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RECONNAISSANCE GEOLOGY OF THE SANTA FE GROUP NEAR AMALIA, NEW MEXICO

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Abstract—The rift-related sedimentary and volcanic rocks of the Amalia area record two distinct phases of aggradation. The Miocene lower Santa Fe Group was deposited by dominantly fluvial processes in a northeast-tilted half-graben (Amalia basin) by laterally opposed piedmont systems and an axial system that flowed to the northwest. These deposits are unconformably overlain by the upper Santa Fe Group, which consists of the lower Pliocene Servilleta Basalt and interbedded gravels.

INTRODUCTION

The Santa Fe Group crops out in scattered exposures and roadcuts along the valley of Costilla Creek in northern Taos County, New Mexico. During Miocene time, about 600 m of dominantly fluvial sediments and minor volcanic rocks of the lower Santa Fe Group accumulated in an asymmetrical, northwest-trending half-graben, here termed the Amalia basin. Subsidence and sedimentation were primarily controlled by down-to-the-southwest displacement along the northwest-trending main bounding fault (Fig. 1) of the Amalia basin. Dip of strata in the lower Santa Fe Group typically ranges from 20° to 40° northeast. These deposits are locally overlain with angular unconformity by the Servilleta Basalt and associated gravels of the upper Santa Fe Group.

Although generally of poor quality, exposures of lower Santa Fe deposits within the Amalia basin are sufficient to allow the discrimination of three ancient depositional systems: two laterally opposed piedmont systems (represented by footwall- and hanging-wall-derived facies) and a valley-floor system (axial facies). These three facies are lithologically distinctive and exhibit paleoflow indicators that reflect their provenance. The hanging-wall-derived, footwall-derived and axial facies are similar to the units Tsv, Tsc and Ts, respectively, recognized by Lipman and Reed (1989), although my depositional interpretations and modifications to the map and cross-section geometries of their units (Fig. 1) are based on my own reconnaissance study.

DEPOSITIONAL FACIES

Hanging-wall-derived facies

This is the most poorly exposed of the three depositional facies recognized in the lower Santa Fe Group. The hanging-wall-derived facies is weakly indurated and generally does not produce resistant outcrops. The best exposures occur near the mouth of an unnamed canyon about 1.2 km southwest of Amalia, and in roadcuts along Highway 196 about 1.0 km northwest of Amalia, where it interfingers with and is overlain by the axial facies.

The hanging-wall-derived facies crops out along the southwestern flank of the Amalia basin and, where present, occurs at the base of the Santa Fe section and is commonly overlain by the axial facies (Fig. 1). The hanging-wall-derived facies is composed dominantly of braided-stream conglomerate and sandstone that were largely or entirely derived from underlying Tertiary volcanic rocks. Pebble imbrication indicates easterly transport (Fig. 2), approximately at right angles to the basin axis. Taken together, the above data indicate the hanging-wall-derived facies records sedimentation on the southwestern piedmont of the Amalia basin, which drained the shallowly dissected Oligocene volcanic rocks on the hanging-wall dip slope (terminology of Leeder and Gawthorpe, 1987) of the Amalia basin.

Footwall-derived facies

This facies also consists primarily of braided-stream conglomerate and sandstone, but differs from the hanging-wall facies in several ways: (1) detritus was derived almost entirely from Precambrian rocks; (2) pebble imbrication indicates west or southwest paleoflow (Fig. 2); and (3) throughout most of the basin, the footwall-derived facies *overlies* the axial facies (Fig. 1). The footwall-derived facies is widely distributed in the study area. However, as noted by Lipman and Reed (1989) for their unit Tsc, many gravels mapped in Figure 1 as footwall-derived facies probably post-date the Santa Fe Group. This is especially true along the southwestern flank of the basin, where poor exposure hinders discrimination between Precambrian-dominated gravels of various ages. Additionally, poorly exposed gravels mapped as footwall-derived facies beneath the Servilleta Basalt in the northern part of the study area may be of late Santa Fe age, as evidenced by the subhorizontal bedding in these gravels and in the overlying Servilleta Basalt.

The footwall-derived facies represents the deposits of the northeastern piedmont of the Amalia half-graben. The presence of only minor amounts of Oligocene volcanic detritus near the base of the unit indicates that the footwall scarp (*sensu* Leeder and Gawthorpe, 1987) was rapidly stripped of Tertiary volcanic cover, resulting in virtual dominance of Precambrian detritus during subsequent sedimentation on the northeast piedmont. Erosional retreat of the footwall scarp as tectonism waned allowed the footwall-derived facies to onlap the footwall block and locally bury the main bounding fault (Fig. 1).

