GEOLOGY OF THE NORTHEASTERN SAN LUIS BASIN, SAGUACHE COUNTY, COLORADO

By
Thomas A. Watkins
Lexam Explorations (U.S.A.) Inc.
P.O. Box 150158
Lakewood, CO 80215

TOC

INTRODUCTION

The San Luis basin is one of a series of late Oligocene to Pliocene extensional basins that comprise the Rio Grande rift in Colorado, New Mexico and northern Mexico. In general, the basins in Colorado and New Mexico are a series of half-grabens filled with synrift sediments of the Santa Fe Group. The asymmetric nature of the basins is evidenced by reversals in the dip of basin fill sediments. Synrift sediments in the San Luis basin dip to the east. To the north and south, sediments in the Upper Arkansas and Espanola basins dip to the west (Chapin and Cather, 1994).

The San Luis basin is roughly 200 km long and 70 km wide with Villa Grove, CO and Taos, NM situated at the approximate northern and southern ends of the basin (Fig. 1). Two half grabens are present in the northern basin, the western Monte Vista graben and the eastern Baca graben, separated by the Alamosa horst (Brister and Gries, 1994). The deepest segment of the San Luis basin occurs within the northwest-trending Baca graben along the west flank of the Sangre de Cristo Range (Kluth and Schaftenaar, 1994).

Recent gold and petroleum exploration, conducted on the Luis Maria Baca Grant No. 4, Saguache County, CO show that the northeastern San Luis basin is structurally analogous to other basins of the Rio Grande rift. Information presented in this paper is based on the results of geological mapping, exploration drilling and seismic, aeromagnetic and gravity surveys conducted in the vicinity of the Baca Grant.

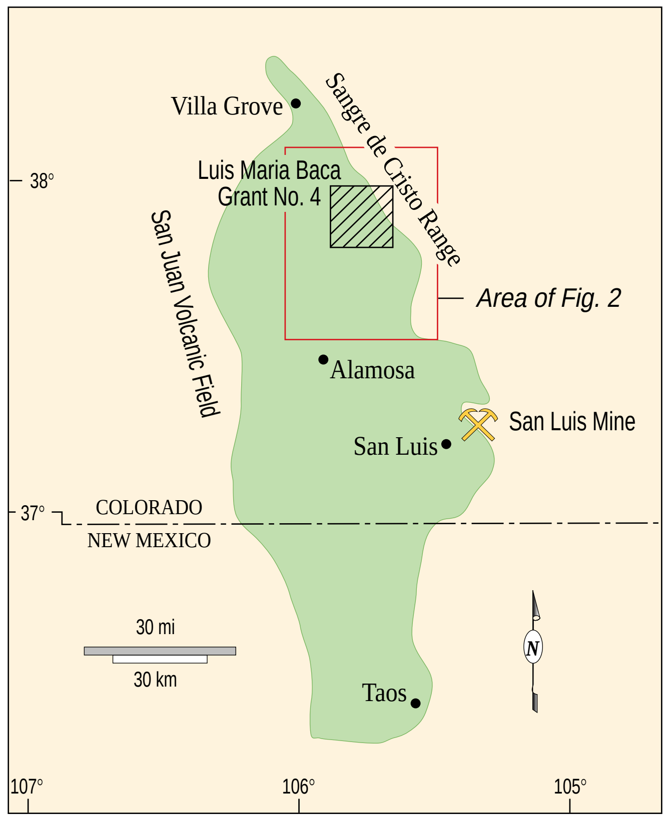

Figure 1: Location map of the San Luis basin in south-central Colorado and north-central New Mexico, showing the location of the Luis Maria Baca Grant No. 4 and the San Luis gold mine. Modified from Brister and Gries (1994).

LITHOLOGIC UNITS

Lithologies in the northeastern San Luis basin and northern Sangre de Cristo Range are grouped into prerift and synrift units. Prerift rocks include Proterozoic metamorphic and intrusive rocks, Mesozoic sediments and Oligocene volcanic rocks. Paleozoic sediments, present in the Sangre de Cristo Range and at the north end of the basin are most likely present but have not been encountered in the subsurface in the vicinity of the Baca Grant. Eocene sediments of the Blanco Basin Formation, present in the Monte Vista graben (Brister and Gries, 1994), have not been observed along the northeastern margin of the Baca graben. Synrift rocks include Miocene - Pliocene sediments of the lower Santa Fe Group, the Pliocene - Pleistocene Alamosa Formation and Tertiary intrusive rocks. Much of the northeastern San Luis Valley floor is covered by deposits of Quaternary alluvium and eolian sand, which obscure outcrops of the Alamosa and Santa Fe formations.

