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PREVIEW

STRATIGRAPHIC FACIES ANALYSIS OF THE UPPER SANTA FE  
GROUP, FORT HANCOCK AND CAMP RICE FORMATIONS,  
FAR WEST TEXAS AND SOUTH-CENTRAL NEW MEXICO

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by

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THESIS

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## ABSTRACT

The Pliocene-Pleistocene (Blancan) Fort Hancock Formation and the Pliocene-Pleistocene (Blancan?-Irvingtonian) Camp Rice Formation are the uppermost units of the Middle (?) Miocene-Pleistocene Santa Fe Group in the Hueco and Mesilla bolsons near El Paso, Texas.

The Fort Hancock Formation consists of sediments deposited in three paleodepositional settings, each of which has been informally designated a facies because each reflects an essentially different depositional environment. The first is the playa/lacustrine facies, best exposed in the southern end of the Hueco bolson. This facies grades northward into the meandering fluvial facies, which is best exposed at the stratotype of the Fort Hancock Formation. Finally, there is the sandy, braided, fluvial facies. This facies is volumetrically predominant in the surface exposures within the two bolsons. Alluvial fan deposits interfinger with each facies. This caused local variations in the paleodepositional environments.

The Camp Rice Formation overlies and is partially incised into the Fort Hancock. It is a fluvial deposit similar to the Donjek or Platte-type deposits described by Miall (1977).

A fossil leporid, Aluralagus virginiae, was recovered from the uppermost part of the Fort Hancock Formation at the Strauss section, Dona Ana County, New Mexico. This places the top of the Fort Hancock, in the Mesilla bolson, near the Blancan-Irvingtonian boundary. As currently defined, the Blancan-Irvingtonian boundary corresponds closely to the Pliocene-Pleistocene boundary. However, precise age correlations of these two formations must await other, more precise, methodologies such as paleogeomagnetic studies. The fossil evidence now available apparently lacks the necessary precision for an accurate age determination.

This paper contains two major departures from previous studies. The presence of Aluralagus virginiae indicates a near contemporaneity between the Fort Hancock Formation and the St. David (Arizona) Formation. Also, the Fort Hancock Formation is interpreted as containing a meandering fluvial facies which is best exposed in the type area.



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PREVIEW

## INTRODUCTION

### Purpose of Study

There is general agreement that the Fort Hancock and Camp Rice formations are the upper units of the Santa Fe Group in the Hueco and Mesilla bolsons of far West Texas and south-central New Mexico and in the Bolson de los Muertos in northern Chihuahua, Mexico. However, there is a current conflict of interpretation concerning the depositional environments of the two formations.

Strain (1966, 1970), Hawley (1975) and others believe the Fort Hancock Formation reflects a lacustrine (playa) depositional environment. They believe that the Camp Rice Formation was fluvially deposited.

Lovejoy (1976a, b), Willingham (1980), and Stuart and Willingham (in review) believe that the Fort Hancock Formation exhibits a lithofacies change between the type area, near McNary, Texas, and Las Cruces, New Mexico. The sediments (the term "sediments," as used in this study is that used by Pettijohn [1975], "sediment is generally, but not always, deposited from a fluid in which it was contained either in a state of suspension or solution. This definition encompasses most of the materials considered sediments (or sedimentary rocks)" [p. 1]) exhibit an overall



increase in grain size northward from the type section. This lithofacies change, in their opinion(s), is the result of a southward decrease in the competency of the fluvial system responsible for depositing the Fort Hancock. Also, Willingham (1980) places the Fort Hancock-Camp Rice boundary, in Campo Grande Arroyo, stratigraphically higher than Strain, placing it just below the level of the Pearlette type B (Huckleberry Ridge) ash in Campo Grande Arroyo. This corresponds roughly with the contact between Strain's lower and upper Camp Rice members. The purpose of this study, then, is to attempt to determine which--if either--of the two interpretations is correct.

I have undertaken a detailed stratigraphic analysis with particular attention to sedimentary facies. By so doing, I believe a determination can be made concerning which contact, Strain's or Willingham's, is correct.

A further consideration in this study is the age correlation of the Fort Hancock and Camp Rice formations.

