GEOLOGICAL REPORT

PROPOSED TAOS TROUGH FEDERAL UNIT

COLFAX, MORA AND TAOS COUNTIES

BEN DONEGAN

LEONARD MINERALS COMPANY

November 15, 1985

TABLE OF CONTENTS

ILLUSTRATIONS

GEOLOGICAL REPORT

Proposed Taos Trough Federal Unit

Colfax, Mora and Taos Counties

New Mexico

INTRODUCTION

The proposed Taos Trough Federal Unit area encompasses the terrigenous shelf facies of the Sandia Formation in the Taos Trough of north-central New Mexico. This area of transition from thick, coarse fluvial clastics to the north and west into organic-rich basinal shales and siltstones to the south and east, is a favorable target for a potentially large oil trap. Unfavorable indications for this area include immature to marginally mature thermal alteration and poor porosity as determined from outcropping sediments in this area and numerous faults that may have allowed hydrodynamic flushing of potential reservoirs. The drilling of a test well to a depth of approximately 6,000 feet at a location in the SW1/4NE1/4 of Section 35, T. 24 N., R. 14 E., N.M.P.M., is proposed to evaluate maturation, reservoir quality and formation waters in the Sandia Formation in the Taos Trough shelf target area.

Location. The proposed 108,600 acre unit area is located in T. 21 N., R. 14. E., T. 22 N., R. 13 and 14 E., T. 23 N., R. 13, 14 and 15 E., T. 24 N., R. 13, 14 and 15 E., and T. 25 N., R. 13, 14 and 15. E., N.M.P.M. in southwestern Colfax, northwestern Mora and eastern Taos Counties, New Mexico (See Figure 1). The unit area is entirely in the southern Sangre de Cristo Mountains and, except for about 200 acres of the unit in the Santa Fe National Forest, all of the proposed area is in the Carson National Forest. The unit area is generally uninhabited except for small villages in the vicinity of Black Lake and Tienditas Creek along the northwestern margin of the area and in the valley of the Rio Pueblo in the southernmost part of the proposed unit area.

