GEOLOGY AND COAL RESOURCES

SHOEMAKER CANYON SE QUADRANGLE, CIBOLA COUNTY, NEW MEXICO

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES

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by

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Contents: (1) Discussion of Geology and Coal Resources

(2) 1:24,000 Geologic Map (accompanying)

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GEOLOGY

General

The Shoemaker Canyon SE quadrangle lies in the southern part of the Zuni Basin, a broad, shallow structure that extends southwestward from the Zuni Mountains of New Mexico into east-central Arizona. As such, the quadrangle lies near the southeast margin of the Colorado Plateau. The regional dip in the study area is very gently, but perceptibly, northeastward toward the axis of the Gallup sag which comprises the northeast and deepest part of the Zuni Basin. The northeastward dips are interrupted locally by broad, low amplitude, NW-SE-trending folds, by minor faulting, and by NW-SE trending monoclinal flexures up on the northeast side. At least two monoclines with sinuous, generally northwest-trending axes have been identified in the general area, the largest of which is the Atarque monocline (Fig. 1; Anderson, 1982a).

The area under consideration is underlain by (1) upper Cretaceous sandstones and shales that exceed 900 ft in thickness where the Torrivio Member of the Gallup Sandstone is present (2) nearly 100 ft of Jurassic eolian sandstone, and (3) 800 to 1000 ft of the Triassic Chinle Formation with a 30 to 40 ft thick section of the Rock Point Member of the Wingate Sandstone capping it. No Jurassic or Triassic rocks are exposed on the Shoemaker Canyon SE quadrangle, but good exposures are present a short distance to the west on the adjacent Mesita de Yeso quadrangle (Anderson, 1982b).