#### Previous Work and Historical Background

Hayden (1869) was the first to use the term Santa Fe "marls" in describing the "recent marls and sands which seem to occupy the greater portion of the Rio Grande, above and below Santa Fe" (p. 166). In 1922, Darton raised the status of these units to that of formation, referring to them as the Santa Fe Formation. The geological (depositional)

context in which these sediments are today considered was first developed by Bryan (1938). He used the term Rio Grande depression to delineate a series of physiographic and structural basins extending from southern Colorado to, and beyond, El Paso, Texas. Work by others in the 1930s and 1940s (principally Cabot, 1938; Church and Hack, 1939; Denny, 1938, 1940a, b; Smith, 1938; and Wright, 1946) increased knowledge of the Late Cenozoic (Middle [?] Miocene-Pleistocene) sediments in the Rio Grande depression.

The term Santa Fe Group was proposed by Baldwin (1956). He proposed that the middle unit in the Santa Fe area, the unit which had until then been referred to as the Santa Fe Formation, be renamed the Tesuque Formation. The lower limit of the Santa Fe Group in the Santa Fe area would then be the "top of the Espinazo volcanics and Cieneguilla limburgite, and . . . the base of the Abiquiu (?) Formation of Stearns (1953). The upper limit of the Santa Fe Group is chosen to exclude only alluvium and terraces of present drainage" (Baldwin, 1956, p. 116). Spiegel and Baldwin (1963) officially proposed that the term Santa Fe Group be applied to the sediments and rocks as delineated above (p. 38-39). The Santa Fe Group as thus defined has a lower age limit of Early Miocene (late Arikareean) according to recent work by Baldrige and others (1980). However, Kottowski (1953, p. 144) notes that he, Baldwin, and Spiegel proposed that the Santa Fe Formation be raised to group status in the

manuscript of a U.S.G.S. water-supply paper which, I believe, was Spiegall and Baldwin (1963). Since 1956, according to Lucas and Ingersoll (1981), "the term has been broadly applied to all Neogene fill of the Atlantic drainage of New Mexico" (p. 924). This is meant to exclude the area of the Ogallala Formation in the eastern part of New Mexico as well as the area which drains toward the Pacific Ocean. In the El Paso region, the Late Cenozoic deposits were first studied in detail by Sayre and Livingston (1945).

Kottlowski (1953) first suggested that the term Santa Fe Group be extended to describe the Late Cenozoic deposits near El Paso in the Mesilla and Hueco bolsons. He maintained that these sediments are equivalents of his informal units IV and V for Cenozoic sediments of the Rio Grande Valley. Unit IV is the "upper varicolored unit of Santa Fe Group which contains a Pliocene fauna" (p. 144). Unit V is "the uppermost bolson and valley fill sediments [which] contains many Pleistocene vertebrate fossils, and includes river sands and gravels, eolian sands, playa silts, local pediment gravels, [and] lake clays" (p. 144).

Kottlowski (1958) also believed that the Rio Grande flowed southwest from Las Cruces before "swinging" to the southeast and cutting a gorge through Cerro del Muleros (p. 46). If this is correct, the ancient stream system flowed into the bolson de los Muertos in northern Chihuahua, Mexico. He states that faulting and/or volcanic activity

may have caused the change in the course of the river and also that the Mexican bolsons, into which the stream system flowed, never overflowed into the Hueco bolson (p. 46).

Albritton and Smith (1965) later used the term Santa Fe Group in describing the Late Cenozoic deposits within the Hueco bolson. Hawley and others (1969) proposed "that the bulk of the Hueco bolson fill be included in the Santa Fe Group" (p. 55). Since then, the Late Cenozoic deposits exposed within both the Mesilla and Hueco bolsons have been considered by most geologists to belong to the Santa Fe Group.

Strain (1966) named and described two lithostratigraphic units, the Fort Hancock and Camp Rice formations, in the Hueco bolson. He believed, at the time, that there was not sufficient justification for the extension of the Santa Fe terminology into the Hueco bolson. The lower unit, the Fort Hancock, consists of claystone, silty clay, and siltstone with varying amounts of gypsum and bentonite, while the overlying Camp Rice is gravelly and sandy with some silty clays and volcanic ash. Strain (1966) interprets the Fort Hancock as "probably . . . lacustrine deposits periodically exposed to the atmosphere during periods of aridity" (p. 12). The Camp Rice is interpreted as "a sequence of channel gravel, sand, sandy and silty clay, and volcanic ash, capped in most places by caliche" (p. 12). He determined the relative age of the

Fort Hancock Formation on the vertebrate fauna, assigning the upper part to the Blancan and stating, "I have found [fossil] remains . . . which constitute a local assemblage of the Blancan Fauna and establish the age of the upper part . . . as probably Aftonian" (p. 19). The age of the Camp Rice Formation is based on both vertebrate fossils and on the presence of an ash-fall tuff unit, the Pearlette ash, type-B. Strain states that "the age of the lower part . . . is probably Aftonian, the middle part is Late Kansan, and the upper part is undetermined" (p. 21). Strain (1970, p. 172) later subdivided the Camp Rice into lower and upper members, with the lower member assigned to the Blancan and the upper member assigned to the Irvingtonian.

