Facies Characterization, Architecture Analysis, and Depositional Environment of Cretaceous-Paleogene Coal Beds and Surrounding Strata within the Raton Basin of Colorado and New Mexico, USA

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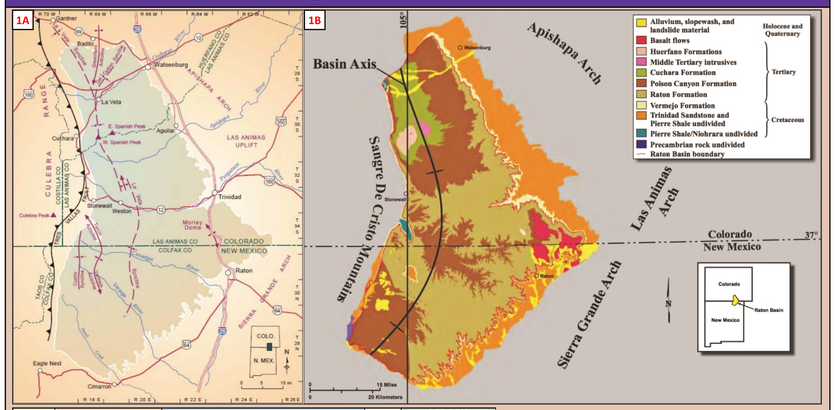
PIONEER NATURAL RESOURCES

Abstract

The Raton Basin of Colorado and New Mexico is a Laramide foreland basin that has been important to coal geology since its first identification as a coal resource in 1821, and as a major Coal Bed Methane resource in the modern era. Raton Basin contains Cretaceous to Paleogene strata representative of the major transgression and subsequent regression of the Western Interior Seaway. The interaction between the distal and proximal lithosomes of strata within the Raton Basin is not fully understood. The coaly, fine-grained rocks of the lower and upper coal zones of the Upper Cretaceous to Paleogene Raton Formation are indicative of deposition in wet, distal lowlands, whereas the coarser grains of the barren series of the Raton Formation indicate that this unit was deposited in a highland setting proximal to the source. While the basin has been explored and produced for petroleum and coal in the past (specifically the Cretaceous Vermejo Formation and Raton Formation), vertical and lateral interaction, geometries, and potential communication between the coal deposits and surrounding fluvial deposits is not well-understood. This project has served as an investigation into the depositional model of the coal deposits and their surrounding fluvial deposits, specifically by: analyzing outcrops using architecture analysis, performing core descriptions and interpretations, conducting coal palynology, organic petrology, and chemical analysis. It has been proposed that the Upper Cretaceous to Paleogene strata of the Raton Basin were deposited within a Distributive Fluvial System (DFS), and that the coal-rich zone is the down-dip expression of this system. Initial results (vertical and lateral relation of facies in core and outcrop, organic petrology, and palynology) reveal that the extensive and laterally continuous coals formed in a woody low-lying fluvio-lacustrine depositional environment, and humid subtropical climate.