Axial facies

The axial facies is distinctly finer-grained than associated piedmont deposits and consists of varying proportions of mudstone, siltstone, sandstone and minor conglomerate. Sandstone and conglomerate were deposited largely by fluvial systems flowing parallel to the basin axis and by distal piedmont streams where they entered the valley floor. Siltstone and mudstone (locally calcareous) accumulated in floodplain, pond and local playa(?) environments. The axial facies coarsens toward the southeast and primarily consists of sandstone in the southeastern part of the study area. Exposure quality is not sufficient to enable detailed analysis of paleoenvironments represented by the axial facies.

The axial facies contains basalts which represent lavas that flowed down the axial valley of the Amalia basin; the presence of agglutinated spatter and scoria indicates the presence of a basaltic vent in the southeast part of the study area (Lipman and Reed, 1989). The axial facies also interfingers to a small extent with the Miocene rhyolite of Gonzales Ranch in the eastern part of the study area.

The axial facies crops out dominantly along the central portion and northeastern flank of the Amalia basin (Fig. 1), and interfingers with both piedmont systems. Paleocurrent data (Fig. 2) indicate northwestward transport, analogous to modern Costilla Creek. This interpretation contrasts with that of Lipman and Reed (1989), who state that Santa Fe Group paleodrainage was "largely unrelated to present drainage basins."

The general trace of axial-facies outcrops in the Amalia basin is subparallel to the main bounding fault, which may indicate tectonic control of axial-drainage location due to faulting. Throughout most of the Amalia basin, the axial facies overlies the hanging-wall-derived facies and is, in turn, overlain by the footwall-derived facies. These relations are indicative of depositional onlap of the hanging-wall block (see cross section, Fig. 1), which is reminiscent of waning- or post-tectonic scenarios proposed by recent workers for aggradation in asymmetrical basins (Leeder and Gawthorpe, 1987; Blair and Bilodeau, 1988; Mack and Seager, 1990). Similarly, the local presence of the

