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1963, pp. 102-111. https://doi.org/10.56577/FFC-14.102

in:

Socorro Region, Kuellmer, F. J.; [ed.], New Mexico Geological Society 14 th Annual Fall Field Conference Guidebook, 204 p. https://doi.org/10.56577/FFC-14

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PENNSYLVANIAN ROCKS OF SOCORRO COUNTY, NEW MEXICO

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INTRODUCTION

Pennsylvanian strata of Socorro County crop out on Mesa Sarca, in the Ladron Mountains, Magdalena Mountains, Socorro–Lemitar range, Joyita Hills, in Abo Pass, Los Pinos Mountains, Cerros de Amado, Coyote Hills, Oscura Mountains, Mockingbird Gap, Little San Pasqual Mountain, and in the San Mateo Mountains near Eaton Ranch. This outcrop control is supplemented by the Mitchell–Red Lake and Spanel–Heinze 1F oil tests drilled in the northwest corner of the county, and the Skelly–Goddard, Sun–Bingham State and three Lockhart oil tests placed on the northern part of the Jornada del Muerto in eastern Socorro County. Important additional control is to the east, just across in Lincoln County, the Standard of Texas–Heard test, and to the south, a few miles within Sierra County, the two Sun–Victorio oil tests.

Throughout most of the county, the Pennsylvanian beds rest with erosional unconformity on Precambrian granitoid and metamorphic rocks. In the west-central part, lower Mississippian strata of the Kelly and Caloso Formations (Armstrong, 1958) underlie the Pennsylvanian and are unconformable on Precambrian rocks. This is the case in the southern Ladron Mountains, Magdalena Mountains, Socorro–Lemitar range, and Coyote Hills. Early Paleozoic beds underlie the Pennsylvanian in the southeast corner of the county in the southern Oscura and northern San Andres mountains where, in order of appearance southward, the Cambrian–Ordovician Bliss Sandstone, Ordovician El Paso Limestone and Montoya Dolomite, various Devonian units, and the lower Mississippian Lake Valley Limestone is beneath the basal clastic beds of the Pennsylvanian.

The early Permian Bursum Formation, of interbedded red beds and limestones, conformably overlies the Pennsylvanian strata in the eastern part of Socorro County, whereas the Abo Redbeds are conformable to erosionally unconformable on the Pennsylvanian throughout the scattered Paleozoic outcrops of the western part. In the central area, centered on the city of Socorro and extending westward an unknown distance, including outcrops in the Socorro–Lemitar range and Coyote Hills and locally in the Magdalena Mountains, Tertiary volcanic rocks rest with erosional unconformity on the Pennsylvanian.

GENERAL PALEOGEOGRAPHY

If we consider thick sections of sedimentary rocks, especially thick sections that are predominantly limestone and dark shale, as marking the site of more persistent (not necessarily the deeper seas) marine sedimentation, a marine channelway extended north-south through west-central Socorro County, trending from the Ladron Mountains area southward to the eastern San Mateo Mountains area. This basinal area of thick Pennsylvanian sediments may have been continuous in a north-south direction, with the strata deposited being about 2700 feet thick, or may have had a sinuous route, swinging southeastward from the southern Ladrons area, the Lucero basin, to the present-day Cerros de Amado, and then turning back southwestward toward the San Mateos. Western Socorro County, especially the northwestern corner, was on the southwest flank of the Zuni upland, the hinge line between shoreline lagoons and deeper-sea normal marine deposits, and, as suggested by Wengerd (1958), may have been the natural habitat of reefs.

Eastern Socorro County was part of a relatively shallow, shelf sea ten to fifty miles west of the Pedernal upland; outcrops in the Oscura Mountains (Thompson, 1942) are typical of this facies. Farther north, in central Torrance County, the western side of the Pedernal upland was marked by an abrupt gulf in Pennsylvanian time, where as much as 4000 feet of beds, mainly clastic rocks, was dumped into the Estancia trough, a narrow, 15-mile-wide sediment trap bordering the upland. To the south, chiefly in western Otero, eastern Dona Ana, and southeastern Sierra counties, more than 3000 feet of clastic rocks accumulated in the Orogrande basin (Pray, 1961) to the west of the Pedernal upland. An unanswered question, in an area not tested by wildcat wells, is whether or not there is a belt of thick Pennsylvanian sediments directly west of the Pedernal uplift, perhaps 15 miles wide, in easternmost Socorro County.

JOYITA HILLS PROBLEM

Also, there is the puzzle of the Joyita Hills (Read and Wood, 1947); is the thin Pennsylvanian section there a clue to an uplift of middle Pennsylvanian age, termed the *Joyita axis* by Wilpolt et al. (1946); is it the west flank of Wengerd's (1959) submarine Manzanita platform, an area of relatively shallow-water deposition between the Lucero basin to the west and the Estancia trough to the east; or is it a much faulted section with thick parts of the Pennsylvanian "faulted-out"? Whatever the answer, the Joyita Hills area was relatively unimportant in the Pennsylvanian seas. The main concept of the Socorro County area is that of a marine channelway trending southward through the center of the county, with the eastern and western margins being under the influence of the Pedernal upland to the east and the Zuni upland to the west, respectively.

