is flattened on a transgressive marine flooding surface. A marine highstand surface in the overlying sequence is also marked with a dashed line. Compare the shingled sand units above the lower flooding surface to the right-hand portion of the previous cartoon.

Figure 5 is a depositional-strike correlation panel from a more expanded sequence which overlies the above example. Compare it to the left-hand portion of Figure 3.

Figure 6 is a panel that runs subparallel to depositional strike. Three sequences are illustrated, and they are increasingly marine-dominated up-section, reflecting long-term Early Miocene sea-level rise. The line is flattened on a transgressive marine ravinement surface which is overlain by marine very fine sands, silts, and muds. There is a shingled nature of the marine tidal bar sediments in the lower tier. The red dashed line in Figure 6 is inferred to be the coalescence of subaqueous delta-platform surfaces.

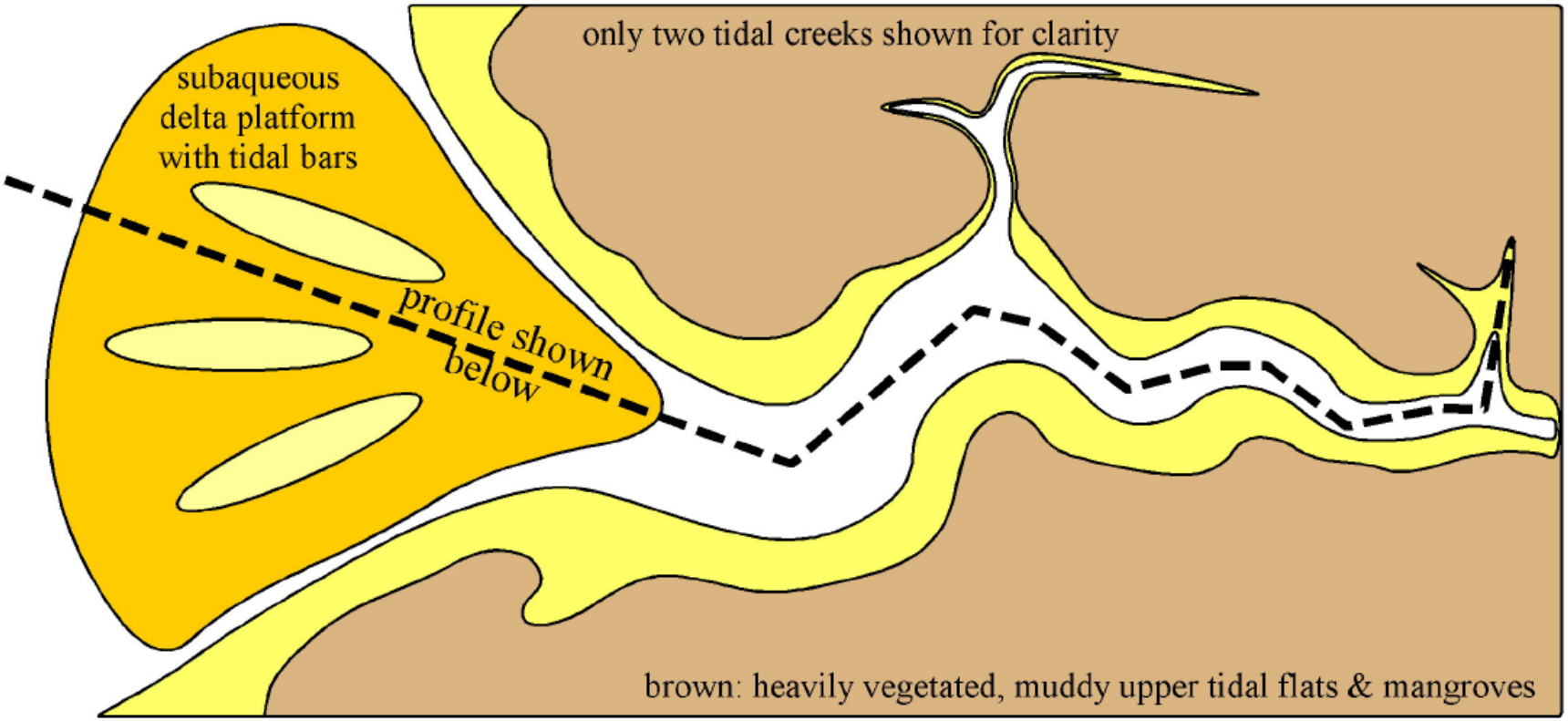

Figure 1. Schematic map of tide-dominated delta, with its various components.

