

Eliminating pull-up below Devonian pinnacle reefs

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ABSTRACT

Velocity pull-up beneath carbonate buildups is a well-understood phenomenon. Pull-up occurs when the carbonate buildups have higher velocities than the surrounding rocks. Winnipegosis pinnacles of the Williston Basin commonly, but not always, are associated with apparent pull-up of underlying horizons, such as the Ordovician Red River Formation. Carbonates of the Winnipegosis have velocities that are much higher (> 6000 m/s) than the overlying Prairie Evaporite (~ 4700 m/s). Furthermore, there are apparent structures at underlying horizons that are not overlain by Winnipegosis pinnacles. Exploring for subtle structures at underlying levels can therefore be challenging. We sought a method to predict pull-up below the pinnacles. We first used forward modeling to constrain the effects of various stratigraphic geometries on pull-up. We found that the primary control should be pinnacle height, and that other factors (e.g., sag at the top of the Prairie Evaporite and inter-pinnacle velocity variations) would have lesser contributions. Conceptually, we could therefore predict pull-up using:

$$\text{Pull-up} = h_{wp}(1/V_e - 1/V_{wp})$$

Where h_{wp} is pinnacle height, V_e is the velocity of the Prairie Evaporite and V_{wp} is the velocity of the Winnipegosis buildup. We used a model-based inversion to predict the velocity of the evaporite and the pinnacles, and derived pinnacle height from seismic mapping. In so doing, we could predict pull-up due to Winnipegosis buildups. Our maps allow us to correct for these effects at the Red River level. These maps show us where other effects (e.g., sag at the top of the Prairie Evaporite) also are important.