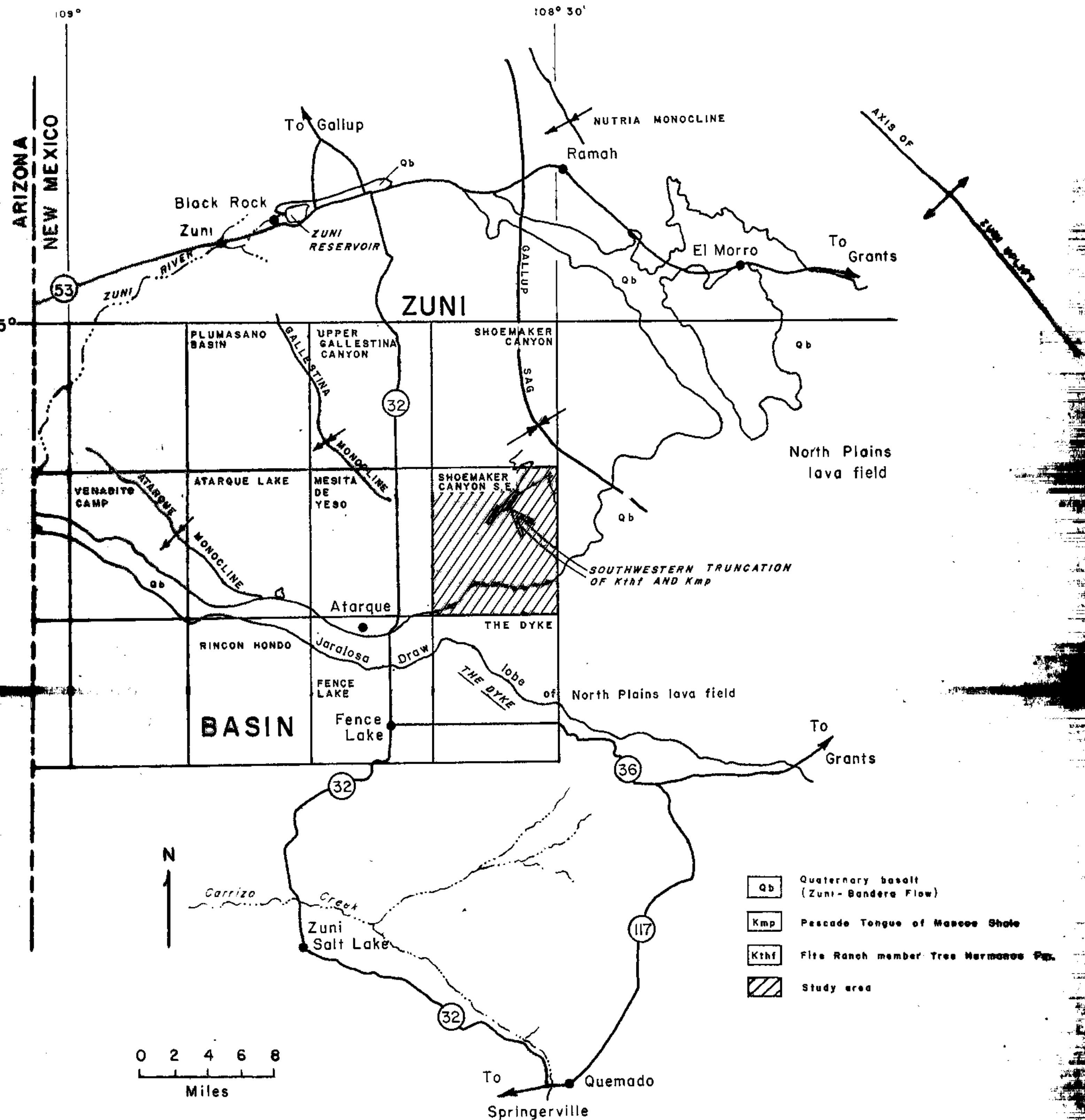


Fig. 1 Index map of the Zuni Basin showing the study area in relation to other quadrangles discussed in text, monoclinal structures, southwesternmost occurence of the Fite Ranch Member of the Tres Hermanos Formation, and the North Plains lava field.

The Paleozoic section in the subsurface may be inferred from an oil test drilled 12 miles to the northwest (hole is in the NE 1/4 sec. 5, T.9N., R.18W., drilled in 1963 by Cities Service Oil Co.; (C. H. Maxwell and L. G. Nonini, written commun., 1977). This test showed a 1,400 ft section of Paleozoic rocks capped by the San Andres Limestone. Assuming locally uniform thicknesses a total sedimentary section of approximately 3,400 ft overlying the Precambrian basement may be present in the study area.

The main body of the Dakota Sandstone, which crops out within 0.7 miles of the western boundary of the Shoemaker Canyon SE quadrangle makes up the lowest part of the Cretaceous section in west-central New Mexico (Hook, Cobban, and Landis, 1980). This unit consists of approximately 100 ft of nonmarine, marginal marine, and marine sandstones and shales that were deposited in front of and immediately behind the shoreline of the advancing interior seaway during Cenomanian time. The lower two-thirds to three-fourths of the formation is nonmarine, with fluvial-channel sandstones at the base overlain by paludal shales. The shales are locally carbonaceous with very minor coaly beds. The very thin, lenticular coaly beds are of very poor quality and represent sedimentation in a transgressive sequence.

Following the Dakota-Mancos transgression, the regressive Atarque Sandstone-Moreno Hill sequence and the partly equivalent Tres Hermanos Formation (Hook, Molenaar, and Cobban, 1983) were deposited throughout much of west-central New Mexico. A subsequent marine transgression, represented by the upper member of the Tres Hermanos Formation (the Fite Ranch Member) and the overlying Pescado Tongue of the Mancos Shale, set the stage for a major regressive episode during which the Gallup Sandstone was deposited.

Basaltic lavas and associated extrusive rocks erupted in Quaternary time in the large North Plains lava field, which lies mostly along the east side of the Zuni Basin east and northeast of the study area (fig. 1). A long, narrow tongue of lava extends from the main body of the lava field, crosses the southern part of the Shoemaker SE and northern part of the Dyke quadrangles, and extends from there westward across the central part of the Zuni Basin for more than 25 miles into Arizona. This tongue of lava follows the course of Jaralosa Draw for much of its length, and is referred to here as the Jaralosa Draw lobe of the North Plains lava field (fig. 1). The basalt has been dated at 1.41 m.y. by Laughlin, Brookins, Damon, and Shafiqullah (1979).

Coal of good quality occurs in the middle part, or Carthage Member, of the Tres Hermanos Formation, and in the middle part of the Gallup Sandstone. Coal beds in these units, and in the partly equivalent Moreno Hill Formation which crops out to the south and west, are commonly 1 to about 3 feet thick, but locally are thicker (Campbell, 1981). The base of the Carthage Member of the Tres Hermanos Formation defines the southern and southwest edge of the Gallup-Zuni coal field. The Jaralosa Draw Lobe of the North Plains lava field immediately to the south intervenes to separate this coal field from the Salt Lake field farther to the south and west. Coal resources in the Shoemaker Canyon SE quadrangle lie within the Gallup-Zuni coal field and are discussed in greater detail in the last section of this report.