Hambleton (1962) studied the carbonate rocks in the Missourian part of the Pennsylvanian from three scattered sections, Mesa Sarca, Cerros de Amado, and the northern Oscura Mountains. He concluded that the Joyita axis was an active, positive element during Missourian time, on the basis that the northern Oscura Mountains section contained less clastic beds than the other two Missourian sections which are nearer the Joyita Hills. However, the Missourian strata throughout Socorro County (and generally throughout New Mexico) are marked by a large percentage of clastic rocks; the Joyita axis would have to have been a large, emergent feature to have supplied several hundred feet of clastic strata spread over the county and adjoining areas. Also, as mentioned by Hambleton, the noncarbonate clastic fractions are chiefly clay and quartz silt, with a much lesser amount of sand-sized grains of quartz, chert, mica, scarce magnetite, and scattered concentrations of feldspar. This fine-grained (mainly clay- and silt-size) clay- and quartz-rich assemblage is much more indicative of sediments brought in from afar (50 to 100 miles) than fresh, coarse-grained clastic materials dumped into shallow seas adjoining an "axis," which here would be an upland composed of granitic and metamorphic rocks.

The clay mineral suite from the insoluble residues of the limestones studied by Hambleton contained moderate to abundant montmorillonite in his three sections, but with generally abundant kaolinite in the two northern sections, Cerros de Amado and Mesa Sarca. Again, this was interpreted as showing an active Joyita axis during Missourian time; it would be important to determine the clay mineralogy of the thick shales in these Missourian sections and see if they check with the quantitatively tiny, clay-fraction of the limestones.

Another interpretation, based on the relative sparseness of kaolinite in the limestones and the lesser percentage of noncarbonate clastic beds in the northern Oscura Mountains Missourian section, as suggested previously, is that a deep sediment-trapping trough bordered the western edge of the Pedernal uplift in easternmost Socorro County. This conclusion is supported by the thick clastic Pennsylvanian sequence encountered in the Standard of Texas–Heard oil test which was drilled a few miles east of the county line. Sediments eroded from the Pedernal uplift, especially the kaolinite, feldspars, and less stable minerals, may have been deposited in this trough within ten or twenty miles of the shoreline, and relatively small amounts were washed westward as far as the northern Oscura Mountains. Of note is that the Missourian section in the southern Oscura Mountains contains large percentages of clastic rocks, including arkoses and finer-grained red beds.

NORTHERN SOCORRO COUNTY

A diagrammatic cross section from west to east along the northern fringe of the county illustrates the relationships of rock types and correlative sequences from the Zuni upland across the Lucero basin, over the Joyita anomaly, into the Estancia trough, and up onto the Pedernal upland (fig. 1). The Huckleberry–Federal oil test in Catron County (Foster, 1957), about 45 miles west-southwest of the northwest corner of Socorro County, encountered Abo-like red beds overlying the Precambrian granite and presumably was up on the Pennsylvanian-age Zuni upland. The Mitchel–Red Lake oil test (no. 33, fig. 1), in the northwest corner of the county, cut through at least 570 feet of Pennsylvanian rocks, with sandstones prominent in the lower third, and shales dominant in the upper two thirds. Twenty-six miles to the east on Mesa Sarca (Wengerd, 1959; Kelley and Wood, 1946), the Pennsylvanian sequence totals 2490 feet; an oil test drilled between these two points, the Spanel and Heinze 1F well, encountered about 1375 feet of Pennsylvanian with lithologies transitional between the Mitchel–Red Lake and Mesa Sarca sections.

Just seventeen miles to the southeast, the southern Ladron Mountains Pennsylvanian section (see road log in this guidebook for columnar section) is about 2700 feet thick (Cheetham, 1950), whereas only 15 miles farther to the east, the Joyita Hills section is only 180 to 400 feet thick!