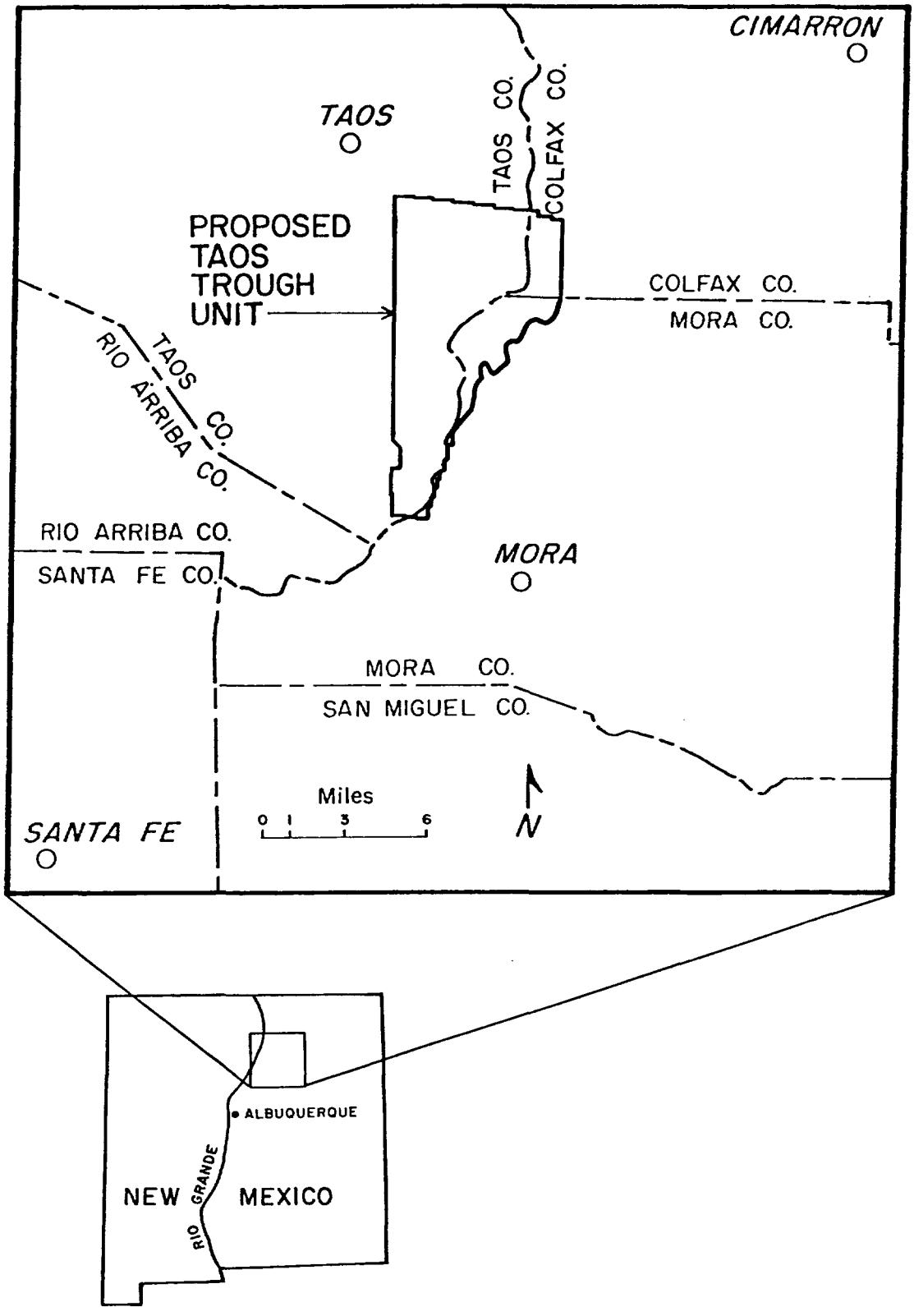

Figure 1. Map showing location of the proposed Taos Trough Unit in north-central New Mexico

Most of the unit area is above 9,500 feet in elevation (See Plate III, Land map with topography). The highest mountain peaks in the proposed unit, Osha Mountain (10,770 feet), Cuchillo de Fernando (11,395 feet), Cerro Vista (11,939 feet), Cerro Olla (11,932 feet) and Cerro del Oso (11,255 feet) are located along the northeast trending divide between the Canadian River and the Rio Grande in the central part of the unit area. The lowest elevations of the unit area are in the valleys along the northwestern margin (Rio Fernando de Taos, 7,900 feet), the western margin (Rio Chiquito and Rito de la Olla, 8,100 feet) and the southwestern margin (Rio Pueblo, 8,600 feet). Dense piñon pine, yellow pine, aspen, spruce and/or fir forests cover most of the proposed unit area.

State Highway No. 3 crosses the southern tip of the proposed unit area, but access to the remainder of the area is limited to a few dirt roads maintained by the Forest Service and to a network of inactive logging trails.

The nearest oil and gas production to the Taos Trough is about 70 miles to the west in the San Juan Basin, the nearest trunk oil and gas pipelines are about 70 miles to the southwest in Sandoval County, and the nearest oil field supply and service center is at Farmington which is located about 240 miles west of the proposed unit area.

Climate. Mean annual snowfall for the Black Lake state climatological station (elevation 8,600 feet), immediately east of the proposed unit, is 73.5 inches with a high in 1980 of 158.2 inches. Mean annual snowfall for Taos (elevation 6,952 feet), five miles northwest of the unit, is 35 inches with a high of 64.6 inches in 1961. Most of the snowfall recorded at Black Lake and Taos occurred in the months of November through April. Mean annual precipitation at Black Lake is 17.77 inches and at Taos is 11.95 inches. Temperature records at Taos show an annual mean of 46.9°F. with a high of 99°F. and a low of -27°F.

GEOLOGY

Stratigraphy. Outcropping formations in the proposed unit are, in general, limited to middle Pennsylvanian sediments except for an isolated Cenozoic volcanic flow on the ridge between Chacon and Tres Ritos and local areas of Quaternary alluvium.