Prerift Rocks

Proterozoic Rocks

Lindsey and others (1984, 1985a, 1985b, 1986, 1987), Johnson, Bruce and Lindsey (1989), Johnson and Bruce (1991) and Bruce and Johnson (1991) published a comprehensive set of geological maps of the northern Sangre de Cristo Range. Interlayered mafic and felsic gneiss, leucocratic granitic to granodioritic gneiss, quartz monzonite porphyry, medium-grained quartz monzonite and minor quartzite are the principal Proterozoic rocks in the range (Lindsey and others, 1986). In the immediate vicinity of the Baca Grant, biotite-rich augen gneiss, porphyritic quartz monzonite gneiss and amphibolite are the main Proterozoic rock types (Fischer, 1988). Chlorite, sericite and epidote are common alteration products.

Mesozoic Sediments

A field check of color air photo anomalies and reconnaissance geological mapping along the southwest flank of the Sangre de Cristo Range resulted in the discovery of two outcrops of Mesozoic sediments, the first reported occurrences in the basin. Subsequently, 17 of 42 gold exploration drill holes, located close to the range front, encountered highly faulted sections of Mesozoic sediments in fault contact with Precambrian gneiss. Thin, highly faulted sections of Mancos Shale were penetrated by the Baca #1 and #2 wells located on the Baca Grant.

Cretaceous Mancos Shale and Dakota Group sandstones and Jurassic Morrison Formation occur as rotated blocks in the hanging wall of a low-angle, normal fault that forms the margin of the basin. Mineral exploration drilling has encountered up to 100 m of steeply dipping Dakota sandstone and Morrison Formation shale, siltstone and arkosic sandstone. Identification of the Dakota and Morrison formations has been by examination of drill cuttings and thin section analysis of outcrop samples. A palynology study of black shale collected from exploration drill holes confirmed the presence of Mancos Shale (Groth, 1994).

Oligocene Volcanic Rocks

Brister (1990) summarized drill hole data from 11 oil and gas wells and one geothermal well drilled in the San Luis basin between 1951 and 1989. Wells drilled in the vicinity of the Baca Grant are shown on Figure 2. All of the wells penetrated Oligocene volcanic rocks that pre-date development of the Rio Grande rift. Intermediate-composition flows, breccias and volcaniclastic rocks of the Conejos Formation and various ash-flow tuffs, erupted from the San Juan volcanic field, are present in the basin. Ash flows of the Carpenter Ridge, Fish Canyon, Masonic Park and Treasure Mountain tuffs have been tentatively identified by Brister (1990). The well data indicates that, in the northern portion of the basin, early andesites and quartz latites of the Conejos Formation pinch out on the Alamosa horst. Younger ash-flow tuffs extend as far east as the Amoco-Mapco well which was drilled on the east flank of the Alamosa horst. (Fig. 2).