The Derryan rocks of the Mesa Sarca and the

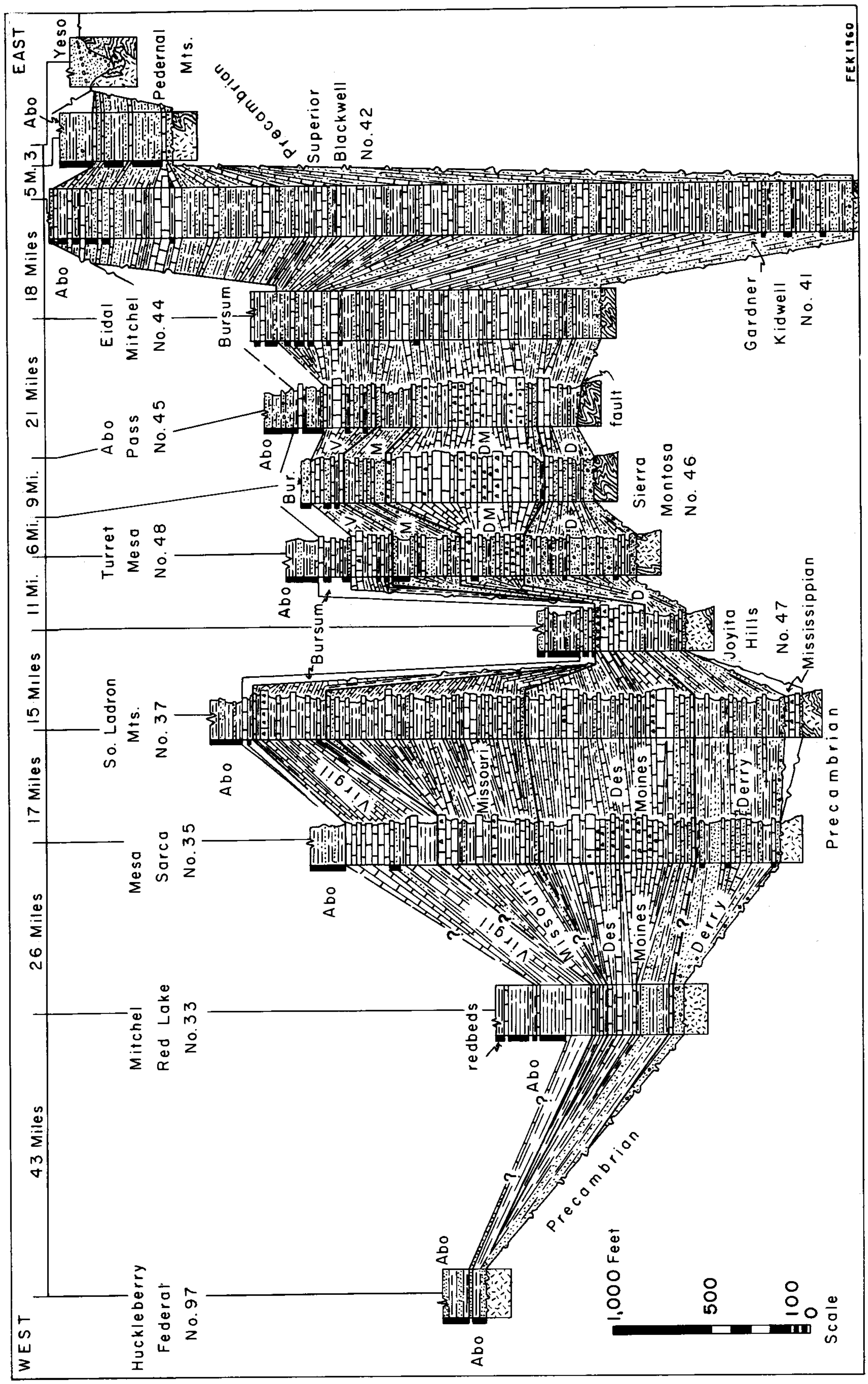

FIGURE 1

Diagrammatic section from Zuni arch eastward to Pedernal Mountains.

southern Ladron Mountains are about 450 feet thick, are dominantly sandstones and shales with lesser amounts of clastic limestone; percentagewise, there is more sandstone in the Mesa Sarca Derryan, a fact not compatible with the sand's source being from the Joyita axis, but rather suggesting derivation from the more distant Zuni upland. The lower 200 feet of the Joyita Hills section is not precisely dated by its fossils, but has been referred to as the clastic member of the Sandia Formation and is thus correlated with the same member in the southern Ladron Mountains, which is of Derryan age (Thompson, 1942). The clastic Sandia Formation in the Joyita Hills is a basal lenticular siliceous sandstone overlain by black shales and minor dark limestones—contrasting greatly with correlative beds both to the west and to the east. The Desmoinesian strata of Mesa Sarca and the southern Ladron Mountains are about 800 to 850 feet thick, thickening slightly eastward, and are dominantly limestone but with considerable amounts of interbedded shale and some sandstone, the sandstones being chiefly near the base of the Desmoinesian and about at the center. In both sections, the sandstones are clean, light gray, and quartzose, cemented by calcite, and with some conglomeratic lenses of limestone cobbles—beds suggestive of marine deposition at a considerable distance from a low landmass and probably derived from the Zuni upland. In contrast, the Desmoinesian of the Joyita Hills, only about 200 feet thick according to Wilpolt et al. (1946), consists almost entirely of cherty limestone.

The Missourian strata are about 500 feet thick on Mesa Sarca, but may be as much as 1000 feet thick in the southern Ladron Mountains. The lithologies are about the same in the two sections, although there is a slightly higher percentage of limestone in the Mesa Sarca section. Shales, gray and calcareous, with minor amounts of dark carbonaceous beds, make up a considerable part of the section, and a few lenticular sandstone beds are scattered throughout. Some of these sandstones are brown, limy, arkosic pebbly beds with grains and pebbles of granite, orange-tinted calcite, weathered feldspar, quartz, chert, and limestone (Kottlowski, 1960). These brownish sandstones contrast with the olive micaceous sandstones in the Missourian of the Los Pinos Mountains (Stark and Dapples, 1946) ten to twenty miles east of the Joyita Hills, and their mineralogic content suggests a different source rather than the same source, which would be the case if the Joyita axis was an emergent debris-shedding upland during Missourian time.