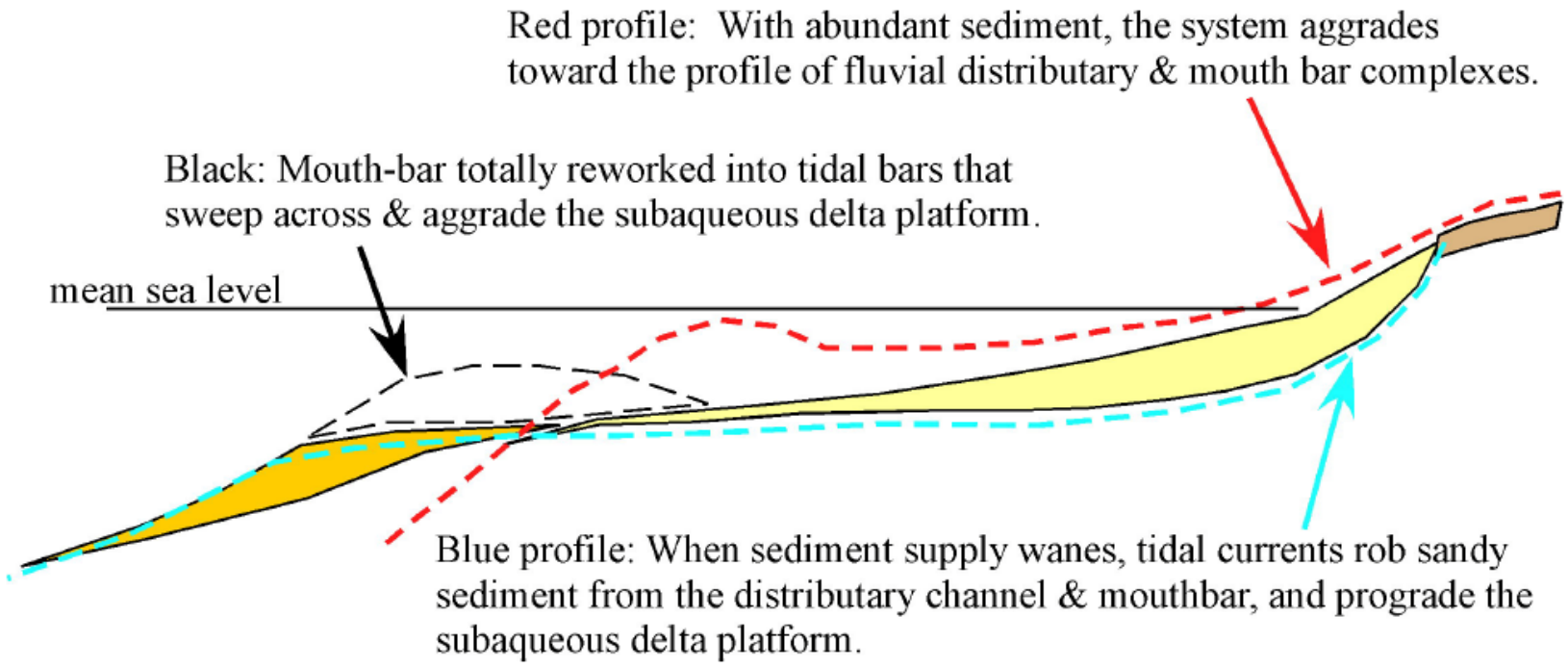

Figure 2. Schematic geomorphic profiles, of a fluvial-dominated complex (red) and, conversely, of a later tide-dominated setting (blue).