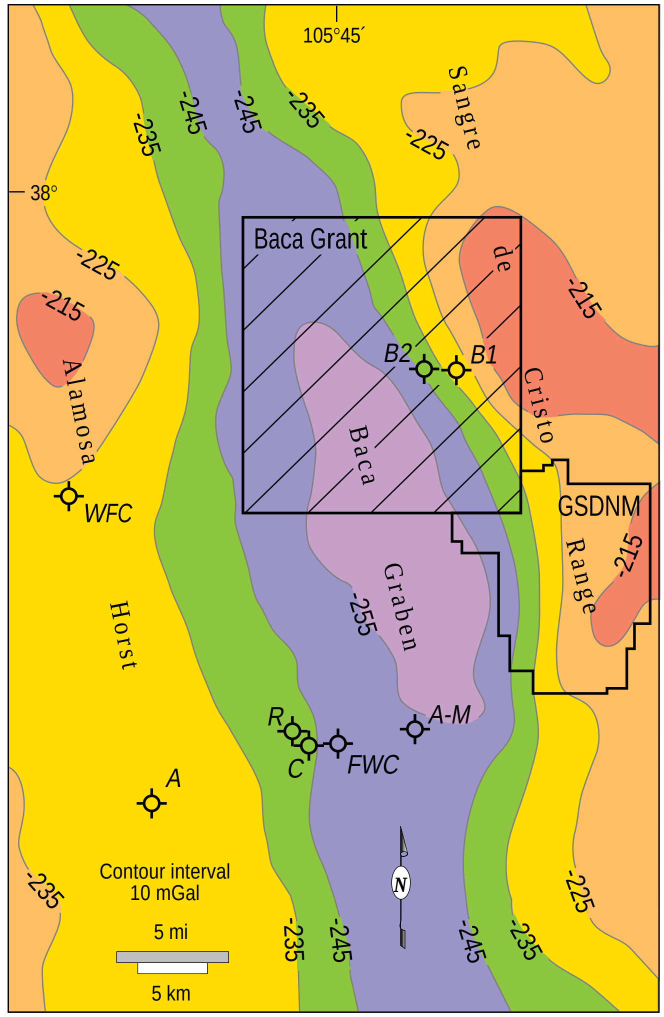

Figure 2: Bouguer gravity map: NE San Luis basin with Alamosa horst, Baca graben and Sangre de Cristo Range. Wells in the area include WFC, W.F. Carr; A, Amerada; R, Reserve; C, Cougar; FWC, F. William Carr; A-M, Amoco-Mapco; B1, Baca #1 and B2, Baca #2.

Synrift Rocks

Lower Santa Fe Group

The Miocene - Pliocene lower Santa Fe Group comprises the bulk of synrift sediments in the San Luis basin. Brister (1990), Brister and Gries (1994) and Wallace (1995) provide excellent descriptions of lower Santa Fe sediments.

Composition and grain size are highly variable and depend on source terrain, distance from source and position within the drainage system. The Baca #1 and Baca #2 wells, located on the Baca Grant and close to the present day mountain front (Fig. 3), penetrated thick intervals of Santa Fe sediments.

The Baca #1 well, located approximately two kilometers from the mountain front, encountered 1076 m of relatively uniform sediments dominated by poorly consolidated coarse sandstone, gravel and boulder conglomerate. The Santa Fe is composed almost entirely of clasts derived from Proterozoic granitic gneiss (>70%) and mafic metamorphic rocks (10-30%). Minor sandstone fragments (<5%) derived from the Dakota and Morrison formations occur in the lower portions of the section. Boulders up to one meter in diameter were penetrated by the Baca #1 well. The 1558 m of Santa Fe sediments encountered in the Baca #2 well, located 1.3 km west of the Baca #1, have a similar composition. Clast size in the Baca #2 well is generally smaller with fewer large boulders than were encountered in the Baca #1 well.

Alamosa Formation

The Baca #2 well penetrated 354 m of the Pliocene - Pleistocene Alamosa Formation. In this well the formation consists of unconsolidated, fine-grained to gravel clasts of granitic and mafic metamorphic rock (80-100%), light tan, biotite-rich volcanic tuff (trace-20%) and black to dark brown peat and wood fragments (trace-5%). At the Baca #2 location the Alamosa Formation is distinguished from the underlying Santa Fe by 1) the overall smaller grain size, 2) the roundness of individual grains, 3) wood fragments and 4) volcanic rock fragments. East of this location the Alamosa includes interbedded lacustrine and volcaniclastic sediments, volcanic ash and sandstone that contain a variety of fossils, including avian and fish skeletal fragments, gastropods and ostracods.

Tertiary Intrusives

Synrift intrusive rocks include felsic dikes and sills and mafic intrusives that occupy a variety of structures along the range front. Felsic rocks containing small feldspar phenocrysts (1-2 mm) and occasionally exhibiting flow banding occur in the footwall of the low-angle fault at the basin margin, in high-angle structures that cut across the range front and in Laramide thrust faults. Benson and Jones (1990) describe similar rocks at the San Luis mine that they interpret as being emplaced concurrently with development of the low-angle fault and gold mineralization. Mafic intrusives consisting primarily of coarse-grained, plagioclase and hornblende (Fischer, 1988) occur as small plugs, dikes and sills. The presence of mafic sills emplaced along the Deadman Creek thrust is evidence that these rocks post-date Laramide thrusting. Mafic dikes also occupy high-angle structures that are located close to and parallel the range-front fault, suggesting that at least some of the mafic intrusives occupy rift structures. The presence of unmineralized mafic plugs adjacent to mineralized Proterozoic gneiss is further evidence that the intrusives post-date gold mineralization and were therefore emplaced during development of the rift.

STRUCTURE

The geometry of the northeastern margin of the basin is dominated by a low-angle, normal fault linked to the early stages of rifting. Benson and Jones (1990) describe a nearly identical structure that hosts the San Luis gold deposit located near the town of San Luis (Fig. 2). McCalpin (1982) mapped high-angle fault scarps in Quaternary deposits along the west flank of the Sangre de Cristo Range, an indication that the Sangre de Cristo fault is a high-angle, normal fault separating the mountain range from the deep basin. New data shows that the Sangre de Cristo fault exhibits relatively little vertical displacement. The northeastern margin of the deep basin is a high-angle fault located southwest of the range front, creating an intermediate fault block between the mountains and the Baca graben. Movement on listric normal faults present in the hanging wall of the low-angle structure may have controlled deposition of the Alamosa Formation along the northeastern margin of the basin.

