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Tidal Rhythmites as High-Resolution Chronometers for Basin Analysis

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The Upper Mississippian (~325 Ma) Pride Shale and Glady Fork Member in the Central Appalachian Basin comprise an upward-coarsening, ~60m-thick succession of prodeltaic-delta front, interlaminated fine-grained sandstones and mudstones gradational upwards into mouth bar and distributary channel sandstones. Analysis of submillimeter- to meter-scale cycles in the Pride Shale reveals a hierarchical bundling of tidal- and climate-forced processes identified by Miller and Eriksson [1]. Sandstone/siltstone-shale couplets between 0.01 and 1 mm thick are interpreted as suspension fallout deposits related to semi-diurnal, ebb-tidal flows associated with the dominant tide of the day. Rare thick-thin pairs record diurnal dominant and subordinate tides. Up to 17 couplets display a progressive upward thickening and thinning in 0.1 to 3 cm thick neap-spring (semimonthly) tidal cycles. Up to 18 neap-spring cycles are arranged in upward thickening and thinning bundles that range from 2 to 50 cm thick and reflect annual cyclicity (Fig. 1) resulting from seasonal fluvial discharge. Annual cyclicity is interpreted to reflect climatic (seasonal) driven cycles related to monsoonal and intermonsoonal periods. These tidal rhythmites thus represent high-resolution chronometers that can be used in basin analysis. Annual cycles average 10 cm in thickness, thus the bulk of the Pride Shale-Glady Fork Member in any one vertical section is estimated to have accumulated in ~600 years. Progradational clinoforms are assumed to have had dips of 0.3-3° with a median dip of 1.7°; the latter infilled a NE-SW oriented foreland trough up to 300 km long by 50 km wide in the relatively short time period of 90 kyr. The total volume of sediment in the Pride basin is ~900 km^3 which, for an average sediment density of 2700 kg/m^3, equates to a total mass of ~2.4 x 10^6 Mt. Thus, mass sediment load can be estimated as 27 Mt/yr. For a drainage basin area of 89,000 km^2, based on the scale of architectural channel elements and cross-set thicknesses in the incised-valley-fill deposits of the underlying Princeton Formation, suspended sediment yields are estimated at ~310 t/km^2/yr equating to a mechanical denudation rate of ~0.116 mm/yr. Calculated sediment yields and inferred denudation rates are comparable to modern rivers such as the Po and Fly and are compatible with a provenance of significant relief and a climate characterized by seasonal, monsoonal discharge. Inferred denudation rates also are consistent with average denudation rates for the Inner Piedmont Terrane of the Appalachians based on flexural modeling.

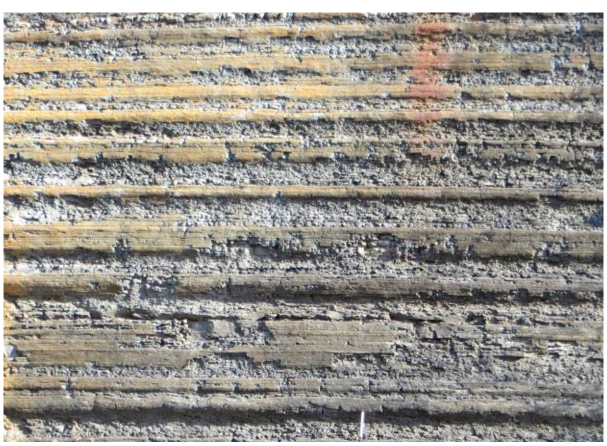

Figure 1: Decimeter-scale annual cycles at roadcut along I-77, southern West Virginia. Each furrow-rib-furrow contains up to 18 neap-spring-neap cycles. Annual cycles reflect monsoonal-intermonsoonal climatic changes. Scale bar is 15 cm long. From Eriksson and Romans, [2]

Reference:
[1] Miller and Eriksson (1997) J Sediment Res B67: 653-660
[2] Eriksson and Romans (2016) Basin Res In press