Study Area

Structure

The monoclines described earlier do not extend into this quadrangle so the structure is simple. Gentle northeasterly dips that define the southwest flank of the Gallup Sag persist across the Shoemaker Canyon SE quadrangle. There is, however, a slight tendency for the dips to become more directly east in the southeastern portion of the quadrangle, but they remain at between 1° and 2°. Dips become slightly south of east in the southwest corner of the quadrangle. The top of the Atarque Sandstone Member (the basal member of the Tres Hermanos Formation) is at approximately 7,200 ft in sec. 3, T6N., R.17W., whereas 3 miles to the south in sec. 22, on the Dyke quadrangle (Campbell, 1982) it is below 6,960. A minimum drop of 250 ft over this distance indicates an average southward dip of about 1°. It is, however, quite likely that the dip is locally somewhat greater than 1° along a short E-W trending segment of a gentle monoclinal flexure down to the south, that is concealed by the Jaralosa Draw lobe of the (fig. 1) basalt flow. The more prominent monoclines in the region have sinuous axial trends and probably the axial trends of less prominent monoclines are also sinuous.

Faulting is minimal on the quadrangle. The only fault mapped is a high-angle normal fault trending just west of north near the quadrangle boundary in sec. 22, T7N., R.17W. The displacement is about 15 ft, upthrown on the east or northeast as are other minor faults in the region.

Stratigraphy

The Paguate Tongue of the Dakota Sandstone crops out several hundred feet west of the Shoemaker Canyon SE quadrangle (near East Joe Windmill in sec. 16, T7N., R.17W., on the Mesita de Yeso quadrangle (Anderson, 1982b). The oldest rocks exposed on the quadrangle are those of the Whitewater Arroyo Tongue of the Mancos Shale (Cretaceous) which overlies the Paguate Tongue of the Dakota Sandstone. Cretaceous rocks exposed on the quadrangle, in ascending order, are divided into the Whitewater Arroyo Tongue of the Mancos Shale, the Twowells Tongue of the Dakota Sandstone, the Rio Salado Tongue of the Mancos Shale, the Atarque Sandstone, Carthage, and Fite Ranch Members of the Tres Hermanos Formation, the Pescado Tongue of the Mancos Shale, the F Member of the Gallup Sandstone, a middle, coal-bearing part, and the Torrivio Member of the Gallup Sandstone. These are the only rocks exposed in the quadrangle other than the Quaternary basalt flows along the southern edge.

The Whitewater Arroyo Tongue of the Mancos Shale overlies the Paguate Tongue throughout the Zuni Basin. The name was proposed by Owen (1966) who applied it to a "well defined, persistent tongue of marine shale separating the Twowells Tongue from the rest of the Dakota Sandstone in the southwestern part of the San Juan Basin" (and in the Gallup sag area). A type section was designated in Whitewater Arroyo in sec. 17 of T.12N., R.19W., near the village of Two Wells, where it is 80 ft thick and described as a gray to olive-gray, silty, oyster-bearing shale. It crops out only sparingly in the present study area where it consists of an estimated 60 ft of medium- to dark-gray fissile shale and contains the relatively large oyster Exogyra trigeri (Coquand) in its middle portion. Also very near the middle is a distinctive white- to orange-weathering 15-inch-thick bentonite bed, but the bentonite is not well exposed in the quadrangle. The best exposures of the Whitewater Arroyo Tongue, albeit only the upper half, may be found in the N 1/2 sec. 10, T.7N., R.17W., where the easily eroded shales are protected by a cover of sandstone of the Twowells Tongue of the Dakota Sandstone.

The Twowells Tongue of the Dakota Sandstone crops out in the northwestern part of the quadrangle where the tongue may reach 20 ft in thickness but is generally less. The Twowells locally consists of 1) a basal, 4-ft-thick, very fine grained, flat- to wavy-bedded sandstone that is locally burrowed and very fossiliferous at the top; this basal portion with a thin, bentonitic clay overlying is well exposed along NM-32 in secs. 6 and 7, T.6N., R.17W., of the adjacent Mesita de Yeso quadrangle, 2) an overlying gray, shaly sandstone of variable thickness, generally poorly exposed, that is also locally fossiliferous; and 3) an upper, fine- to lower-medium-grained, pale-yellowish-gray, crossbedded sandstone, characteristically with thinly interbedded shale, and clay clasts; wavy bedding is also a characteristic of this upper sandstone. The Twowells may be seen, though poorly, at the quadrangle boundary in the SW 1/4 sec. 34, T.8N., R.17W., and in sec. 10 one mile to the south.

Fossils in the Twowells consist almost exclusively of Pycnodonte kellumi, fragments of Exogyra trigeri (Coquand), and small specimens of Exogyra levis. Evidence of burrowing and bioturbation is common throughout; the burrows include Ophiomorpha. Both the Twowells and the Paguate Tongues may represent minor regressive pulses in the Dakota-Mancos transgressive sequence. The Twowells in particular contains features, such as opposed cross-bedding, that suggest deposition in a tidal channel environment.