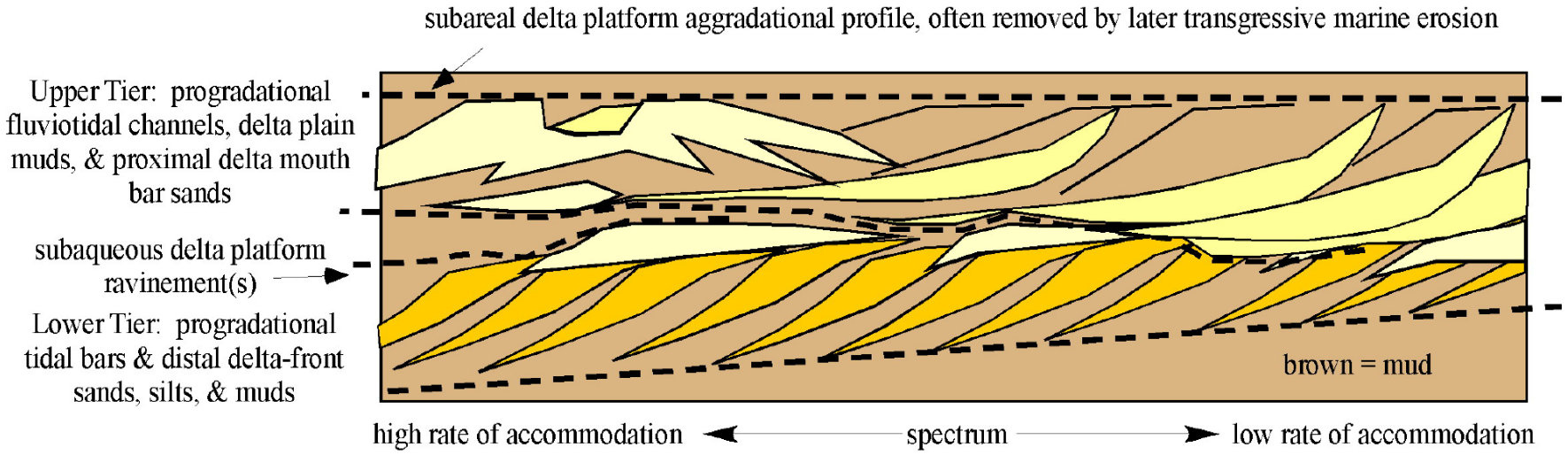

Figure 3. Lower tier and upper tier depositional model.