In the Joyita Hills, Wilpolt et al. (1946) reported the early Permian Bursum Formation strata unconformable on Desmoinesian limestones. They suggested, therefore, that the Joyita axis was a positive element elevated in middle Pennsylvanian time; a greater thickness of Desmoinesian limestone may have been deposited on the axis but would have been stripped off in late Desmoinesian, Missourian, and Virgilian time. Thus no Missourian nor Virgilian strata were reported from the Joyita Hills, and there should be some detritus in adjoining areas washed from the emergent Joyita axis.

The Virgilian beds on Mesa Sarca and in the southern Ladron Mountains are about 375 to 450 feet thick, thinning southeastward *toward* the Joyita Hills, and are of interbedded gray limy shales and fossiliferous limestones. Sandstone is essentially absent in the Virgilian of the southern Ladron Mountains and sparse on Mesa Sarca. The clastic rocks of the Missourian and Virgilian strata in these sections 15 to 25 miles west of the Joyita Hills are fine-grained, clay and silt predominating, quartz rich, high in calcite, and do not appear to be sediments dumped offshore from a nearby upland.

Where was the Joyita axis? Pennsylvanian rocks in the Joyita Hills (see geologic map of Joyita Hills in the road log section of this guidebook) crop out as a narrow, shattered belt along the west side of the Precambrian core of the hills, extending in various fault blocks for a length of about three miles. In the Joyita Hills, the Precambrian is overlain only by Pennsylvanian rocks, the clastic member of the Sandia Formation. Six miles to the northeast of the northern tip of the Joyita Hills' Precambrian core, Precambrian rocks again crop out but are overlain by alluvial fan gravels and clastic beds of the Cenozoic Santa Fe Formation. Is this granite outcrop, about a mile long and a maximum of half a mile wide, a remnant of a Precambrian core of the Joyita axis? However, the Missourian and Virgilian strata directly west (northern Ladron Mountains) and directly east (Sierra Montosa in the Los Pinos Mountains; no. 46, fig. 1) of this northern Precambrian outcrop contain, if a trend can be noticed, less clastic materials than sections west, east, and south of the Joyita Hills proper. About ten miles almost directly south of the southern Joyita Hills, in the Cerros de Amado section (North Coyote Hills of Wilpolt and Wanek, 1951), the Missourian and Virgilian strata are 540 to 630 feet thick. They consist of a lower half of gray shales with minor argillaceous limestones and limy quartzose sandstones, and an upper half with lower interbedded siltstone, sandstone, and fossiliferous limestone, and upper cherty massive limestones. Other than a few lenses of reddish brown feldspathic sandstones near the middle of this Late Pennsylvanian sequence, the clastic materials are chiefly fine-grained quartz- and clay-rich fractions, suggesting derivation from a distant landmass and not detritus dumped offshore from a nearby granitic island. As Pennsylvanian outcrops are almost continuous (except for a four-mile gap due east of Polvadera) from the southern Los Pinos Mountains to Cerros de Amado, being only seven to fifteen miles east of the Joyita Hills, and the Late Pennsylvanian rocks are similar in lithology and thickness throughout this outcrop belt, there does not appear to have been room for an emergent upland in late Pennsylvanian time south of the Joyita Hills.

So, where was the Joyita axis? On Turret Mesa, in the southern Los Pinos Mountains (no. 48, fig. 1) ten miles due east of the Joyita Hills, the Late Pennsylvanian beds are about 710 feet thick, and the Missourian part of the section contains a higher percentage of clastic strata than in any nearby area except farther to the east toward the Pedernal upland. If the Joyita axis was a debris-shedding island during Late Pennsylvanian time, it probably was a small, low, emergent feature located somewhere near the east side of the present Precambrian core of the Joyita Hills.

Wilpolt et al. (1946) regarded the thinness of the Derryan (?) and Desmoinesian beds in the Joyita Hills as indicating that a resistant monadnock, their Joyita axis, was a stable feature during "Sandia and early Madera time." The abundant pink feldspars in this lower part of the Pennsylvanian on Turret Mesa were believed to have been derived from the Joyita axis. If so, obviously the black carbonaceous shales of the lower Pennsylvanian in the Joyita Hills do not indicate an environment or source similar to that of the arkosic sandstones in the Derryan of Turret Mesa. The Desmoinesian in the Joyita Hills, even though it may be only a remnant, is of massive cherty limestones in contrast with the arkoses, dark shales, and cherty limestones of Turret Mesa's Desmoinesian strata.

The sandstones and arkoses of the lower Pennsylvanian beds in the Los Pinos Mountains (nos. 46 and 48, fig. 1) total a considerable bulk of clastic material and may just as well have been washed (40 miles?) from the east from the Pedernal upland.