The Rio Salado Tongue of the Mancos Shale represents a rapid return to open-marine, deeper water conditions or an interruption in the sand supply following deposition of the Twowells. The Rio Salado consists of up to 240 ft of medium-gray and grayish-brown shale, calcareous shale, and thin calcarenites with a sequence of interbedded shale and very fine grained sandstone at the top where the tongue grades into the overlying Tres Hermanos Formation.

The name Rio Salado Tongue was proposed by Hook, Molenaar, and Cobban (1983). It is defined as the shale tongue lying between the Twowells Tongue of the Dakota Sandstone and the Atarque Sandstone Member of the Tres Hermanos Formation (Atarque Sandstone to the southwest) and is coextensive with these two units.

Thin calcarenite and calcareous shale beds occur 30-40 ft above the base of the Rio Salado and represent the Bridge Creek Limestone Member of the Greenhorn Formation (Hook, Cobban, and Landis, 1980). The Bridge Creek Beds may often by recognized at a distance in outcrop because the yellow-weathering calcarenites stand out in contrast to the typically gray Mancos Shale. The Beds are well exposed locally on the adjacent Mesita de Yeso quadrangle, where the thin calacrenites contain abundant fragments of Pycnodonte newberryi (Stanton). These Beds were deposited during the very late Cenomanian (Greenhorn) transgressive maximum, a time that was marked by the deposition of limestone beds throughout most of the Western Interior seaway. The Beds form important marker horizons for regional correlation. The guide fossil Pycnodonte newberryi (Stanton) appears in abundance at or just below this interval (Hook and Cobban, 1977). P. newberryi were collected in the NE 1/4 sec. 1, T.6N., R.18W., on the adjacent Mesita de Yeso quadrangle; they were also found as weathered specimens in float in the extreme northwest corner of the Shoemaker Canyon SE quadrangle. In the subsurface the Bridge Creek Beds may be recognized by a distinctive resistivity kick they produce on the electric log, which is helpful in correlations.

About 100 ft above the Bridge Creek Beds, limestone concretions commonly appear in the section, but are found only sparingly in the Shoemaker Canyon SE quadrangle. Associated with the concretions in the vicinity are the ammonites Mammites depressus, M. nodosoides, Proplacenticeras cumminsi, and Neoptychites cephalotus (Anderson, 1982). Also, found locally in association with the concretions are Ostrea sp., Veniella mortoni, Baculites sp., Turritella sp. and other gastropods, but none of these were collected on the Shoemaker Canyon SE quadrangle. This part of the Rio Salado is best exposed in the west-central portion of the quadrangle in secs. 14, 22, 23, 27, and 34 of T.7N., R.17W.