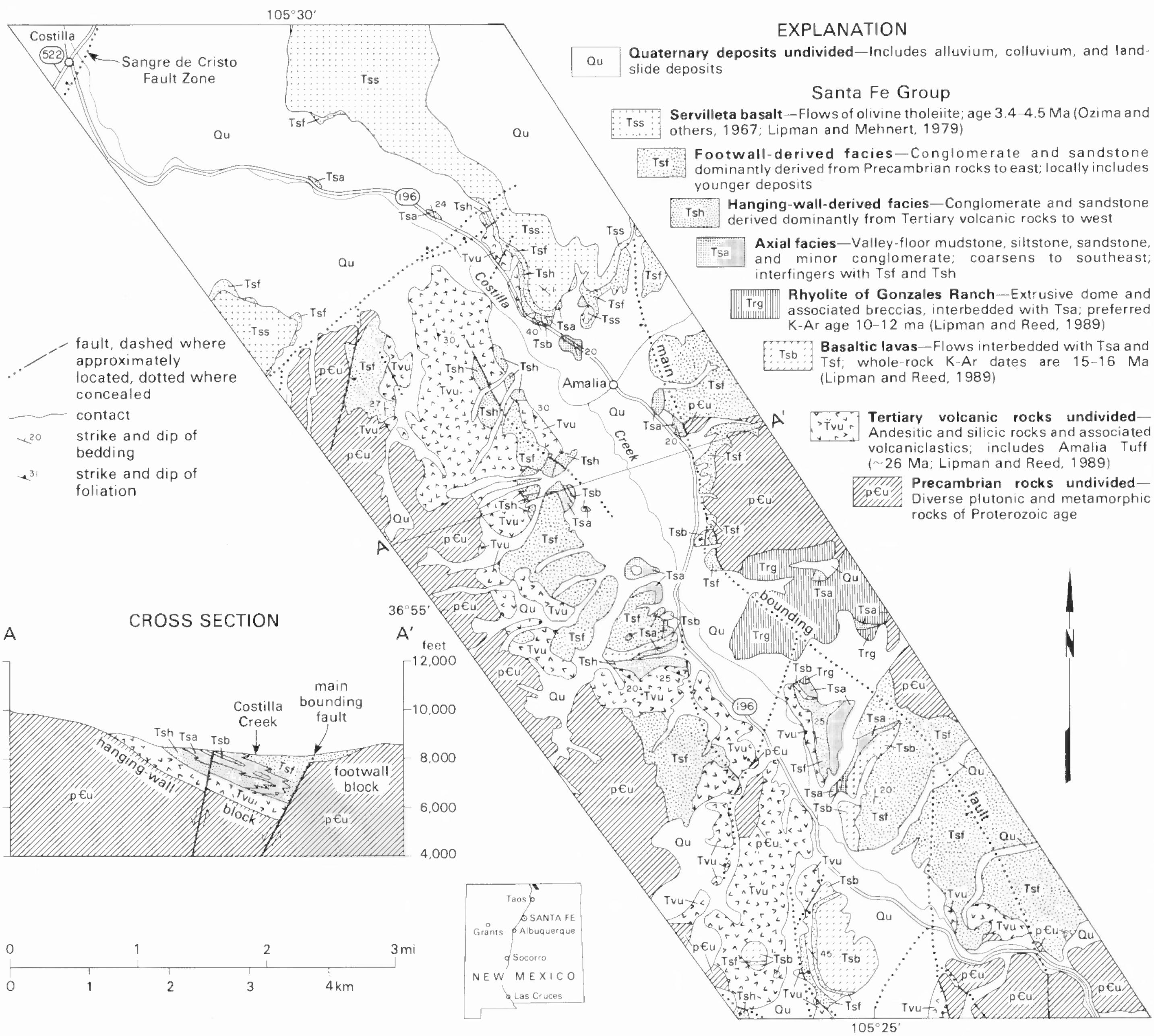

FIGURE 1. Geologic map and cross section of the Amalia area, New Mexico, modified from Lipman and Reed (1989).

axial facies adjacent to the main bounding fault may record episodes of migration of the axial drainage into the area of maximum subsidence near the downfaulted edge of the basin. Possible relations between tectonism and lateral migration of the axial system within the Amalia basin, however, have not been documented and are in need of further study.

AGE AND CORRELATION

In this paper, I use the term Santa Fe Group to denote all sedimentary and volcanic rocks that fill basins of the Rio Grande rift, except for terrace deposits and alluvium of the present valleys (e.g., Spiegel and Baldwin, 1963; Chapin, 1988). As such, the Servilleta Basalt is regarded as part of the Santa Fe Group. Many basin areas of the Rio Grande rift show evidence of two distinct phases (typically latest Oligocene to late Miocene and early Pliocene to middle Pleistocene) of basin-filling by sedimentary and volcanic processes. The resultant deposits were termed lower and upper Santa Fe Group by Kottlowski (1953, 1958, 1960; see also Hawley et al., 1969) in his pioneering studies in the southern part of the rift; these terms have subsequently been supplanted by formation names in most areas.

The bipartite nature of the Santa Fe Group in the Amalia area is quite apparent. Because no formation name has yet been applied to the older Santa Fe deposits in the study area, I will utilize Kottlowski's informal terms: the lower Santa Fe Group consists of the older, tilted sedimentary and volcanic rocks that form the bulk of the fill of the Amalia half-graben and are the principal subject of this study; the upper Santa Fe Group is represented by the Servilleta Basalt and associated gravels. As will be discussed below, these subdivisions of the Santa Fe Group near Amalia are chronostratigraphically equivalent to parts of the lower and upper Santa Fe Group in areas to the south.

Age constraints for the Santa Fe Group in the Amalia basin are based on K/Ar ages of intercalated and subjacent volcanic rocks; no fossils have been collected in the area. The lower Santa Fe Group disconformably overlies the Amalia Tuff (~26 Ma; Lipman et al., 1986; Lipman and Reed, 1989). Basaltic lavas (15–16 Ma; Lipman et al., 1986; Lipman and Reed, 1989) and the rhyolite of Gonzales Ranch