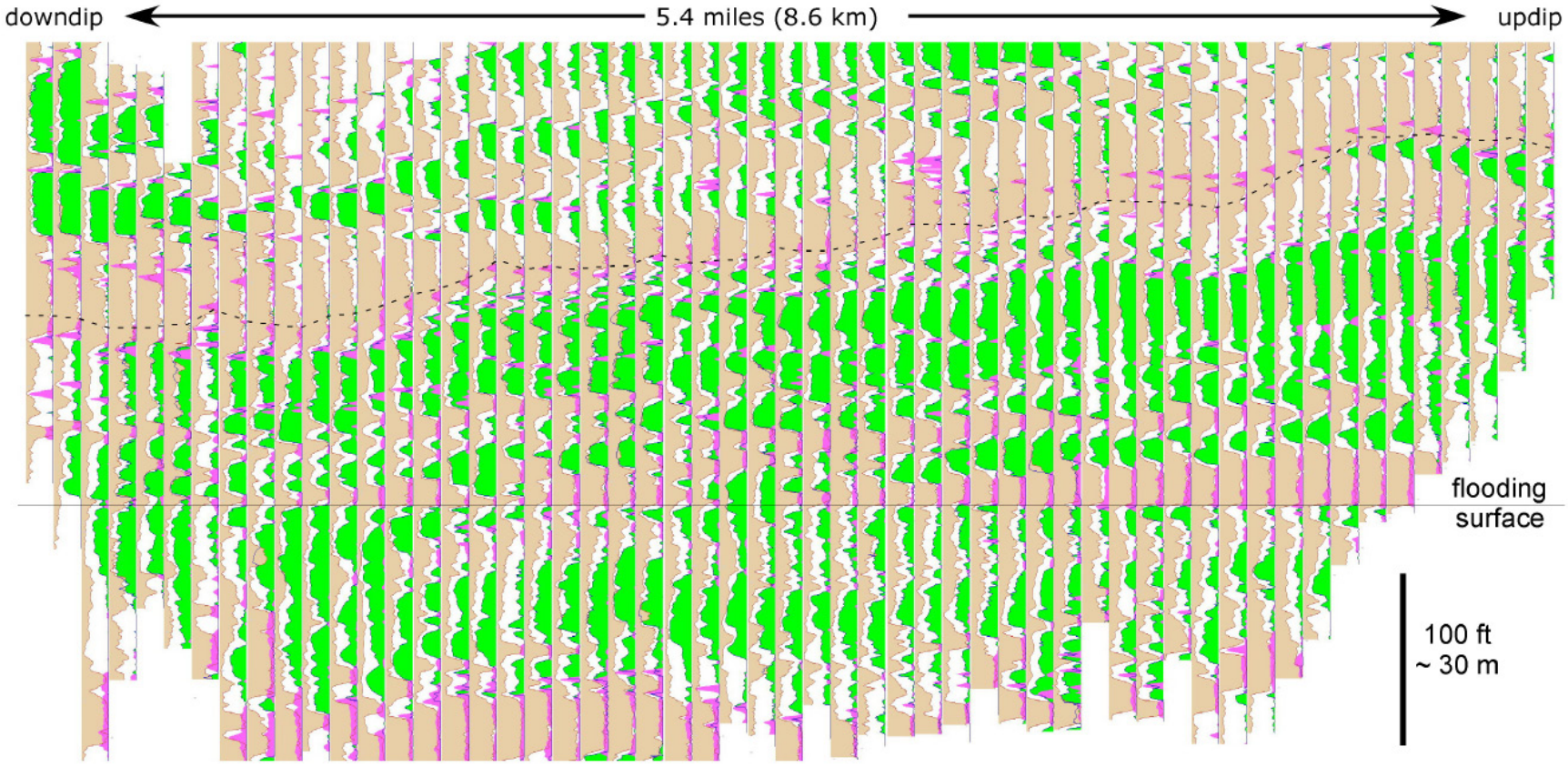

Figure 4. Depositional-dip correlation panel of composite wireline logs (Vsh, porosity, oil saturation) from a densely drilled field.

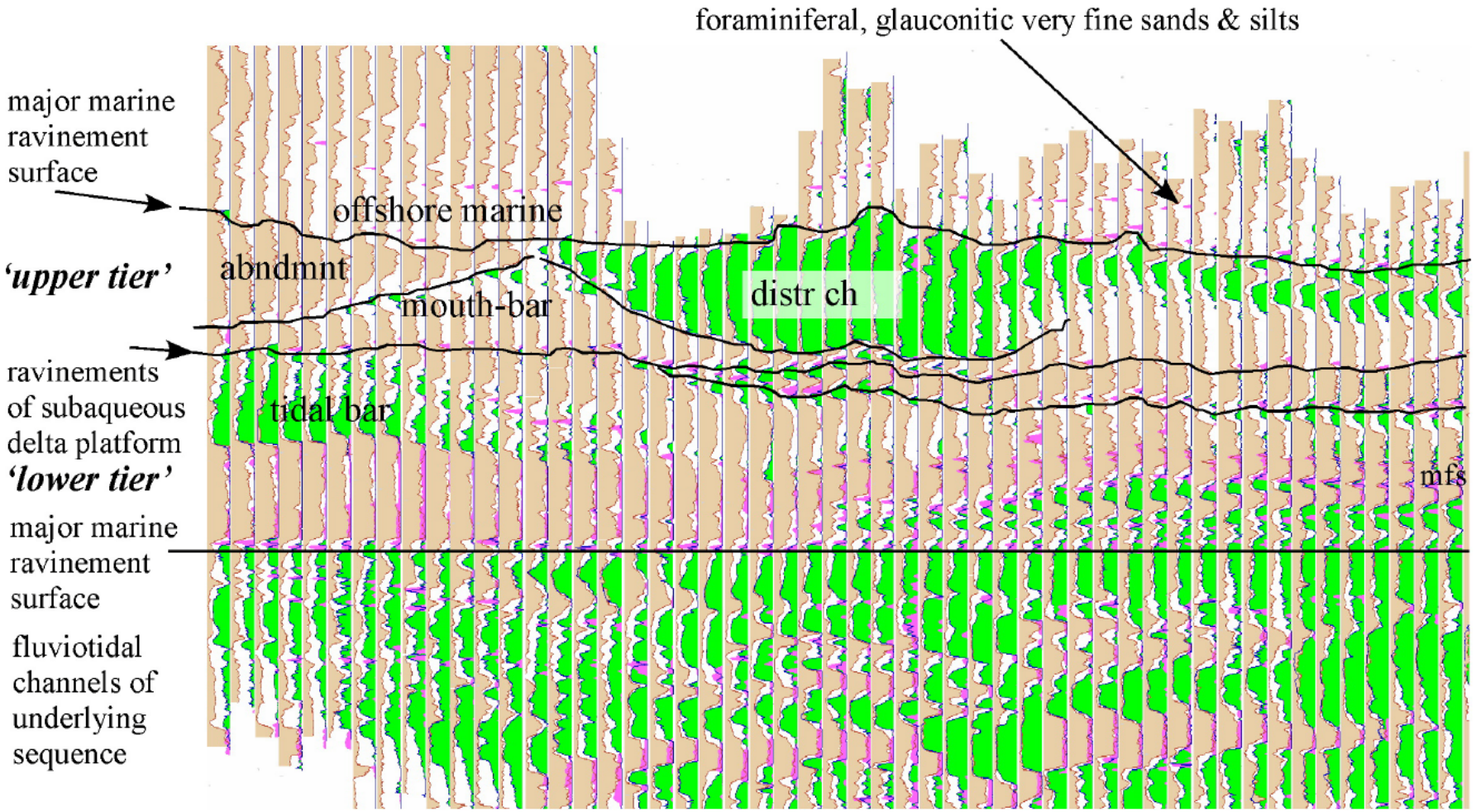

Figure 5. Depositional-strike correlation panel of composite wireline logs (Vsh, porosity, oil saturation) from a more expanded sequence in a densely drilled field.

