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Siliciclastic sedimentation and basin subsidence in the latest Pennsylvanian western Orogrande basin, southern Ancestral Rocky Mountains

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The mixed carbonate-siliciclastic, Upper Pennsylvanian (Virgilian) section of the western Orogrande basin (New Mexico) records the interval of most rapid subsidence in the basin, but remains only cursorily studied owing to its location on the restricted White Sands Missile Range (WSMR). We focused on facies, sequence stratigraphy, paleodispersal of siliciclastic strata, and thickness trends of the Upper Pennsylvanian section (Panther Seep Formation and equivalents) in the San Andres and Oscura Mountains (WSMR) in order to better assess paleogeography and basin subsidence in this southernmost Ancestral Rocky Mountains basin.

Detailed field observations indicate three distinct siliciclastic facies associations that include relatively isolated occurrences of fluvial facies throughout the study region, transitional (deltaic facies) predominating in the central region (Rhodes and Hembrillo canyons, San Andres Mountains), and shallow marine facies in the south (Ash Canyon, San Andres Mountains). Fluvial facies consist of 5-10 m thick, lenticular packages of basal conglomerate, fining-upward sandstone to siltstone, and rare red mudstone. Transitional (deltaic) facies consist of 20-50 m thick packages of coarsening-upward claystone to fine sandstone (pro-deltaic to mid-deltaic deposits), overlain either by a tabular unit of coarsening-upward sandstone (mouth-bar deposits) or a lenticular, fining-upward sandstone (deltaic distributary channel deposits). Shallow marine facies consist of 1.5-15 m thick, laterally continuous, medium to fine sandstone displaying rare hummocky cross-stratification, pervasive convolute stratification, and abundant (up to 50%) sand-sized carbonate lithoclasts, bioclasts and allochems (e.g., ooids). For lower to middle parts of the study sections, paleocurrents from fluvial and deltaic sandstones record southwesterly directed flow, and shallow-marine sandstones exhibit a west-southwest direction. In contrast, paleocurrents from fluvial units in upper parts of the sections exhibit southeasterly directed flow.

The pervasive high-frequency cyclicity of the Upper Pennsylvanian section reflects extreme shifts in relative sea level, documented in several previous studies as the result of high-amplitude glacioeustasy associated with widespread Late Paleozoic glaciation (Schoderbek, 1994; Soreghan 1994; Soreghan and Giles, 1999). Such high-amplitude variations operating in an epeiric sea, resulted in the rather odd juxtaposition of normal marine carbonate (with or without clastics) truncated by surfaces of subaerial exposure in shelf regions, and peritidal carbonates with marine (and locally non-marine) clastics in basinal regions. This scenario of open-marine carbonates on the shelf and restricted marine deposition in the basin has been well documented in the eastern Orogrande basin and has been termed cyclic and reciprocal sedimentation (Wilson, 1967; Raatz and Simo, 1998; Rankey et al., 1999).

During lowstands, shelfal areas were exposed and calcretes developed atop normal-marine carbonates. Basinward, peritidal carbonates accumulated, and were exposed only during lower 3rd order sea level fluctuations during which initial transgression was marked by clastic sediment bypassing the shelf and deposited in the basin sharply above peritidal carbonates. As sea level continued to rise, clastic deposition shifted northward and southwesterly prograding deltas developed in the central region, whereas offshore shale dominated deposition in the basin. As sea level reached highstand, shelfal areas were ultimately submerged allowing for normal-marine carbonate accumulation, while minimal clastics reached the basin. Sea level fall exposed the shelf areas as clastic sediment bypassed these regions and was deposited basinward in shallow-marine settings sharply atop offshore shale. These shallow-marine sandstones represent the falling stage systems tract of Plint and Nummedal (2000) in forced regressive systems (Posamentier and Morris, 2000).

The latest Pennsylvanian represents the most rapid pulse of basin subsidence with > 800 m of strata (compacted) deposited in a relatively short interval. Thickness trends indicate that the basin exhibits a rhombic shape with pronounced hingelines on the east, southeast, and west basin margins, and less pronounced hingelines to the north and southwest, possibly reflecting the influence of basin-margin fault systems on sediment distribution. North to south thickness trends, paleocurrents, and depositional environments suggest that the Orogrande basin was a north to south oriented ramp. Isopach patterns also indicate that local highs existed syndepositionally and caused development of intraformational unconformities (e.g., Soreghan, unpublished data, Caballo Mountains). A shift in paleocurrents from southwesterly directed flow in the lower to middle Virgilian sections to southeasterly flow in the upper part of the sections records a change of clastic source areas from the northeast during early-middle Virgilian to the northwest during late Virgilian. Similarly, these changes record a shift in the basin depocenter from the southwest part of the basin during early-middle Virgilian to the southeast during late Virgilian.