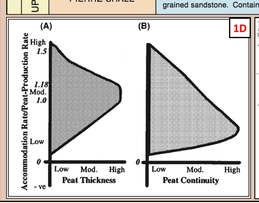
Background Information

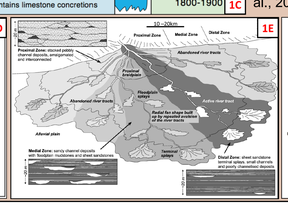


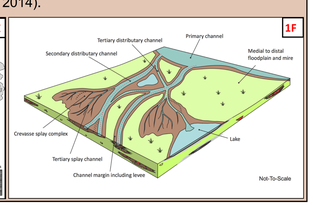
AGE		FORMATION NAME	GENERAL DESCRIPTION	LITHOLOGY	APPROX. THICKNESS IN FEET
TERTIARY	PALEOCENE	POISON CANYON FORMATION	SANDSTONE--Coarse to conglomeratic beds 13–50 feet thick. Interbeds of soft, yellow-weathering clayey sandstone. Thickens to the west at expense of underlying Raton Formation		500+
		RATON FORMATION	Formation intertongues with Poison Canyon Formation to the west UPPER COAL ZONE--Very fine grained sandstone, siltstone, and mudstone with carbonaceous shale and thick coal beds BARREN SERIES--Mostly very fine to fine-grained sandstone with minor mudstone, siltstone, with carbonaceous shale and thin coal beds LOWER COAL ZONE--Same as upper coal zone; coal beds mostly thin and discontinuous. Conglomeratic sandstone at base; locally absent		0(?)–2,100 ← K/T boundary
MESOZOIC	UPPER CRETACEOUS	VERMEJO FORMATION	SANDSTONE--Fine to medium grained with mudstone, carbonaceous shale, and extensive, thick coal beds. Local sills		0–380
		TRINIDAD SANDSTONE	SANDSTONE--Fine to medium grained; contains casts of *Ophiomorpha*		0–300
		PIERRE SHALE	SHALE--Silty in upper 300 ft. Grades upward to fine-grained sandstone. Contains limestone concretions		1800-1900

1C

Figure 1A displays a map of Raton Basin, with major structural features (from Topper, 2011). **Figure 1B** displays a map of Raton Basin, with major lithologic units (from Flores and Bader, 1999). **Figure 1C** is a stratigraphic column of the Cretaceous-Paleogene strata in Raton Basin (from Johnson and Finn, 2001). **Figure 1D** displays major controls on peat deposition and geometry (from Bohacs and Suter, 1997). **Figure 1E** displays the development of an avulsing fan-shaped system over time, with the proximal, medial, and distal zones, and the architectural characteristics, of a Distributive Fluvial System (DFS) highlighted (from Nichols and Fisher, 2007). **Figure 1F** displays the typical facies associations and architectural relations in a low net-gross high accommodation fluvial overbank setting (from Stuart et al., 2014).



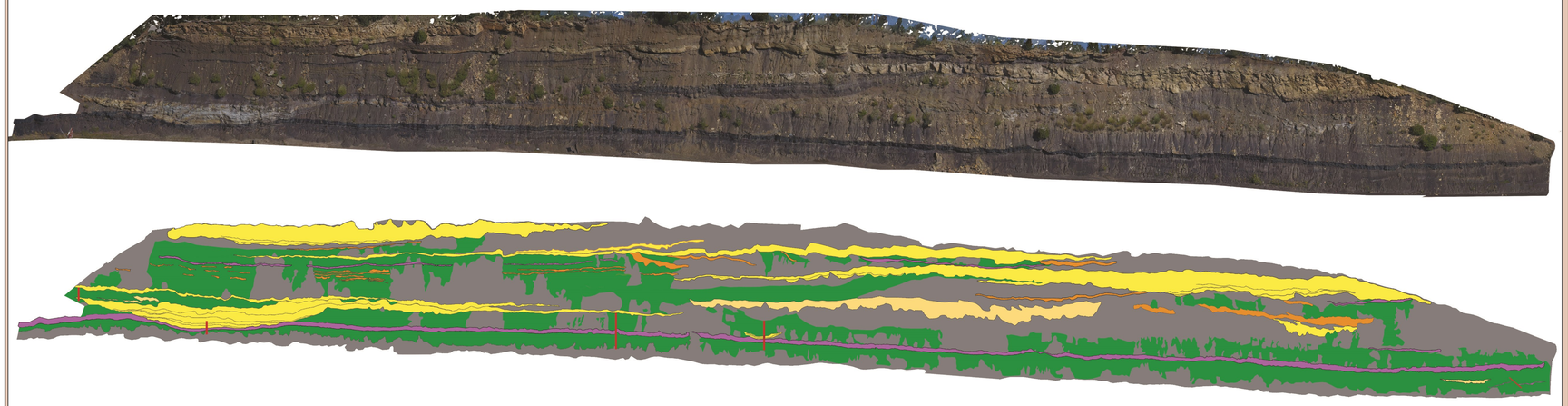




Results

2A

Plate 1: Trinidad Lake State Park Digital Outcrop Model and Interpretation



Legend

Channel-Belt Assemblage	Splay / Sand Sheet Assemblage	Floodplain-Backswamp Assemblage	Additional Features
Channel-belt	Splay / Sand Sheet	Coal/Carbonaceous Mudstone	Cover
Mud-Filled Channel		Lacustrine	