Low-angle Structure

The northeastern margin of the basin is a low-angle, normal fault that strikes northwest, parallel to the Sangre de Cristo Range and dips 25º - 30º southwest. Movement along this structure accommodated the deposition of at least 2600 m of synrift sediments in the basin. Keeping with Benson and Jones' (1990) description of the San Luis gold deposit, the structure is interpreted as a detachment-style fault that formed during the early stages of rifting.

The detachment surface is marked by a thin layer of clay gouge that is typically gray-green in color but can be a variety of colors depending on local changes in alteration of the footwall. Close to the mountain front, synrift sediments were deposited directly on clay gouge or a thin, highly sheared zone of Mesozoic sediments. The Baca #1 and #2 wells encountered thin, faulted section of Mancos Shale in the hangin wall of the detachment. High resolution seismic data shows that beds of the Santa Fe are truncated at the fault, indicating at least minor movement following deposition. Further into the basin, Santa Fe beds were deposited on rotated blocks of Mesozoic sediments that form the hanging wall of the detachment. The footwall of the detachment is predominantly brecciated Proterozoic gneiss. Aphanitic, porphyritic felsic dikes and sills are present locally.

Hydrothermal alteration of footwall rocks is similar to descriptions of the San Luis gold deposit by Benson and Jones (1990), ranging from intense silicification to quartz-sericite-pyrite and chlorite-carbonate-hematite assemblages. Rocks in the hanging wall of the fault have not been subjected to hydrothermal alteration.