The line of cross section shown in Figure 1 is not straight west to east; it is approximately eastward from the Huckleberry–Federal oil test to Mesa Sarca, then trends southeast to the Joyita Hills, hence eastward to Turret Mesa, then northeast to the Gardner–Kidwell oil test, and then eastward to the Pedernal Mountains. The Abo Pass section is about on the Socorro–Torrance county line with the eastern sections (chiefly of oil tests) illustrating the sediments in the Estancia trough. The large percentage of limestone in the Desmoinesian beds of the Sierra Montosa (central Los Pinos Mountains) and Abo Pass sections is noteworthy; these are the most carbonate-rich Desmoinesian beds in northern Socorro County; yet they could not have been more than ten to fifteen miles away from the Joyita axis wherever (and if) it was. The thickness of the various series shown in Figure 1 for the Turret Mesa, Sierra Montosa, and Abo Pass sections follows the fusulinid zoning of Stark and Dapples (1946). Wilpolt et al. (1946) believed that the upper sandy units shown in Figure 1 as upper Derryan on Turret Mesa grade laterally into the massive limestones shown as lower Desmoinesian on Sierra Montosa. Unfortunately, outcrops between the two sections are in places poorly exposed and interrupted by thrust faults, so that very detailed field mapping is needed to clarify the relationships.

In the Los Pinos Mountains, the Pennsylvanian rocks range from 1300 to 1400 feet in thickness. The Derryan (and older?) strata range from 230 to 530 feet in thickness, thicken toward the southwest and become slightly coarser and more arkosic in that direction. Desmoinesian rocks, 550 to 770 feet thick, thin abruptly from Sierra Montosa to the southwest and become more clastic. Missourian beds, 230 to 340 feet thick, also thicken toward the southwest, and although their clastic ratio in all three sections is greater than 1.0, there is a change from fine-grained clastic beds to arkosic pebbly sandstone in a southwest direction. Strata of Virgilian age, 200 to 230 feet thick, are relatively constant in lithology and thickness, consisting of massive noncherty limestones with interbeds of green to red shale and sandstone. Locally, they appear to grade up into the Wolfcampian Bursum Formation, whereas in other places rubbly limestone conglomerates of the basal Bursum seem to be unconformable on the Virgilian beds.

CENTRAL SOCORRO COUNTY

An east-west line through central Socorro County would pass near the Pennsylvanian outcrops in the Magdalena Mountains, Socorro–Lemitar range, Coyote Hills, Cerros de Amado, and the Skelly–Goddard oil test, with no control in the west-central and east-central parts of the county. Rocks in the Magdalena Mountains are broken by more faults than even in the Joyita Hills area. Beds of Pennsylvanian age crop out in the northern part of the range in the

Kelly mining district and southward to Water Canyon, with some poorly exposed outcrops to the north on the southeast edge of the Bear Mountains —these latter rocks can be seen to the north of U.S. Highway 60 several miles east of Magdalena. This, the Kelly mining district, is the type area of the Magdalena Group (Gordon, 1907), and the sequence is about as unsuitable a type section as could be found; however, it was one of the better-known Pennsylvanian sections when Gordon did his work. Loughlin and Koschmann (1942), in their mapping of the mining district, found only about 1200 feet of Pennsylvanian, apparently only of Derryan (Atokan), Desmoinesian, and Missourian age, and reported that the Pennsylvanian was erosionally unconformably overlain by Abo Redbeds and locally by Tertiary volcanic rocks. Examination of key outcrops mapped by Loughlin and Koschmann revealed only fault contacts between the Pennsylvanian and Abo Redbeds; however, just south of their mapped area, the Abo does appear to rest with depositional contact on the Pennsylvanian, but higher, younger beds than those previously reported underlie the Abo Redbeds.

In the Magdalena Mountains, the Magdalena Group is unconformable on the Mississippian Kelly Limestone and consists of the lower Sandia Formation and upper Madera Limestone. The Sandia Formation is about 600 feet thick and includes six members: (1) basal quartzite, (2) lower limestone, (3) middle quartzite, (4) shale members, (5) upper limestone, and (6) upper quartzite. On Tip Top Mountain near the ghost mining town of Kelly, the Madera Limestone is more than 400 feet thick and may be as much as 1000 feet thick although upper beds have been removed by recent erosion. The lower 100 to 300 feet is of interbedded shale and limestone with lenses of limestone-pebble conglomerate, whereas the upper strata are chiefly massive limestones forming cliffs and ledges.

Loughlin and Koschmann measured only 1185 to 1200 feet of Pennsylvanian beds which include strata only as young as Missourian. Along the north fork of Patterson Canyon near the south end of the Pennsylvanian outcrops in the Magdalena Mountains, uppermost Pennsylvanian strata occur; they are mostly gray, olive, pale purple, and pink limy shales with interbeds of limestone and limestone conglomerate containing advanced forms of *Triticites*. Younger beds were removed by recent erosion, so that a sedimentary contact with the Abo Redbeds is not exposed, and the lower part of the section is concealed by faulting; therefore, a complete thickness of the Pennsylvanian is not known. As these younger Pennsylvanian beds appear to be 400 to 600 feet thick above units described by Loughlin and Koschmann, 1800 feet is suggested as a reasonable total original thickness for the Pennsylvanian of the area.