Indicates Measured Section — 20 m — N

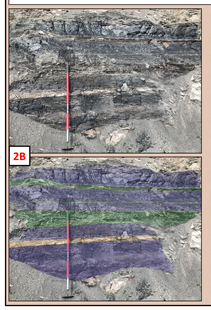
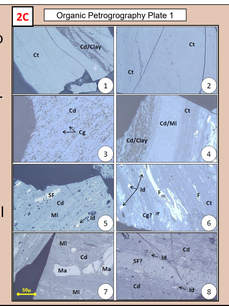
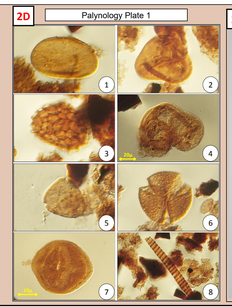
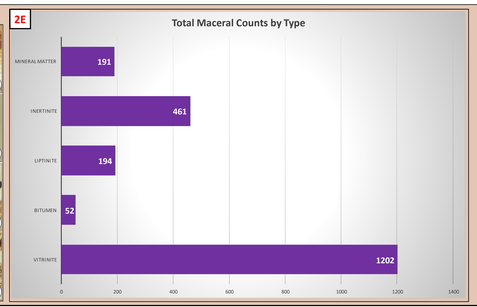


Figure 2A displays an unannotated and annotated digital outcrop model of Trinidad Lake State Park Outcrop. **Figure 2B** displays an unannotated and annotated photograph of coal (purple), sandstone (yellow), and mudstone (green). **Figure 2C** and **2D** display two plates of organic petrography and palynology analysis, respectively. Figure **2E** is a graph depicting total maceral count results from seven coal samples. **Figure 2F** is a collection of preserved and coalified roots and trees in study outcrops.







Discussion, Conclusions, and Modern Analog

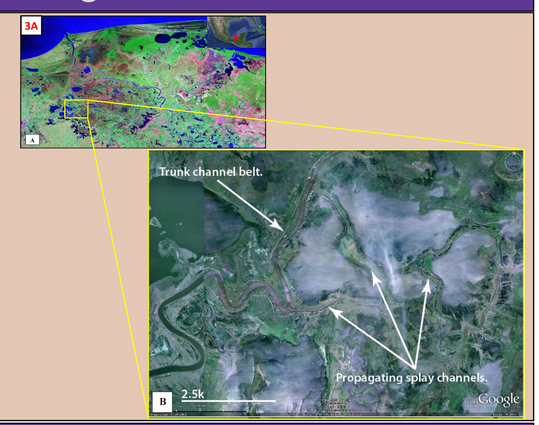
. Organic petrography results from coal samples in this study reveal a vitrinite-dominated (woody) coal composition (**Fig. 2E**).

. Sparse palynology results (counts not possible due to lack of spores) included a dominance of fern spores, which suggests a wet paleoenvrionment. Analysis also reveals a relatively high abundance of non-descript lacustrine algae. Palynofloral assemblage suggests that standing water was present during the life of the mire (Demchuk, Personal Comm.) (**Fig. 2D**).

. Core and Outcrop analysis reveals that coals are most commonly vertically and laterally associated with carbonaceous mudstone lithologies.

. **The combination of the coals and the carbonaceous mudstone deposits are interpreted to be representative of a lacustrine lithosome, and the depositional system for the Upper and Lower Coal Zones of the Raton Formation is interpreted to be a fluvio-lacustrine system.**

. It is determined that a possible modern analog for this ancient peat-forming depositional environment is the Grijalva flood plain lake in the Tabasco, Mexico (**Figure 3A**).



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