Predicted subsurface stratigraphy of the proposed unit area as shown in Figure 2 is based on studies of the outcropping Precambrian, Mississippian and Pennsylvanian formations around the margins of the Taos Trough in as much as no test wells have been drilled in the proposed unit. The oldest sedimentary unit in this area is a 50-foot thick transgressive sandstone of the Espiritu Santo Formation which rests on the peneplained surface of Precambrian metasedimentary, metavolcanic and plutonic rocks. About 50 feet of Espiritu Santo dolomite is present above this basal sandstone in outcrops west of the proposed unit but is absent east of the unit area. Above the Espiritu Santo is about 50 feet of limestone of the Mississippian Tererro Formation.

The Lower Pennsylvanian Sandia Formation (= lower part of Flechado Formation), uncomformably overlies the Tererro limestone. The Morrowan lower part of the Sandia Formation consists of about 200 to 500 feet of fluvial to near-shore marine sandstone, shales, limestones and thin coal beds in outcrops east, west and south of the unit are.

The Atokan upper part of the Sandia Formation north and west of the proposed unit consists of about 1,000 feet of conglomerates and sandstones with interbedded marine limestones and shales in eastward and southeastward progradational alluvial fan, braided stream and fan-delta systems. Southeast of the unit area, the Atokan upper part of the Sandia Formation consists of more than 2,000 feet of basinal black shales and siltstones with local

SYSTEM	SERIES	FORMATION	LITHOLOGY	THICKNESS
PENNSYLVANIAN	DESMOINESIAN	lower part of ALAMITOS	conglomerate, sandstone and shale	500-1,500
		upper part of FLECHADO (=PORVENIR)	conglomerate sandstone and shale	100-2,000
	ATOKAN MORROWAN	SANDIA (=lower of FLECHADO)	conglomerate, sandstone, siltstone and shale	1,000-2,000
MISSISSIPPIAN	CHESTERIAN MERAMECIAN	TERERRO	limestone	100
	OSAGEAN	ESPIRITU SANTO	dolomite, and sandstone	100

Figure 2. Paleozoic Formation in the Taos Trough Unit Area.

turbidites. In the Pecos Shelf area southwest of the proposed unit, the Atokan Sandia thins to less than 200 feet of shallow-water limestones with minor sandstones and shales. The cross section of Figure 3 shows schematically the location of the proposed unit in relationship to the area of transition from the fluvial Sandia facies to the basinal facies. Plate II shows the areal distribution of Atokan Sandia Formation facies and the relationship of the proposed unit area to the location of the transition facies.

The lower Desmoinesian upper part of the Flechado Formation of the western part of the Taos Trough consists of about 1,500 feet of sandstone and conglomerate with interbedded siltstones and shale in fluvial-deltaic systems that, similar to the underlying Atokan sediments, prograde eastward and southeastward into the Taos Trough. In the Mora area to the southeast, the lower Desmoinesian Porvenir Formation consists of about 1,600 feet of shale and limestone with minor sandstone. In the Pecos Shelf area to the south of the proposed unit, equivalent lower Desmoinesian sediments consists of about 500 feet of limestone with minor shale and sandstone.

Above the Flechado and outcropping over most of the proposed unit is the Alamitos Formation of medial Desmoinesian age which consists of about 500 to 1,500 feet of arkosic sandstones, gray shales, siltstones and thin limestones.

Tectonic Setting. The unusually thick Pennsylvanian section in the Taos Trough (twice that of other Pennsylvanian sections in New Mexico), is probably related to its proximity to the intersection of the north trending Pecos-Picuris wrench fault which forms the west boundary of the Taos Trough and the northwest trending Wichita-Uncompahgre fault zone which forms the north boundary of the Taos Trough. Early Pennsylvanian uplift of the Uncompahgre highland west of the Pecos-Pecuris fault and later Pennsylvanian uplift of the Cimarron highland north of the Wichita-Uncompahgre fault belt yielded large volumes of coarse clastics into the rapidly subsiding Taos Trough. Coarse