These Pennsylvanian rocks are types deposited in shallow seas and some were laid down in shoal areas where previously lithified limestone was broken and then reworked into flat-pebble conglomerates. Some of the lower sandstones are arkosic and contain many angular grains and pebbles (including considerable Mississippian-like? chert) suggesting derivation from local hills. Above the middle of the Sandia Formation, the clastic rocks are either quartz-chert-quartzite-rich sandstones or silty to limy shales whose constituents probably were transported long distances before being deposited. Lithologically, the sequence is similar to that of the southern Ladron Mountains and somewhat like the Cerros de Amado section of Pennsylvanian strata.

Only the lower part of the Pennsylvanian remains beneath the early Tertiary erosion surface in the Socorro–Lemitar range, even though eight miles to the east across the Rio Grande the full Pennsylvanian section is about 2130 feet thick in Cerros de Amado. Partial sections, complicated by faulting and some poor exposures, measured by Lawrence J. Herber on Socorro Mountain suggest that the remnant Pennsylvanian there may be as much as 1200 feet thick. The lower part consists of brownish pebbly quartzites containing lenses of arenaceous fossiliferous calcarenites; lenticular greenish to brownish, pebbly to silty, quartzitic to limy sandstones; blackish, greenish, and gray, carbonaceous to limy shales; and minor amounts of thin-bedded nodular to lenticular dark gray limestones. Lenticular one-inch seams of bone coal occur in the dark shales, in places only a few inches horizontally from fossiliferous marine limestone laminae.

The upper part of the remnant section is of ledge- and cliff-forming cherty limestones with many interbeds of limy shale in lower sequences and shaly nodular limestone near the top. Lower beds include greenish to brownish feldspathic quartzitic pebbly sandstones that grade laterally into brownish arenaceous fossiliferous calcarenites. Needham (1937) identified *Fusulina* and *Wedekindellina* in the upper part of the exposed Pennsylvanian section, referring it to the Desmoinesian, and suggested that the lower part is Deryan in age. The fusulinid zones, as far as is known from the sparse data, appear to be thinner than those to the east; therefore, the total Pennsylvanian section prior to erosion during the Tertiary may have been about 1900 feet thick.

The southern part of the Socorro–Lemitar range is called the Chupadera Mountains south of U.S. Highway 60, and the southern tip of the range, southwest of San Antonio, is known locally as the Coyote Hills. In this southern end of the range, Precambrian metamorphic and granitic rocks are exposed, overlain in places by Tertiary boulder conglomerates and volcanic rocks, and in other localities by limy red arkoses and massive crinoidal limestones of the Mississippian Caloso Formation. In one canyon, about 200 feet of Pennsylvanian strata crops out, its base concealed by alluvium, and the upper contact against banded and brecciated rhyolite. Thin-bedded fossiliferous limestones and much brown to black shale, of probable Derryan age, make up the exposed section. As erosion during early Tertiary time has differentially removed parts of the Paleozoic sequence in the Coyote Hills area, it is possible the entire Pennsylvanian section is preserved a few miles away to the east in the Rio Grande graben or to the west beneath the Cenozoic volcanic rocks. Just ten miles to the southeast on Little San Pasqual Mountain, or twelve miles to the northeast near Cerros de Amado, thick, complete Pennsylvanian sequences occur overlain by thousands of feet of Permian and Mesozoic rocks. Therefore, early Tertiary erosion of Paleozoic beds must have been concentrated near the Coyote Hills area. Further proof is the composition of the basal Tertiary on the south side of the Precambrian inlier—whereas the Tertiary there lies on Precambrian rocks, the basal beds are locally a boulder conglomerate containing huge blocks of Precambrian, Mississippian, and Pennsylvanian rocks, some of which are remnants of broken beds measuring 10 by 5 by 4 feet. Such large, relatively unbroken, fragments could not have traveled far.

Exposures of Pennsylvanian strata about 2130 feet thick occur in the Cerros de Amado area (a group of broken fault-block hills, east of the Rio Grande, five miles northeast of Socorro, and ten miles south of the Joyita Hills).

The Pennsylvanian rests unconformably on Precambrian granite and grades upward into the red beds and limestones of the Wolfcampian Bursum Formation. The lower 805 feet appear to be Derryan in age, and consist of brownish, reddish, and greenish pebbly sandstones, green to black, limy to carbonaceous shales, and dark gray silty limestones. The Desmoinesian beds are about 785 feet thick and are typical gray cherty and noncherty limestones but with considerable interbedded gray limy shale and some lenses of pebbly to arkosic gray sandstone. The upper Pennsylvanian rocks, 540 or 630 feet thick, of Missourian and Virgilian age, consist of a lower third chiefly of gray shale with interbeds of pebbly sandstone, a medial part of interbedded shale, limestone, and sandstone, and upper beds of massive cherty limestone.

The Skelly–Goddard oil test, drilled on the northwest flank of Jornada del Muerto fifteen miles east of Cerros de Amado and ten miles southeast of the southern Los Pinos Mountains (Turret Mesa), penetrated at least 1480 feet of Pennsylvanian strata underlain by Precambrian quartzite and overlain by the Bursum Formation. The cuttings are contaminated by caved Abo Redbeds, but there seems to be much red shale, siltstone, and arkosic sandstone in upper Pennsylvanian units and the lower 250 feet is dominantly blackish shales.

