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Facies architecture of an ancient delta front deposit using GPR: Cretaceous Wall Creek Member, Frontier Formation, Wyoming

Very few studies investigate the bed-scale facies architecture of deltaic depositional systems in outcrop, despite the economic importance of deltas in hydrocarbon production worldwide. Outcrops represent analogs for improved subsurface reservoir characterization. In this study, we integrate outcrop sedimentology and shallow subsurface Ground Penetrating Radar (GPR) to image and map the 3D facies architecture of dipping, river-dominated delta front sandstones and mudstones in the Turonian Wall Creek Member of the Frontier Formation, in Wyoming. Regionally, the Wall Creek Member shows a mixture of different upward coarsening facies successions associated with distinctly different overlapping sandstone bodies separated by prodelta mudstones that form in different delta lobes. The southern lobe, which is the focus of our study, is about 15 m thick. It grades upward from burrowed to current rippled sandstones, interbedded with oyster-bearing mudstones, into structureless to flat stratified and ripple cross-laminated sandstones interpreted as delta front turbidites. Photomontages along depositional dip show inclined beds dipping southeast, in the same direction as paleocurrents, suggesting that they are delta front clinoforms. Three line-kilometers of 50 MHz GPR data were acquired and processed on a coarsely-spaced 2D grid of lines lying parallel and perpendicular to depositional dip. Dip lines show offlapping clinoform beds with tangential bottomsets that match those observed in the outcrop. Strike-lines show mounded, lens-shaped geometries, suggesting that individual delta front bodies are about 0.5 km wide. This 2D grid is the basis for quantifying large-scale facies architecture typically not imaged by the relatively low resolution of 40Hz seismic data.