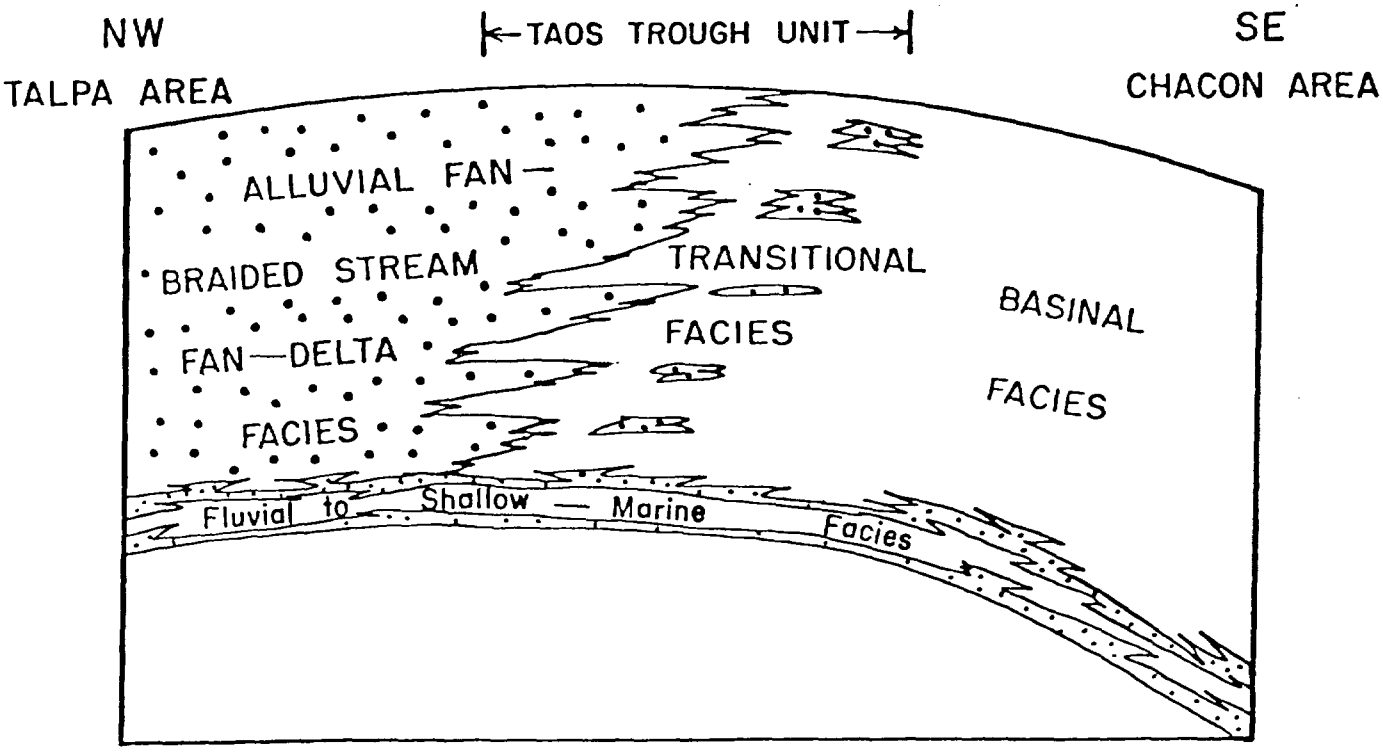

Figure 3. Schematic cross-section showing the location of the proposed Taos Trough Unit in relationship to the depositional facies of the Sandia Formation.

clastics were also intermittently shed into the Taos Trough from local intrabasinal fault blocks and arches.

The Pecos-Picuris fault was the site of rejuvenated wrenching in the Laramide orogeny when regional compression from the west resulted in folding and reverse faulting of the Taos Trough strata. Later Miocene and Pliocene extensional deformation associated with the development of the Rio Grande Rift uplifted the Taos Trough into numerous tilted blocks separated by steeply dipping normal faults.

OIL AND GAS POTENTIAL

Source rocks and thermal alteration. Organic geochemical analyses of samples from outcrops west and south of the proposed unit and cuttings from wells drilled east of the proposed unit indicate favorable source rocks for the Sandia Formation in the unit area and a trend from immature thermal alteration at the surface west of the unit to overmature alteration in the subsurface east of the proposed unit. Average total-organic-carbon values from the Sandia varied from .68 percent in samples from outcrops west of the proposed unit to 3.06 percent in cuttings from the True 1 Medina well drilled six miles east of the unit, to .97 percent in cuttings from the Amoco 1-A Salman Ranch well drilled sixteen miles southeast of the unit, and to 1.0 percent in samples from outcrops south of the proposed unit. Maturation levels in the Pennsylvanian shales samples analyzed varied from immature to marginally mature in outcrops west of the unit, to oil from 3,620-5,640 feet and condensate and gas from 6,650-9,000 feet in the True 1 Medina well, to condensate and gas from 5,300-8,420 feet and dry gas from 8,740-9,790 feet in the Amoco 1-A Salman Ranch well, and to oil in outcrops south of the proposed unit.