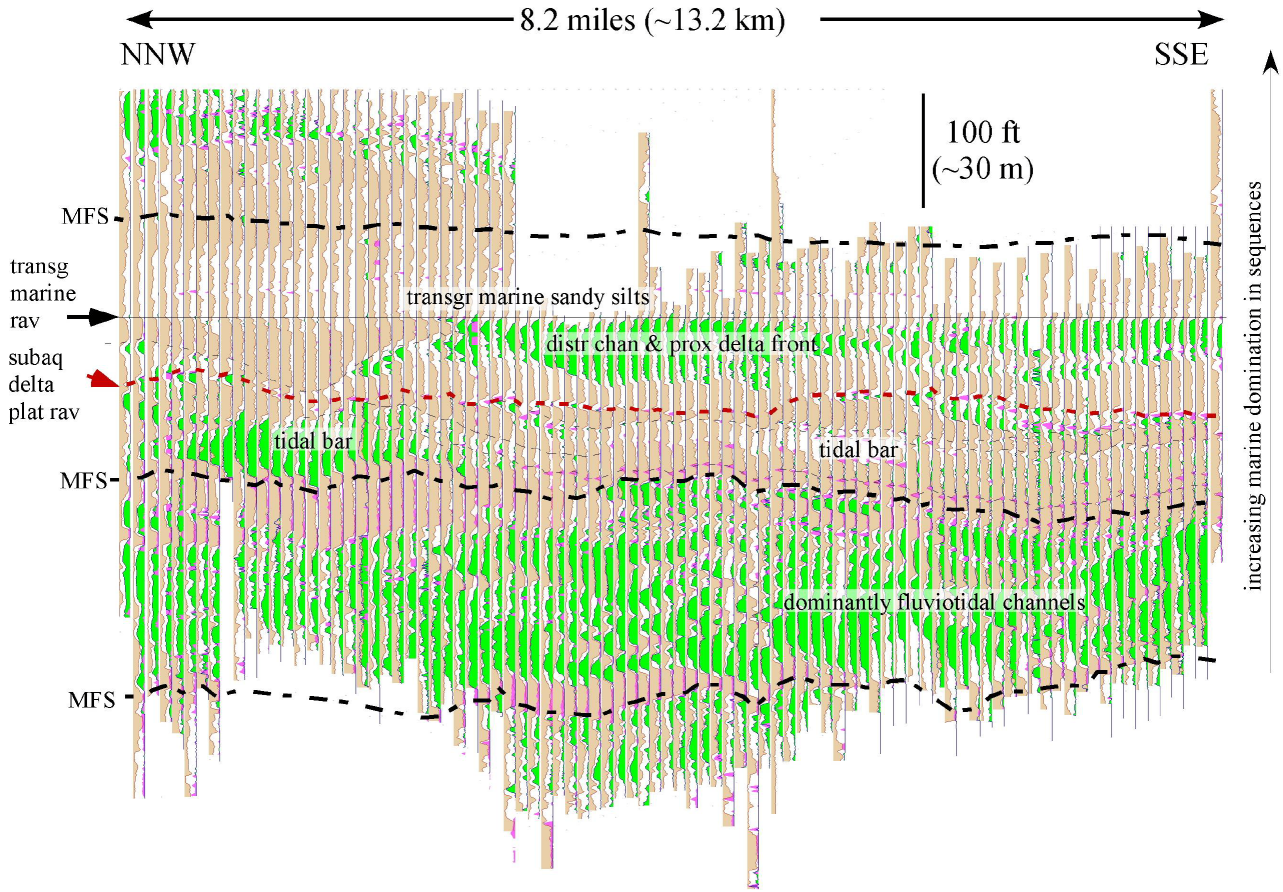

Figure 6. Correlation panel of composite wireline logs (Vsh, porosity, oil saturation) that runs subparallel to depositional strike, showing three sequences.