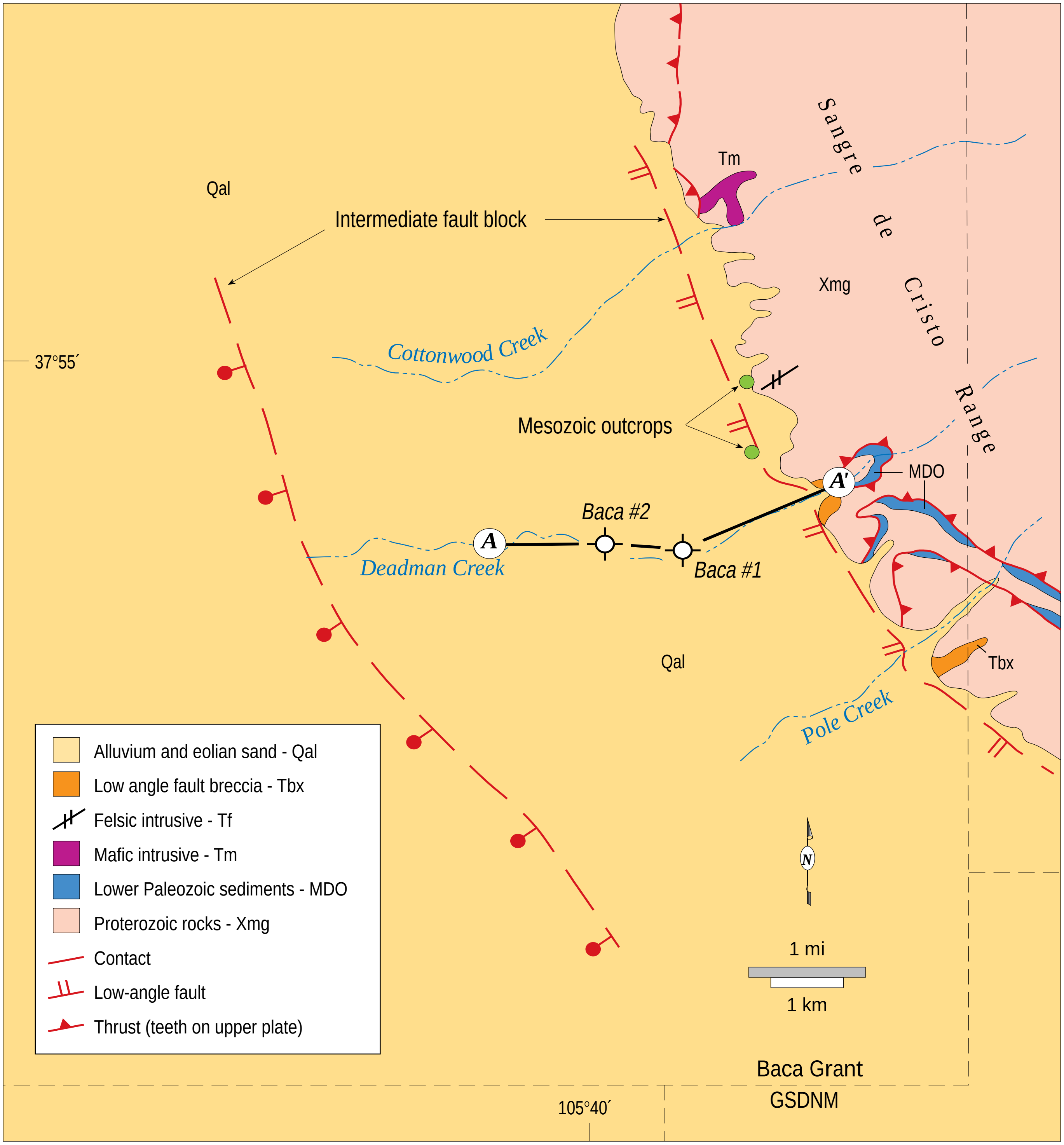

Figure 3: Geologic map of the eastern Baca Grant. Modified from geological mapping by Limbach and Powell (1993).

Erosional remnants of the footwall breccia are present at several locations along the west flank of the Sangre de Cristo Range (Fig. 3). The breccia typically consists of sub-angular to sub-rounded clasts of feldspar and quartz in a chloritic matrix, resulting in a rubbly texture with little or no foliation. Thickness of the breccia ranges from 5m to more than 60m. Clement (1952) mapped a prominent outcrop of chloritic breccia at the mouth of the Deadman Creek canyon (Fig. 3) and interpreted it as part of the Deadman Creek thrust. The breccia is interpreted here to be part of the footwall of the detachment fault. The rubbly nature of the breccia contrasts markedly with well developed cleavage typical of sheared rocks above and below the thrust. The close proximity of the Deadman Creek thrust to outcrops of chloritic breccia at the mount of the canyon indicates that the thrust fault is truncated by the detachment.

Sangre de Cristo Fault

The presence of a high-angle, normal fault along the front of the range is confirmed by close-spaced mineral exploration drilling. Vertical displacement on this structure is constrained by drill data and by erosional remnants of footwall breccia present along the range front. Outcrops of chloritic and silicified breccia near Deadman Creek and Pole Creek can be correlated with breccia penetrated by drill holes collared southwest of the range front. At these locations, vertical displacement is probably less than 60 m and certainly less than 150 m. At other locations, drill holes collared just west of the fault and drilled to depths of 245 m did not penetrate any of the highly sheared rocks associated with the Deadman Creek thrust that outcrop just east of the range front. Vertical displacement along some segments of the range front clearly exceeds 250 m.

Intermediate Fault Block

Regional seismic, gravity and well data (Kluth and Schaftenaar, 1994; Brister and Gries, 1994; Davis and Keller, 1978) document that the deepest part of the Baca graben is located west and northwest of the Great Sand Dunes National Monument. The northeastern boundary of the graben is interpreted to be a high-angle normal fault that truncates the detachment fault. Seismic profiles presented by Kluth and Schaftenaar (1994) indicate that synrift sediments of the Santa Fe Group thicken across the high-angle fault that bounds the deep basin. The resulting intermediate fault block is 6-8 km wide. This intermediate block is similar to benches on the master fault sides of the northern and southern Albuquerque basins described by Chapin and Cather (1994) and Russell and Snelson (1994). Well data and seismic profiles across the block show that it is not cut by major high-angle faults that parallel the mountain front. Only minor vertical displacement (150 - 200 m) is evident where high-angle faults cut the detachment fault within the intermediate block (Fig. 4). Aeromagnetic and gravity surveys suggest that the intermediate fault block may be cut by a series of northeast-trending, high-angle faults. No seismic or well data exists to determine if significant vertical displacements occur in the strike direction.

Mapping by Wallace (1995) along the west flank of the Culebra Range near San Luis identified a series of northeast-trending faults that juxtapose Santa Fe beds with Proterozoic gneiss and Oligocene volcanics. This area may provide a structural analogy for the intermediate fault block west of the