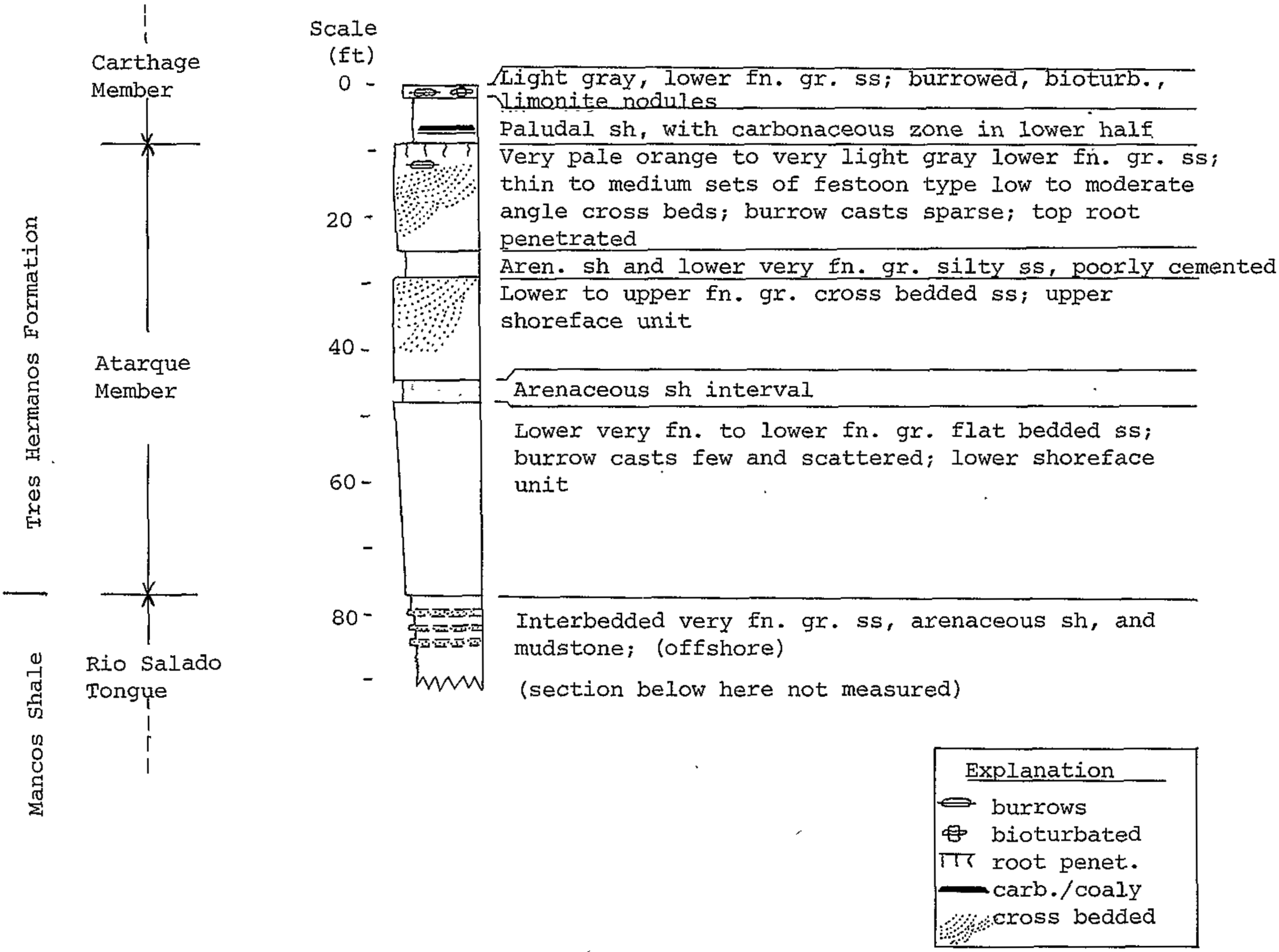
The Atarque Sandstone Member of the Tres Hermanos Formation is the term proposed by Hook, Molenaar, and Cobban (1983) for the regressive coastal-barrier sandstone unit that overlies the Rio Salado Tongue of the Mancos Shale and as such marks the first major regression of the seaway following the Dakota-Mancos (Greenhorn) transgression. The Atarque Member and the overlying nonmarine Carthage Member are equivalent to the Atarque Sandstone and the Moreno Hill Formation respectively (Hook, Molenaar, and Cobban, 1983; and McLellan and others, 1983); the last two stratigraphic names are used to the south and west of the Shoemaker SE quadrangle where the Pescado Tongue and the Fite Ranch Member are not present (Anderson, 1982a).

As the Late Cretaceous shoreline had assumed a general NW-SE trend in this area, the Atarque prograded northeastward into the Mancos seaway and thus it is a diachronous unit that becomes younger to the northeast. Throughout much of the Zuni Basin, it is a cliff-forming unit and consists of 1) a lower flat-bedded sandstone which appears in most outcrops as the first massive unit overlying the transitional zone at the top of the underlying Mancos Shale. This unit coarsens upward from very fine to fine grained; 2) a medial, fine-grained, shaly unit of varying thickness, but generally 5-15 ft; and 3) an overlying, lower- to upper-fine-grained, mostly crossbedded sandstone, fossiliferous at the top, that is 14-20 ft thick. Units 1) and 3) are similar to the lower and upper shoreface sandstones or Molenaar (1973). The lower shoreface unit is thought to have been deposited offshore beyond the zone where wave action or longshore currents influenced sedimentation. Deposition of the upper shoreface unit probably took place in the zone where longshore currents were active. Burrows, including Ophiomorpha, are common in the lower flat-bedded unit and less common above.

In addition to these three units, on this quadrangle and east of it, an upper unit composed of white to very pale orange, upper-fine-grained, crossbedded sandstone forms a small but conspicuous cliff that rises above a small bench developed on the upper shoreface unit (Fig. 2). Twelve miles to the west of the quadrangle, this uppermost sandstone is present as a nonmarine unit, a fluvial or distributary channel sandstone (Anderson, 1982a), and was included with the overlying Moreno Hill Formation. On the present quadrangle, this white upper sandstone is more marine in nature (no clay clasts, no ripple marks, etc.) and is a relatively widespread, uniform deposit. The top is commonly burrowed and root penetrated and is overlain by a paludal shale (see again Fig. 2). The thicker Atarque sequence here could indicate a shoreline stand between here and the Atarque Sandstone outcrops 12 mi to the west, with a resultant build-up of the upper shoreface unit.