According to Strain (1966), the Camp Rice-Fort Hancock boundary is unconformable and the difference in the lithology of the two represents a change in the paleodepositional environment from a closed basin (Fort Hancock) to a through-flowing stream system (Camp Rice).

Lovejoy (1976a), however, disputes this interpretation of the paleodepositional setting(s). His interpretation is based on two lines of reasoning; they are the concept that the "mixed rounded gravels" (1976b) are precisely correlatable to the Camp Rice Formation and his (1976a) observation that northward from the type locality, "there is a most noticeable increase in the sand proportion of the buff sand and clay (Fort Hancock)." He further

states, "that at the Las Cruces locality sand is predominant in the lower unit [of the Fort Hancock] and clay is much less abundant" (p. 101). Using these criteria, he postulated that an already through-flowing Rio Grande system existed at the time of Fort Hancock deposition. Hence, the lithostratigraphic differences exhibited between the Fort Hancock and Camp Rice formations represent, not a change in paleodepositional setting, but, rather a "geomorphic" influence being exerted upon a (relatively) stable paleodepositional environment. Also, he interpreted the increase in the sand fraction of the Fort Hancock northwest from the type area as a facies change (1976a, p. 101).

In the same paper, Lovejoy related a note which he received from John Hawley regarding a difference of opinion he had with Lovejoy's interpretation of the Fort Hancock and Camp Rice. Hawley believed that any "dilution" of the concept of the Fort Hancock (and Rincon Valley) as lacustrine and the Camp Rice as fluvial deposits, as originally defined by Strain, caused a loss in the mapping value of the units involved (p. 99-100). Strain and LeMone, however, question whether the Fort Hancock terminology should be extended beyond the Hueco bolson (pers. comm., 1984).

Willingham (1981) examined facies relationships of the Fort Hancock and Camp Rice formations from the Camp Rice type area in Hudspeth County, Texas, north to Rincon, New

Mexico. His research was based primarily on mechanical analysis (sieve analyses) of measured sections. He specifically wished to determine whether or not a fluvial facies existed within the Fort Hancock Formation. The solution of this problem would establish the veracity of either Strain's or Lovejoy's paleodepositional interpretations.

Willingham concluded that there are two distinct lithofacies in each of the formations. The Fort Hancock contains "a lower claystone facies [which was] deposited on a fluvial floodplain and an upper sandstone facies of river channel origin" (p. 78). The Camp Rice "consists of two fluvial facies--a lower sandstone and pebble-conglomerate facies and an upper brown sandstone floodplain facies" (p. 71).

Willingham places the "mixed rounded gravels" of Hawley within the lower sandstone and pebble-conglomerate facies of the Camp Rice Formation. Also, he places the Camp Rice-Fort Hancock boundary in Campo Grande Arroyo stratigraphically higher than does Strain (p. 23, 25).

Numerous other, perhaps less controversial, studies of the Santa Fe Group in the El Paso area were made during the 1960s and '70s. A selection of these would include Cliett (1969), Galusha and Blick (1971), Hawley (1965, 1969, 1975, and 1978), Hawley and Kottowski (1969), and Ruhe (1962, 1964). Paleontologic and correlation studies would

include such works as those by Izett (1977), Metcalf (1967), and, more recently, a review by Tedford (1981).

### Location

The study area is located in far West Texas and south-central New Mexico, near El Paso, Texas. It is within the valley cut by the Rio Grande (El Paso Valley and Mesilla Valley), in exposures created by this downcutting.

On the south it is bounded by  $31^{\circ} 0' N$  latitude and on the north by  $32^{\circ} 58' N$  latitude. The east and west boundaries are  $105^{\circ} 41' W$  longitude and  $106^{\circ} 41' W$  longitude respectively.

### Methods of Investigation

Five stratigraphic sections (146 m [477 ft]) were measured in the upper Santa Fe Group sediments of far western Texas and south-central New Mexico using a Jacob's staff and Brunton compass.

An initial section was measured at the Fort Hancock stratotype in Madden Arroyo, east of McNary, Texas (Pl. 18) for stratigraphic control in determination of such problems as the depositional regime of the unit. An additional section (Pl. 18) was measured on the north side of Madden Arroyo (Fig. 1).