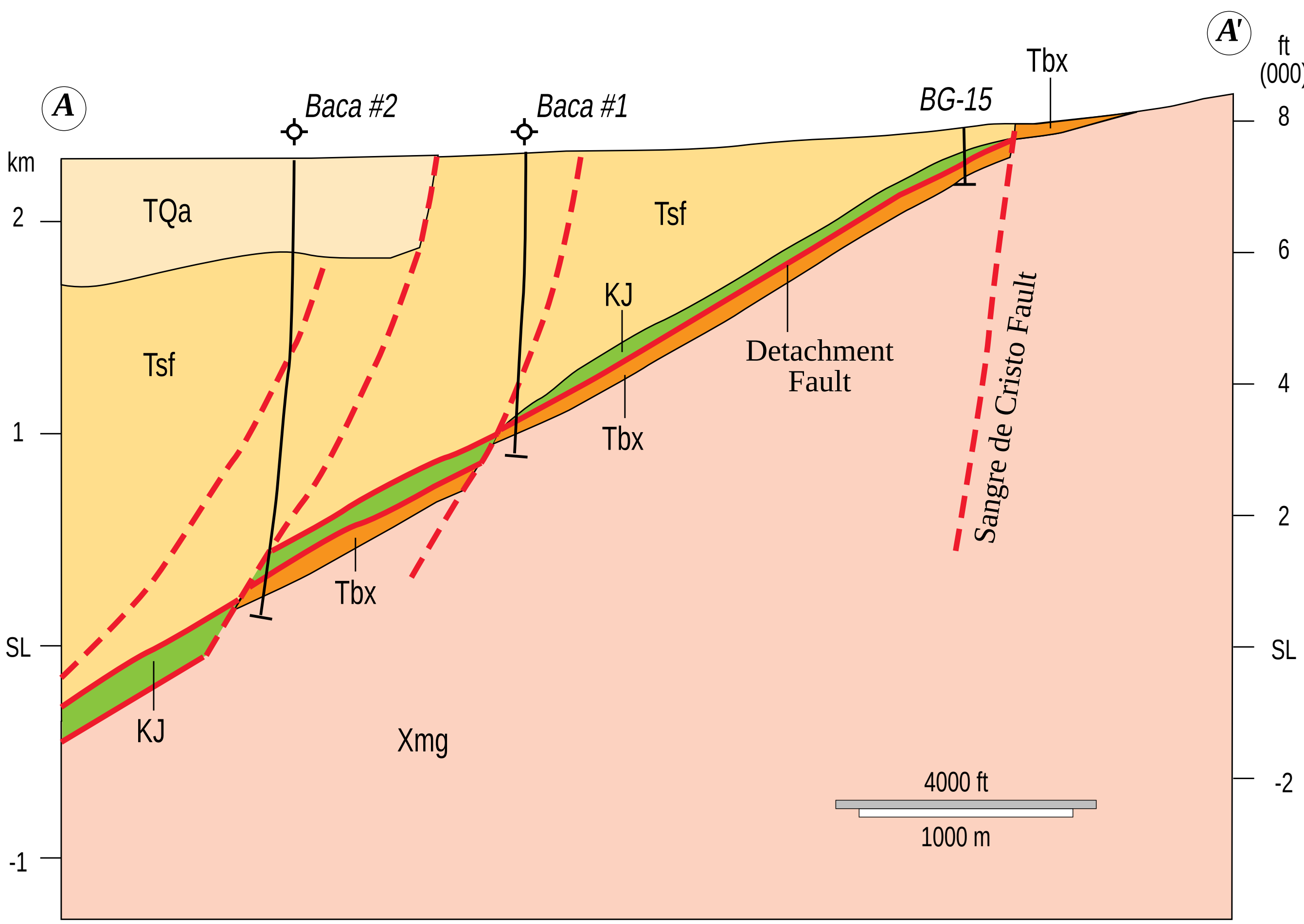

Figure 4: Geological cross section across that part of intermediate block confirmed by drilling. TQa, Alamosa Formation; Tsf, lower Santa Fe Group; KJ, Mesozoic sediments; Tbx, low-angle fault breccia; Xmg, Proterozoic gneiss.

Sangre de Cristo Range, particularly in the strike direction.

Listric Normal Faults

Sediments of the Santa Fe Group deposited above the detachment fault are cut by a series of listric normal faults that tend to merge with the detachment. East of the Baca #2 well, the Alamosa Formation is faulted against coarse conglomerate of the Santa Fe along one or more faults that do not offset the underlying detachment by a corresponding amount (Fig. 4). These structures are interpreted as listric faults that formed in the hanging wall of the detachment after the deep basin developed.

DISCUSSION

The discovery of Mesozoic sediments and new information regarding the geometry of the basin margin require modifications to existing geological interpretations of the northern San Luis basin/ Sangre de Cristo Range area. Preservation of a Mesozoic sedimentary section in the basin has significant implications for the tectonic history of south-central Colorado and the natural resource potential of the San Luis basin. Modifications to the geology of the basin margin illustrate that the San Luis basin is structurally similar to the northern and southern Albuquerque basins of central New Mexico.

The full extent of Mesozoic sediments preserved in the northeastern San Luis basin has not been determined. To date, geological mapping and drilling have confirmed the presence of highly faulted sections of Mancos Shale, Dakota Group sandstones and Morrison Formation sediments. Widespread, near surface shows of live, Cretaceous oil along the margin of the basin are evidence that a significant section of Mancos Shale is present.