Fig. 2

Shoemaker Canyon SE stratigraphic section, upper part of The Rio Salado Tongue of Mancos Shale, and lower part of Tres Hermanos Formation in SE¼ NE¼ sec. 12, T. 7N., R. 17W.



The Atarque Sandstone Member of this report corresponds in part to the Lower Gallup, or the Atarque Member of the Gallup, of Molenaar (1973); he also, however, included overlying nonmarine carbonaceous shales, fluvial channel sandstones, and thin coal beds in his Atarque Member. The faunal evidence presented by Hook, Molenaar, and Cobban (1983) points to a significant age difference between the lower and upper parts of Molenaar's (1973) Gallup. They recognize their redefined Atarque as having been deposited during a much earlier regressive cycle than their Gallup Sandstone and as being separated from the Gallup by the Pescado Tongue of the Mancos Shale and the underlying transgressive marine sandstone unit which they named the Fite Ranch Member of the Tres Hermanos Formation (Fig. 3).

Overlying the Atarque Member of the Tres Hermanos Formation is the coal-bearing Carthage Member. This member was deposited on the emergent coastal-plain formed as the sea regressed. It consists of paludal shales with thin coals, splay sandstones, and fluvial-channel sandstones. The basal portion is paludal shale; the contact with the underlying root-penetrated Atarque Member is sharp. The basal coal zone, where present, lies 3-7 ft above the base and characteristically has a 2-inch-thick white claystone, formed from volcanic ash, near the middle. Immediately overlying this is a sequence of thin, flat-bedded, burrowed and root-penetrated sandstones (Figs. 4, 5, 6). These marginal marine, flat-bedded sandstones have been used as an aid in identifying the top of the Atarque locally, but the top is more appropriately placed at the base of the first paludal

Fig. 3 Shoemaker Canyon SE stratigraphic section through the upper Tres Hermanos Formation, the Pescado Tongue of the Mancos Shale, and the Gallup F' Sandstone in the S¼ SW¼ sec. 34, T. 7 N., 16 W., south side of Terreo △ station.