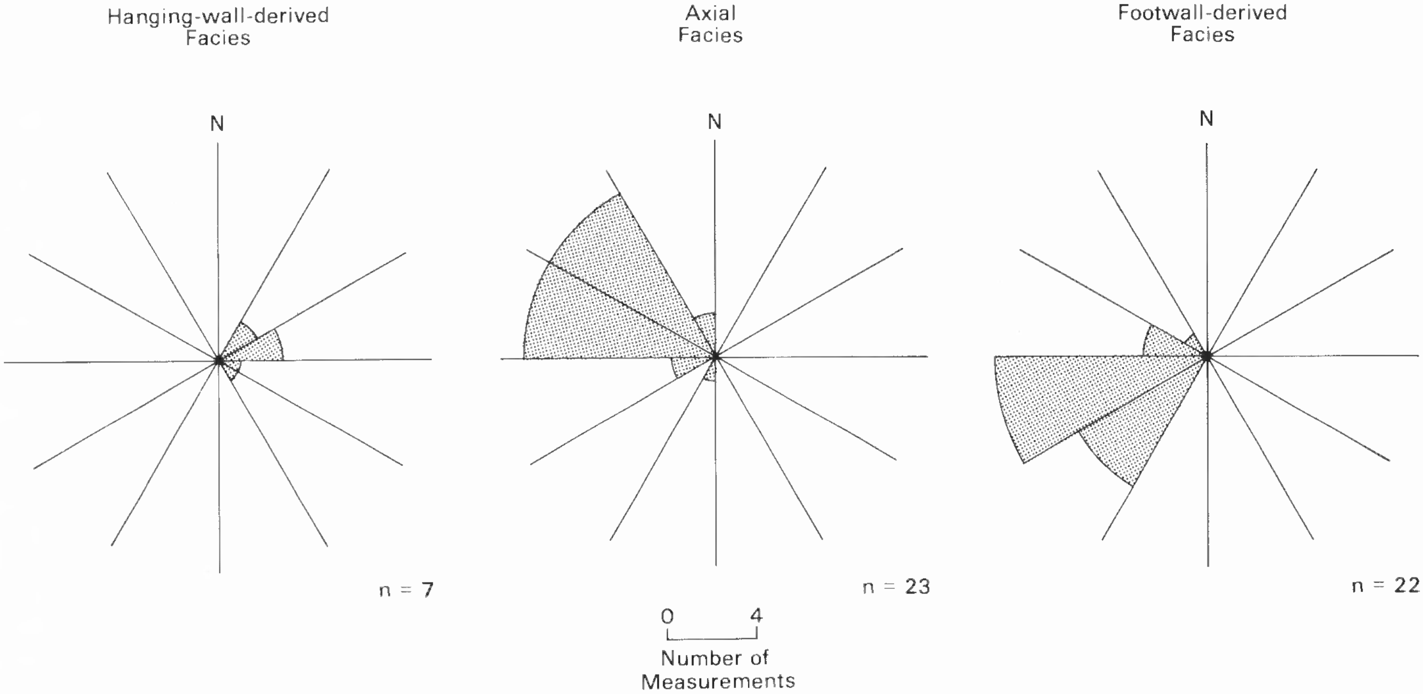

FIGURE 2. Paleocurrent rose diagrams based on pebble imbrications for hanging-wall-derived facies, axial facies and footwall-derived facies of lower Santa Fe Group.

(10–12 Ma; Lipman and Reed, 1989) are intercalated with the axial facies, indicating that the lower Santa Fe Group in the Amalia basin spans at least the middle Miocene.

The Servilleta Basalt comprises the majority of the upper Santa Fe Group in the study area, where it overlies the lower Santa Fe Group with angular unconformity. Most K/Ar ages for the Servilleta Basalt are in the 3.4 to 4.5 Ma range (Ozima et al., 1967; Lipman and Mehnert, 1979), although ages as old as 4.6 Ma (Baldridge et al., 1980) and as young as 2.8 Ma (Manley, 1979) have also been reported. Based on these data, the Servilleta Basalt of the upper Santa Fe Group in the study area is interpreted to be of early Pliocene age.

The main bounding fault for the Amalia basin trends northwest, at high angles to the north- to northeast-trending faults (Sangre de Cristo fault zone of Personius and Machette, 1984) that demarcate the eastern boundary of the nearby San Luis basin (Fig. 1; Lipman and Reed, 1989). Although the axial paleodrainage of the Amalia basin flowed toward the present San Luis basin, the factors controlling aggradation of early rift deposits within these basins are poorly understood. At least two scenarios are possible. The Amalia basin may have been a prong of the Miocene San Luis basin, and both basins may have aggraded contiguously and simultaneously. In this case, the Sangre de Cristo fault zone would have acted locally as a growth fault that divided the relatively thin lower Santa Fe deposits of the Amalia basin from the great thickness of early rift deposits present in the subsurface of the San Luis basin (Gries and Brister, 1989). Alternatively, footwall uplift along the Sangre de Cristo fault zone may have produced a structural sill near the town of Costilla that induced aggradation in the Amalia basin. In this case, both basins would have aggraded simultaneously but separately, with the Amalia basin forming a "hanging valley" on the footwall block of the Sangre de Cristo fault zone. Further study of the structural and sedimentologic evolution of the Amalia basin and other Neogene basins of the Sangre de Cristo Mountains (e.g., Valle Vidal basin, Moreno basin) may help resolve these uncertainties.