The San Luis basin detachment fault is analogous to the Santa Fe fault, a low-angle structure that forms the western margin of the southern Albuquerque basin (May and Russell, 1994). Both structures contain faulted Mancos Shale overlain by synrift sediments of the Santa Fe Group. The Humble-Santa Fe Pacific well, located about 8 km east of the Albuquerque basin margin, penetrated Mesozoic sediments in the hanging wall of the Santa Fe fault. (May and Russell, 1994 and Russell and Snelson, 1994). Using the Santa Fe fault and Albuquerque basin as an example, the presence of faulted Cretaceous and Jurassic sediments in the hanging wall of the San Luis basin detachment fault suggests that a relatively intact section of Mesozoic sediments is likely to be present in the northeastern San Luis basin. The exact timing and mechanism responsible for preserving Mesozoic sediments is yet to be determined. It is apparent however that the entire Mesozoic section was not eroded from all of the northern San Luis basin/ Sangre de Cristo Range area during the Laramide.

Historically, the Sangre de Cristo fault has been interpreted as a high-angle fault with as much as 7.6 km of vertical displacement (Davis and Keller, 1978; Tweto, 1979; Brister and Gries, 1994 and Kluth and Schaftenaar, 1994). Drill data which document the intermediate fault block and accompanying detachment fault along the northeastern margin of the basin limits displacement on some segments of the Sangre de Cristo fault to less than 60 m. An apparent dip slope that generally conforms to the dip of the detachment fault is present on a number of mountain ridges of the Sangre de Cristo Range located in the vicinity of the Baca Grant and the Great Sand Dunes National Monument. This dip slope, combined with seismic and well control across the intermediate fault block, indicates that as much as 6 km of vertical displacement previously assigned to the Sangre de Cristo fault can be accounted for by the dip of the detachment fault. Much of the remaining displacement is taken up by the high-angle fault located at the western edge of the intermediate fault block.

The geometry of the basin margin suggests that low-angle, detachment style faults characterize early rifting. Continued development of the rift transferred movement to high-angle faults that cut the detachment, creating the intermediate fault block and a thicker section of synrift sediments in the deep basin. Movement was subsequently transferred to a series of listric normal faults in the hanging wall of the detachment. Movement along these faults accommodated deposition of the Alamosa Formation and eventually placed unconsolidated, fine-grained sediments of the Alamosa against coarse conglomerates of the Santa Fe.

ACKNOWLEDGEMENTS

John Belcher, Peak Energy; Robbie Gries, Priority Oil and Gas; and Mark Longacre, MBL, Inc. have made important contributions to the development of a new geological interpretation for the northeastern San Luis basin through interpretation of the data and lively discussions.

REFERENCES

Benson, R. G., and Jones, D. M., 1990, Geology of the San Luis gold deposit, Costilla County, Colorado, *in* Hausen, D. M., Halbe, D. N., Petersen, E. U. and Tafuri, W. J., eds., Gold '90: Proceedings of the Gold '90 Symposium, Salt Lake City, Utah: Littleton, Colorado, Society for Mining, Metallurgy, and Exploration, Inc., p. 83-91.

Brister, B. S., Tertiary sedimentation and tectonics: San Juan sag-San Luis basin region, Colorado and New Mexico [Ph.D. thesis]: Socorro, New Mexico Institute of Mining and Technology, 267 p.

Brister, B. S. and Gries, R. R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa basin (northern San Luis Basin), Rio Grande rift, south-central Colorado, *in* Keller, G. R. and Cather, S. M., eds., Basins of the Rio Grande rift: Structure, stratigraphy and tectonic setting: Boulder, Colorado, Geological Society of America Special Paper 291, p. 39-58.

Bruce, R. M. and Johnson, B. R., 1991, Reconnaissance geologic map of parts of the Zapata Ranch and Mosca Pass quadrangles, Alamosa and Huerfano Counties, Colorado: U. S. Geological Survey, Miscellaneous Field Studies Map MF-2168, scale 1:24,000.

Chapin, C. E. and Cather, S. M., 1994, Tectonic setting of the axial basins of the northern and central Rio Grande rift, *in* Keller, G. R. and Cather, S. M., eds., Basins of the Rio Grande rift: Structure, stratigraphy and tectonic setting: Boulder, Colorado, Geological Society of America Special Paper 291, p. 5-25.

Clement, J. F., 1952, The geology of the northeastern Baca Grant area, Saguache County, Colorado [M.S. thesis]: Golden, Colorado School of Mines, 129 p.