SOUTHERN SOCORRO COUNTY

An east-west line in southern Socorro County would pass near the Pennsylvanian outcrops in the southern San Mateo Mountains, Little San Pasqual Mountain, in the Oscura Mountains, and join eastward to the sequence penetrated in the Standard of Texas–Heard oil test of western Lincoln County. Such a line in Pennsylvanian time would have crossed the San Mateo basin (Kottlowski, 1962), go up on a relatively shelflike depositional area near the Oscura Mountains, and then plunge into a detritus-filled trough along the western edge of the Pedernal upland. To the southeast and south was the large debris trap, the Orogrande basin.

On the southeast side of the San Mateo Mountains, a thick section of Pennsylvanian rocks is exposed in a complex fault block near Eaton's (Foster's) Ranch (fig. 2). The measured section shows more than 2600 feet of Pennsylvanian beds but studies of the fusulinid faunas by Garner L. Wilde, Humble Oil and Refining Company, and Wendell J. Stewart, Texaco, Inc., suggest bedding-plane faults that repeat parts of the sequence. Thus, the actual thickness may be only 2000 feet. Nevertheless, this thick section occurs on the east edge of the Datil–Mogollon volcanic plateau and indicates that Pennsylvanian seas extended far to the west, although the resulting strata are now deeply buried beneath Cenozoic volcanic rocks.

Derryan beds, cut by faults (unit 8, fig. 2), may be as much as 450 feet thick; they are interbedded light gray, green, and brown sandstones, gray to dark gray arenaceous fossiliferous calcarenites, and blackish shales with basal channel-filling beds of tan to light gray cross-laminated pebbly sandstone. The channels were cut into the underlying brown, coarse-grained Precambrian muscovite granite.

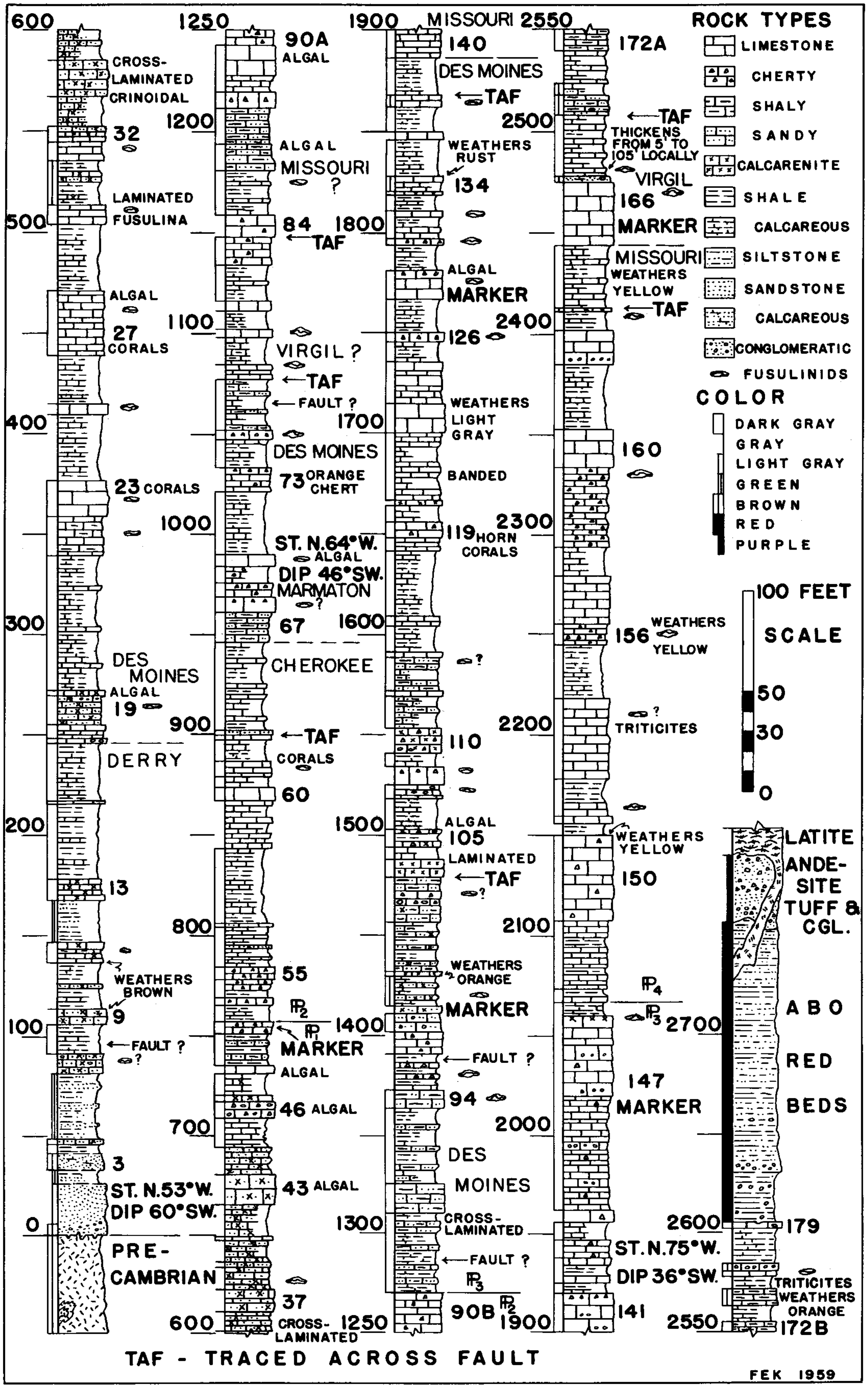

FIGURE 2

Eaton Ranch columnar section.