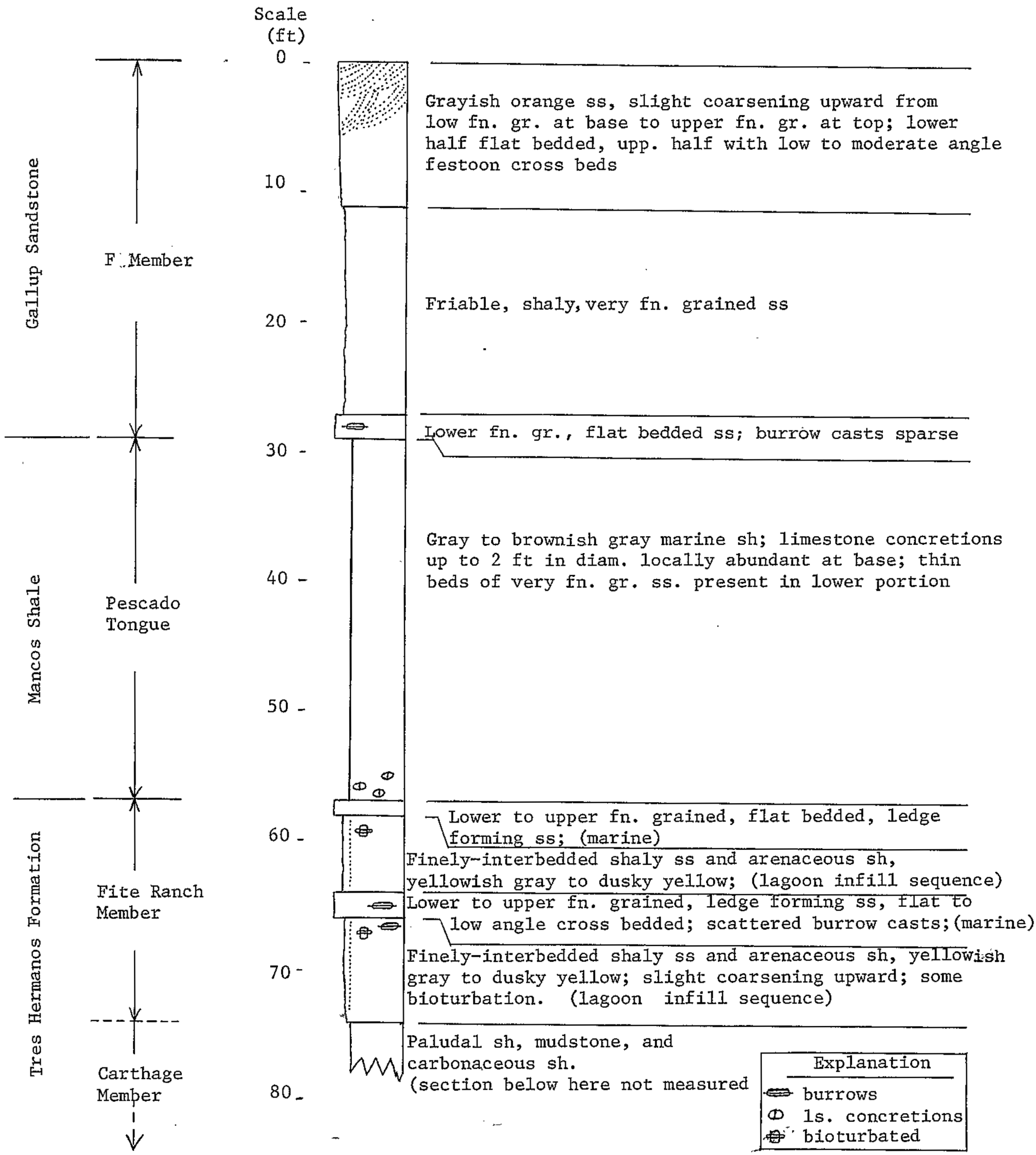


Fig. 4 Shoemaker Canyon SE stratigraphic section through lower part of Tres Hermanos Formation, in the SW¼ NW¼ sec. 3, T. 6N., R. 16W.