Davis, G. H. and Keller, G. R., 1978, Subsurface structure of San Luis Valley, *in* Hawley, J. W., ed., Guidebook to Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines nd Mineral Resources Circular 163, p. 28.

Fischer, J. F., 1988, Petrographic report of samples from the Sangre de Cristo Range, Colorado: unpublished report prepared for Abermin, Inc., 111 p.

Groth, P., 1995, Palynology and kerogen observations of samples from drill hole BG-34, Baca Land Grant, San Luis Valley, Colorado: unpublished report prepared for Lexam Explorations (U.S.A.) Inc., 23 p.

Johnson, B. R., Bruce, R. M. and Lindsey, D. A., 1989, Reconnaissance geologic map of the Medano Pass quadrangle and part of the Liberty quadrangle, Alamosa, Huerfano and Saguache Counties, Colorado: U. S. Geological Survey, Miscellaneous Field Studies Map MF-2089, scale 1:24,000.

Johnson, B. R. and Bruce, R. M., 1991, Reconnaissance geologic map of parts of the Twin Peaks and Blanca Peak quadrangles, Alamosa, Costilla and Huerfano Counties, Colorado: U. S. Geological Survey, Miscellaneous Field Studies Map MF-2169, scale 1:24,000.

Kluth, C. F. and Schaftenaar, C. H., 1994, Depth and geometry of the northern Rio Grande rift in the San Luis basin, south-central Colorado, *in* Keller, G. R. and Cather, S. M., eds., Basins of the Rio grande rift: Structure, stratigraphy and tectonic setting: Boulder, Colorado, Geological Society of America Special Paper 291, p. 27-37.

Limbach, F. W. and Powell, J. L., 1993, Geological map of a portion of the northeastern Baca Grant, unpublished map prepared for Challenger Gold, Inc., scale 1:12,000.

Lindsey, D. A., Scott, G. R., Soulliere, S. J. and DeAngelis, B. L., 1984, Geologic map of the Horn Peak quadrangle, Custer and Saguache Counties, Colorado: U. S. Geological Survey, Miscellaneous Field Studies Map MF-1623, scale 1:24,000.

Lindsey, D. A., Soulliere, S. J., and Hafner, K., 1985, Geologic map of Electric Peak and southwestern part of Beckwith Mountain quadrangles, Custer and Saguache Counties, Colorado: U. S. Geological Survey, Miscellaneous Field Studies Map MF-1786, scale 1:24,000.

Lindsey, D. A., Soulliere, S. J., Hafner, K. and Flores, R. J., 1985, Geologic map of Rito Alto Peak and northeastern part of Mirage quadrangles, Custer and Saguache Counties, Coloardo: U. S. Geological Survey, Miscellaneous Field Studies Map MF-1787, scale 1:24,000.

Lindsey, D. A., Johnson, B. R., Soulliere, S. J., Bruce, R. M. and Hafner, K., 1986, Geologic map of the Beck Mountain, Crestone Peak and Crestone quadrangles, Custer, Huerfano and Saguache Counties, Colorado: U. S. Geological Survey, Miscellaneous Field Studies Map MF-1878, scale 1:24,000.

Lindsey, D. A. and Soulliere, S. J., 1987, Geologic map and sections of the Valley View Hot Springs quadrangle, Custer and Saguache Counties, Colorado: U. S. Geological Survey, Miscellaneous Field Studies Map MF-1942, scale 1:24,000.

May, S. J. and Russell, L. R., 1994, Thickness of the syn-rift Santa Fe Group in the Albuquerque basin and its relation to structural style, *in* Keller, G. R. and Cather, S. M., eds., Basins of the Rio Grande rift: Structure, stratigraphy and tectonic setting: Boulder, Colorado, Geological Society of America Special Paper 291, p. 113-134.

McCalpin, J. P., 1982, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Colorado School of Mines Quarterly, v. 77, no. 3, 97 p.

Russell, L. R. and Snelson, S., 1994, Structure and tectonics of the Albuquerque basin segment of the Rio Grande rift: Insights from reflection seismic data, *in* Keller, G. R. and Cather, S. M., eds., Basin of the Rio Grande rift: Structure, stratigraphy and tectonic setting: boulder, Colorado, Geological Society of America Special Paper 291, p. 83-112.

Tweto, O., 1979, The Rio Grande rift system in Colorado, *in* Riecker, R. E., ed., Rio Grande rift: Tectonics and magmatism: Washington, D.C., American Geophysical Union, p. 33-56.

Wallace, A. R., 1995, Cenozoic rift-related sedimentation and faulting, northern Culebra Range, southern Colorado: New Mexico Geological Society, 46th Field Conference, Geology of the Santa Fe Region, Guidebook, p. 147-154.

TOC