Evidence of rapid subsidence, shifting depocenters, intraformational unconformities, and rhombic fault-bounded basin geometry are all consistent with an origin in a transcurrent system. The Late Pennsylvanian (Virgilian) of the Orogrande basin exhibits a diverse array of depositional facies that is characterized by abrupt lateral facies variations. Greater than 800 m of sediment (compacted) accumulated in the Orogrande basin during the Virgilian, relfecting a relatively short time interval of maximum basin subsidence. These data along with the location of possible fault-controlled hingelines along basin margins suggest that the Orogrande basin may have tectonically resembled a transcurrent basin (Nilsen and McLaughlin, 1985). The change in depocenters and source areas through time marked by the shift in paleocurrent directions are indicative of continued lateral movement along basin-margin fault systems (Nilsen and McLaughlin, 1985). This is consistent with previous work that suggests at least a moderate amount of right-lateral deflection along a dominantly, north-south oriented Pennsylvanian fault system implying that the Orogrande basin resembles a stepover basin (e.g., Singleton, 1990; Beck and Chapin, 1995; Nilsen and McLaughlin, 1995; Woodward et al., 1999; Cather and Harrison, 2002).

REFERENCES

Beck, W.C., and Chapin, C.E., 1995, Structure, timing and tectonic interpretation of Ancestral Rocky Mountain deformation within central New Mexico: Oklahoma Geological Society Circular, v. 97, p. 297-300.

Cather, S.M., and Harrison, R.W., 2002, Lower Paleozoic isopach maps of southern New Mexico and their implications for Laramide and Ancestral Rocky Mountain tectonism: New Mexico Geological Guidebook 53, in press.

Nilsen, T.H., and McLaughlin, R.J., 1985, Comparison of tectonic framework and depositional patterns of the Hornelen strike-slip basin of Norway and Ridge and Little Sulphur Creek strike-slip basins of Californian: SEPM Special Publication, v. 37, p. 79-103.

Plint, A.G., and Nummedal, D., 2000, The falling stage systems tract: Recognition and importance in sequence stratigraphic analysis *in* Hunt, D. and Gawthorpe, D.L., eds., Sedimentary Responses to Forced Regressions, Geological Society Special Publication, 172, p. 1-17.

Posamentier, H.W., and Morris, W.R., 2000, Aspects of the stratal architecture of forced regressive deposits *in* Hunt, D., and Gawthorpe, D.L., eds., Sedimentary Responses to Forced Regressions, Geological Society Special Publication, 172, p. 19-46.

Raatz, W.D., and Simo, J.A., 1998, The Beeman Formation (Upper Pennsylvanian) of the Sacramento Mountains, New Mexico: Guide to the Dry Canyon area with discussion on shelf and basin responses to eustasy, tectonics, and climate: New Mexico Geological Society Guidebook, 49th Field Conference, p. 161-175.

Rankey, E.C., Bachtel, S.L., and Kaufman, J., 1999, Controls on stratigraphic architecture of icehouse mixed carbonate-siliciclastic systems: A case study from the Holder Formation (Pennsylvanian, Virgilian), Sacramento Mountains, New Mexico *in* Harris, P.M., Saller, A.H., and Simo, J.A., eds., Advances in Carbonate Sequence Stratigraphy: Application to Reservoirs, Outcrops, and Models, SEPM Special Publication, 63, p. 127-150.

Schoderbek, D.A., 1994, Environments of deposition of patterns of cyclicity of the Panther Seep Formation, southern San Andres Mountains *in* Garber, R.A., and Keller, D.A., eds., Field Guide to the Paleozoic Section of the San Andres Mountains, SEPM Permian Basin Section Publication No. 94-35, p. 87-103.

Singleton, D.S., 1990, Depositional environments and tectonic significance of the Bar B Formation (Virgilian), Sierra County, New Mexico: [M.S. Thesis]: Las Cruces, New Mexico State University, 132 p.

Soreghan G.S., 1994, Stratigraphic responses to geologic processes: Late Pennsylvanian eustasy and tectonics in the Pedregosa and Orogrande basins, Ancestral Rocky Mountains: Geological Society of America Bulletin, v. 106, p. 1195-1211.

Soreghan, G.S., and Giles, K.A., 1999, Amplitudes of Late Pennsylvanian glacioeustasy: Geology, v. 27, p. 255-258.

Wilson, J.L., 1967, Cyclic and reciprocal sedimentation in Virgilian strata of southern New Mexico: Geological Society of America Bulletin, v. 29, p. 5-34.

Woodward, L.A., Anderson, O.J., and Lucas, S.G., 1999, Late Paleozoic right-slip faults in the Ancestral Rocky Mountains: New Mexico Geological Society Guidebook, 50th Field Conference, p. 149-153.