Reservoir potential. The large volumes of coarse clastics in the progradational alluvial fan - braided stream - fan-delta systems afford a potential for extensive reservoirs, particularly in their distal facies. However, studies of the sandstones in the outcrops west of the proposed unit indicate that porosities have been greatly reduced by post-depositional compaction and cementation. Porosities have also been greatly reduced by silica overgrowths, probably hydrothermal, in the Sandia Formation sandstones in wells drilled in the area of numerous igneous intrusives east of the proposed unit. More favorable porosities are expected in the proposed unit area because intrusives are absent and the reservoirs of the transitional facies should be mainly well-sorted quartz arenites without the authigenic clay and chlorite characteristic of the near-source fluvial clastics to the northwest.

Trap and seal potential. The area of transition from fluvial to basinal sediments, which is encompassed by the proposed unit area, is the most favorable area in the Taos Trough for the occurrence of large stratigraphic traps. Structural traps may also be locally present in the unit area. The overlying shales and siltstones of the Alamitos and Flechado Formations should provide adequate seals for Sandia Formation oil traps except where post-depositional faulting may have locally breached reservoirs and allowed hydrodynamic flushing. Laramide and late Cenozoic faults are locally numerous in this area, but the plasticity of the thick, dominantly clastic sedimentary section probably minimized seal damage from faulting.

Proposed test well. The drilling of a well at a location in the SW1/4 NE1/4 of Section 35, T. 24 N., R. 14 E., Taos County is proposed to test the Sandia Formation or a depth of 6,000 feet, whichever is shallower. The proposed well site is located in the central part of the area of transition facies of the Sandia Formation. In addition to being located to test the

central part of the area of transition facies, the proposed site was also selected to test a small surface anticline and for accessibility.

DELINEATION OF THE PROPOSED UNIT.

As shown on Plates II and III, the area of the proposed Taos Trough Unit encompasses the area of transitional facies of the Sandia Formation. The unit area is delineated to the west and north by the margin of the fluvial facies, to the south by the margin of the carbonate facies, to the southeast by the margin of the basinal facies and to the northeast by the western limit of the area where sandstone porosities have been greatly reduced by the introduction of hydrothermal silica.

The outside land boundaries of the proposed unit conform with the geological boundaries as shown on Plate III, Land Map as follows:

Beginning at the northeast corner of the proposed unit area being the east one-quarter corner of Section 1, T. 24 N., R. 15 E., thence west and north following the boundaries of 40 acre legal subdivisions to the northwest corner of the northeast one-quarter of the northwest one-quarter of Section 36, T. 25 N., R. 13 E., being the northwest corner of the proposed unit area, thence south following 40 acre legal subdivision surveys through Section 36, T. 25 N., R. 13 E., to the north boundary of the Rancho del Rio Grande Grant, thence southeast along the north boundary of the Rancho del Rio Grande Grant to the northwest corner of the east one-half of the Rancho del Rio Grande Grant, thence south along the center line of the Rancho del Rio Grande Grant to the south boundary of the Rancho del Rio Grande Grant, thence southeast along the south boundary of the Rancho del Rio Grande Grant to the west line of T. 22 N., R. 14 E., thence south along the west line of T. 22 N., R. 14 E., to the north boundary of the Santa Barbara Grant, thence southeast, south and west following the boundary of the Santa Barbara Grant to the west line of T. 21 N., R. 14 E.,