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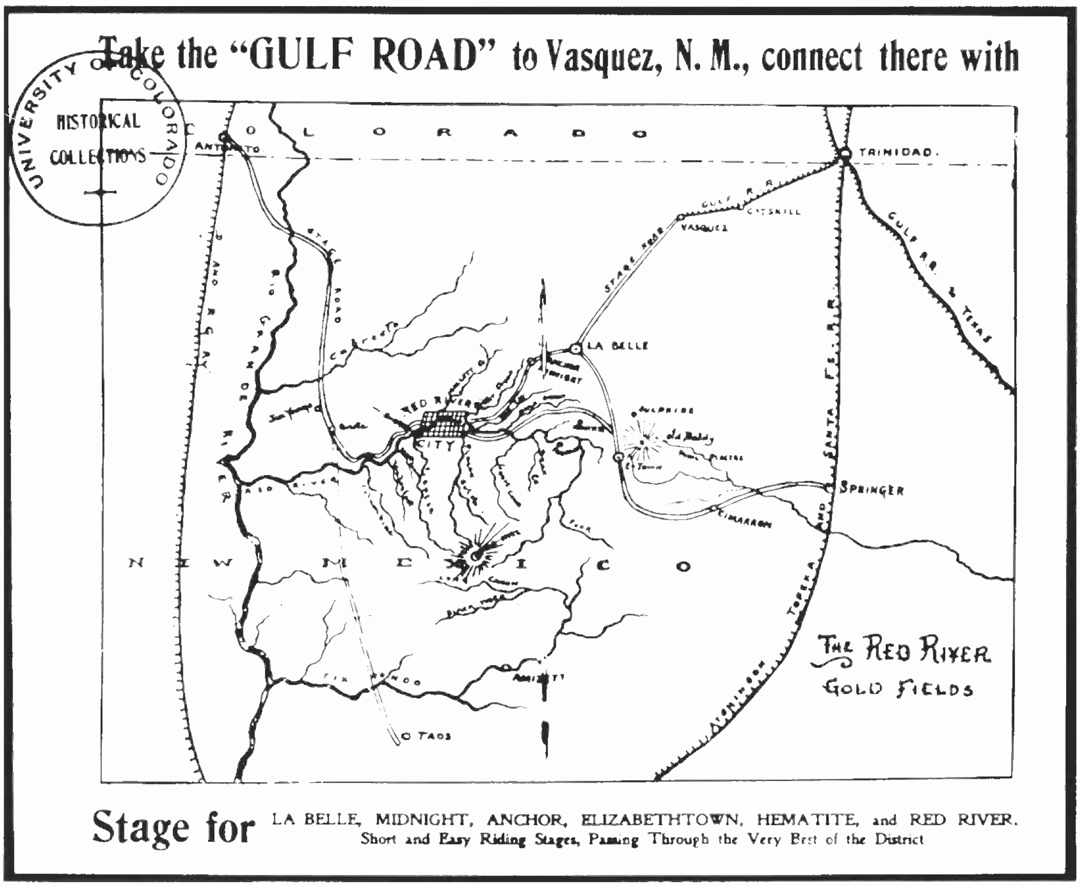

Cracking whips, pounding hooves, and a mighty "Hyaa" marked the dramatic departure of the local stage. But it was all for show—soon after reaching the town limits, the driver reined back to 4–6 mph and the cacophony of departure gave way to the steady jangle of trace chains, the crunch of steel tires on unpaved roads and an occasional "snort" from the motive power. Mix in the unpredictable nature of the "old geezer" in the seat box and the passenger was due for an interesting, if somewhat uncomfortable, journey. Until the arrival of the automobile, stagecoaching provided the only regularly scheduled passenger service to LaBelle, E'town, Red River, Baldy and other camps shunned by the iron rail. Beginning with a single, three-times-a-week stage between Cimarron and Taos after the Civil War, no less than three lines were operating by 1900. H. H. Hankin's Moreno Valley line offered daily (Sundays excepted in all cases) service between E'town, Cimarron and the Santa Fe Railroad at Springer. Lawton's line offered the "quickest" time from the D&RGW RR at Antonito, Colorado, to Red River via Dunn's Crossing. Joseph Bruder's line provided a connection between the Union Pacific, Denver & Gulf Railway at Vasquez, near the Colorado border, and Catskill, LaBelle, Baldy, Hematite and E'town. Courtesy of University of Colorado Historical Collections.