Desmoinesian beds are the problem; are they 1640 feet thick or are they cut by several dip-slip faults that repeat the section (throughout several miles of outcrop in numerous transverse fault-block slices)? Even if the Desmoinesian strata are only 900 feet thick, it is an unusually thick section and the lithologies are greatly different from most Desmoinesian rocks in central New Mexico—dark shales, dark gray to black silty limestones, arenaceous calcarenites, intraformational limestone flat-pebble conglomerate, and local algal lenses along with gray, nodular limy shale and some massive cherty limestones.

Rocks of Missourian age are about 560 feet thick and are lithologically similar to the blackish Desmoinesian limestones although tending to include more massive beds. Virgilian strata grade up into the Abo Redbeds and are about 220 feet thick, consisting of light gray, crinoidal crystalline limestone, lenticular interbedded limy shale and argillaceous limestone, greenish gray calcareous pebbly sandstone, and lenses of limestone conglomerate.

Unanswered is the question as to whether these rocks are (1) deposits in a slightly deeper, partly stagnant basin amid a shallow shelf sea or (2) sediments laid down in wide, partly restricted lagoons bordering a detritus-supplying upland (Zuni upland) that was some distance to the northwest.

Geddes (1963) measured a partial section of Pennsylvanian rocks on Little San Pasqual Mountain, reporting a thickness of about 1600 feet, somewhat similar in thickness and lithology to the Pennsylvanian sequence penetrated by the Sun–Victorio oil tests to the south in northermost Sierra County. Although thicker, the Pennsylvanian section also is like that of the Oscura Mountains to the east, except for thicker clastic beds at the base of the Derryan part of the section.

The Missourian and Virgilian beds of the northern Oscura Mountains are in Thompson's (1942) type sections for these strata. The Pennsylvanian is only 920 feet thick, although it is 1100 feet thick in the Sun–Bingham State oil test a few miles to the west, and 1260 to 1375 feet thick in the three Lockhart oil tests drilled five to ten miles to the north on the Oscura anticline. Basal Derryan beds unconformably overlie Precambrian granites, whereas the uppermost Virgilian strata are in places apparently conformable and in other localities unconformable beneath the overlying early Wolfcampian Bursum Formation. The Derryan beds are 100 to 150 feet thick, the lower strata being conglomerates, sandstones, and black shales of variable thickness, and the upper beds consisting of dark gray cherty, nodular limestones. The Desmoinesian, about 325 feet thick, is of the typical cherty thick- to massive-bedded limestones. Missourian strata consist of thin- to massive-bedded limestones with interbeds of arkosic sandstone and red shale, totaling about 235 feet thick. The Virgilian rocks are about 210 feet thick and are composed of lower interbedded light gray limestones, arkosic sandstones, and red shale; medial massive limestones; and upper red shales with interbeds of nodular limestone.

In the central Oscura Mountains, about nine miles southeast of Thompson's northern Oscura Mountains section, Wilpolt and Wanek (1951) measured more than 700 feet of Late Pennsylvanian (Missourian and Virgilian) strata, compared with the 445 feet to the north and the 1170 feet found near Mockingbird Gap between the Oscura and San Andres mountains. These upper Pennsylvanian rocks are more clastic southward and eastward (Kottlowski et al., 1956) and suggest that one of the higher parts of the Pedernal upland in late Pennsylvanian time was near the present site of Sierra Blanca, south of Carrizozo. The Standard of Texas–Heard oil test drilled in westernmost Lincoln County, twenty miles east of the central Oscura Mountains, penetrated 1350 or 1745 feet of Pennsylvanian beds before encountering Precambrian diorite and gneiss. The contact between the upper Pennsylvanian beds and the overlying interbedded red beds and limestones of the Bursum Formation is difficult to pick. Numerous red beds and arkosic sandstones occur in the Pennsylvanian sequence especially in the upper part; these feldspathic clastic rocks indicate the nearness of the deposits to the Pedernal upland. Large amounts of angular feldspar grains and numerous pebbly sandstone beds are typical of this nearshore Pennsylvanian sequence.

SUMMARY

These three traverses west to east across northern, central and southern Socorro County have shown similar features in the Pennsylvanian sequences; sediments derived from the Zuni upland in the western part of the county, basinal deposits near the center, relatively thin sequences of mixed marine shelf and siliceous clastic strata in the east-central area, and along the eastern edge of the county, or along that longitude where the Pennsylvanian has been penetrated by the drill, there are thick beds of siliciclastic rocks dumped from the west edge of the Pedernal upland. The Joyita axis probably was merely a small island or shoals area barely interrupting the general north-south trend of basins, shelf, and uplands.

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