thence south along the west line of T. 21 N., R. 14 E., to the southwest corner of the northwest one-quarter of the northwest one-quarter of Section 18, T. 21 N., R. 14 E., being the southwest corner of the proposed unit area, thence east and south following the boundaries of 40 acre legal subdivisions to the southeast corner of Section 16, T. 21 N., R. 14 E., being the southeast corner of the proposed unit, thence north and east following the boundaries of 40 acre legal subdivisions to the southeast corner of the southwest one-quarter of the southwest one-quarter of Section 23, T. 22 N., 4. 14 E., thence east along the south line of Section 23, T. 22 N., R. 14. E., to east boundary of Exchange Survey No. 513, thence north and east along the east boundary of Exchange Survey No. 513, to the southwest corner of Exchange Survey No. 512, thence northeast along the southeast boundary of Exchange Survey No. 512 to the northeast corner of Exchange Survey No. 512 in the north boundary of the Mora Grant, thence east along the north boundary of the Mora Grant to east line of T. 24 N., R. 15 E., thence north along the east boundary of T. 24 N., R. 15 E., to the east one-quarter corner of Section 1, T. 24 N., R. 15 E., being the northeast corner of the proposed unit area and the point of beginning.

CONCLUSION

The proposed 108,600 acre Taos Trough Unit encompasses a specific untested geological target with a potential for significant oil production. Approval of the proposed area as a federal exploratory unit will enhance the orderly exploration and development of this area and mitigate the problems of exploring this densely forested, largely unsurveyed, high mountain country. The proposed area is logically subject to unitization as the Taos Trough Unit Area.

Respectfully submitted,

LEONARD MINERALS COMPANY

By: _____

Ben Donegan
Regional Manager
Certified Professional Geologist 648

SELECTED REFERENCES

Baltz, E. H., 1965, Stratigraphy and history of Raton Basin and notes on San Luis Basin, Colorado-New Mexico: American Association of petroleum Geologists Bulletin, v. 49, p. 2041-2075.

_____1972, Geologic map and cross sections of the Gallinas Creek area, Sangre de Cristo Mountains, San Miguel County, New Mexico: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-673, 2 sheets.

Baltz, E. H., and Myers, D. A., 1984, Porvenir Formation (new name) ___ and other revisions of nomenclature of Mississippian, Pennsylvanian, and lower Permian Rocks, southeastern Sangre de Cristo Mountains, New Mexico: U.S. Geological Survey Bulletin 1537-B, 39 p.

Baltz, E. H., and O'Neill, J. M., 1984, Geologic map and cross sections of the Mora River area, Sangre de Cristo Mountains, Mora County, New Mexico: U.S. Geological Survey Map I-1456.

_____1980b, Preliminary geologic map of the Sapello River area, Sangre de Cristo Mountains, Mora and San Miguel Counties, New Mexico: U.S. Geological Survey Open-file Report 80-39B.

Casey, J. M., 1980, Depositional systems and basin evolution of the late Paleozoic Taos Trough, northern New Mexico: University of Texas at Austin Ph.D. dissertation, 236 p.

Coxe, C. L., 1980, Depositional systems and genetic stratigraphy of lower Desmoinesian fluvial deltaic complexes, Taos, New Mexico: University of Texas at Austin, M. A. thesis, 108 p.

Houle, J. A., 1980, Depositional systems, sandstone diagenesis, and cobble study in the lower Pennsylvanian Taos Trough, northern New Mexico: University of Texas at Austin, M.A. thesis, 128 p.

Miller, J. P., Montgomery, A., and Sutherland, P. K., 1963, Geology of part of the southern Sangre de Cristo Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 11, 106 p.

Roberts, J. W., Barnes, J. J., and Wacker, H. J., 1976, Subsurface Paleozoic stratigraphy of the northeastern New Mexico basin and arch complex, in Ewing, R. C., and Kues, B. S., eds., New Mexico Geological Society Guidebook, 27th Field Conference, p. 141-152.

Seimers, C. T., 1979, Sedimentology and petrology of Pennsylvania strata, central and eastern Rowe-Mora Basin, southeastern Sangre de Cristo Mountains (abs.): 9th International Congress of Carboniferous Stratigraphy and Geology, Abstracts of Papers, p. 201-202.

Sutherland, P. K., and Harlow, F. H., 1973, Pennsylvanian brachiopods and biostratigraphy in southern Sangre de Cristo Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 27, 173 p.