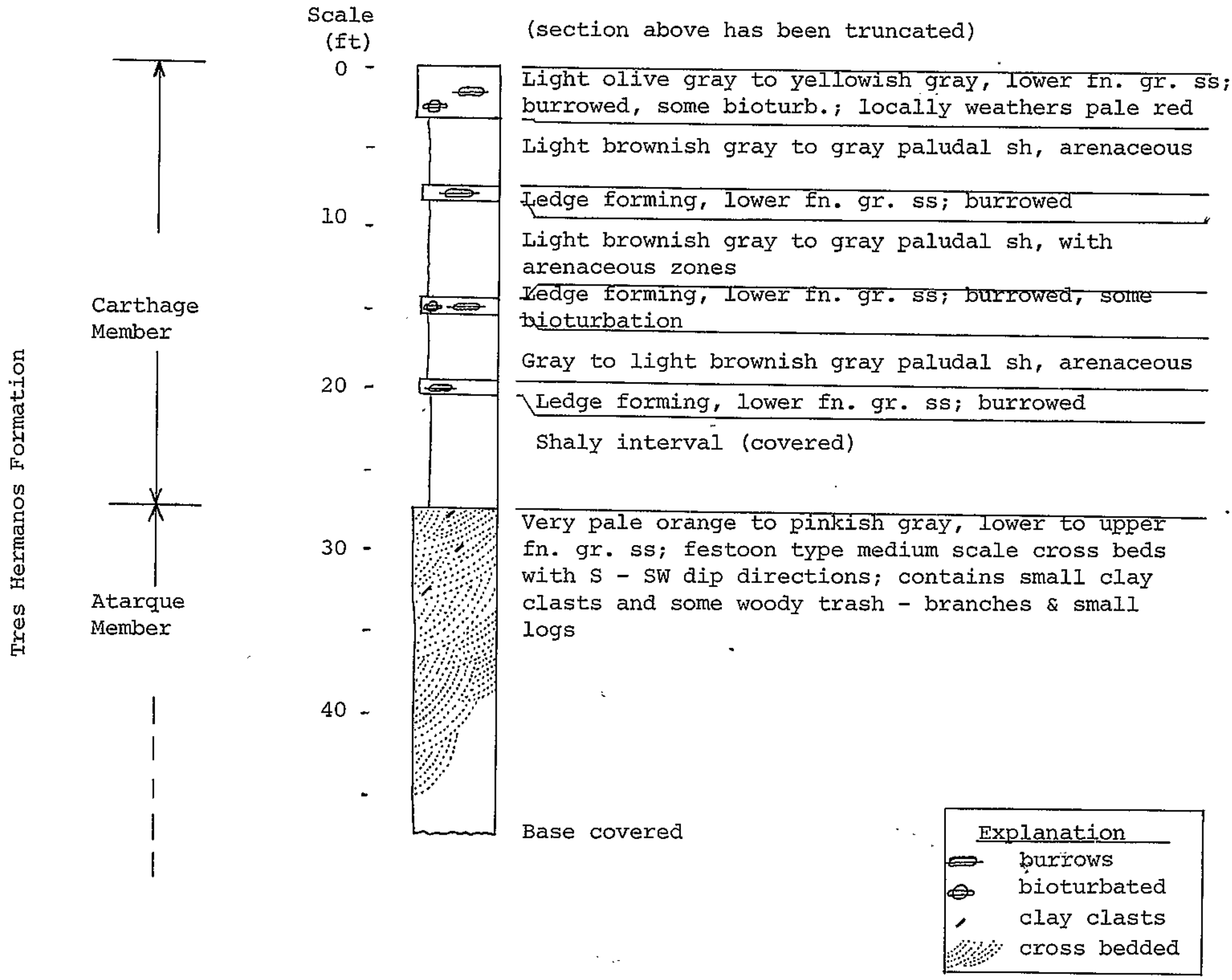


Fig. 5

Shoemaker Canyon SE stratigraphic section, lower part of Tres Hermanos Formation in SW¼ SW¼ sec. 30, T. 7N., R. 16W.

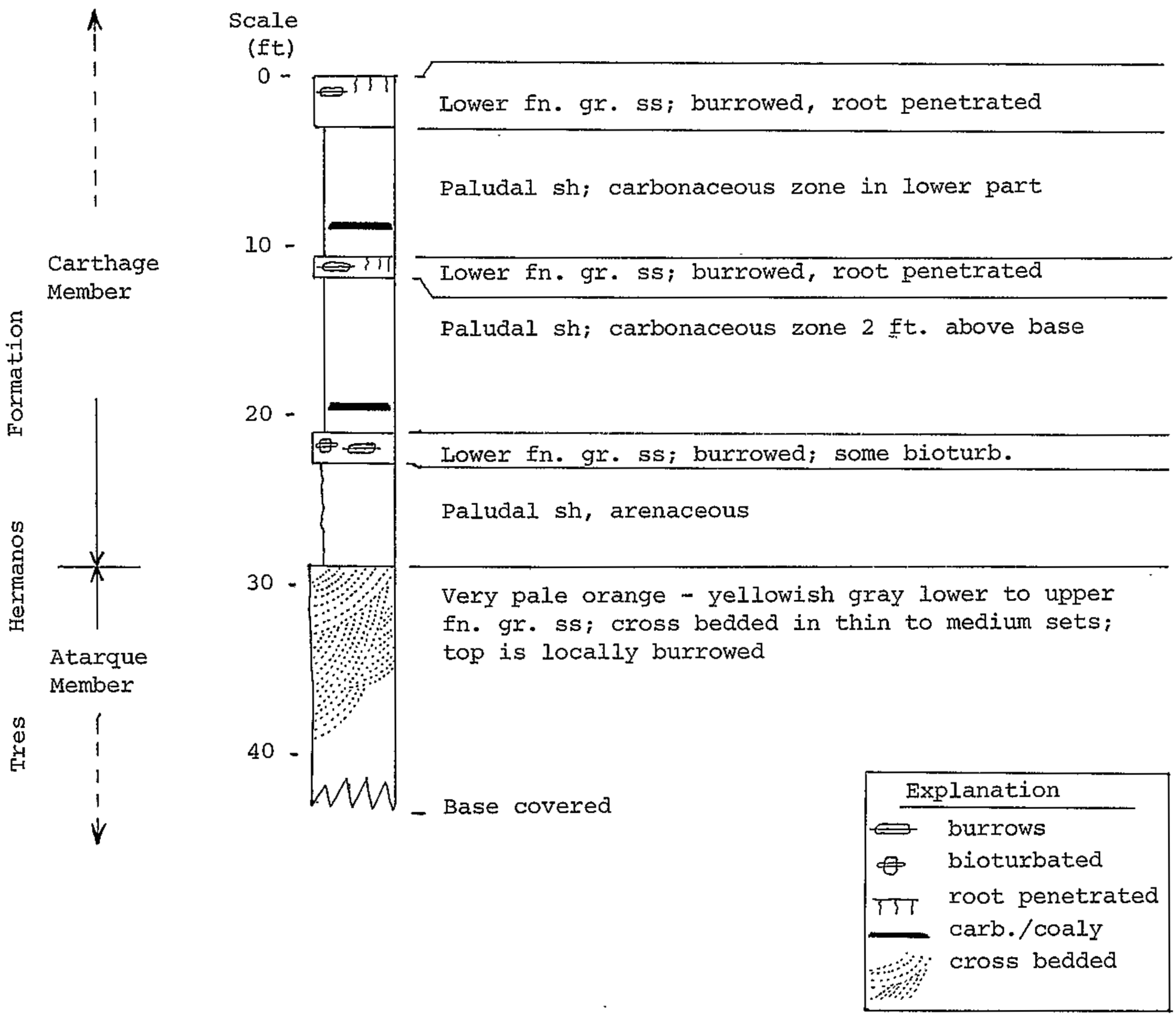
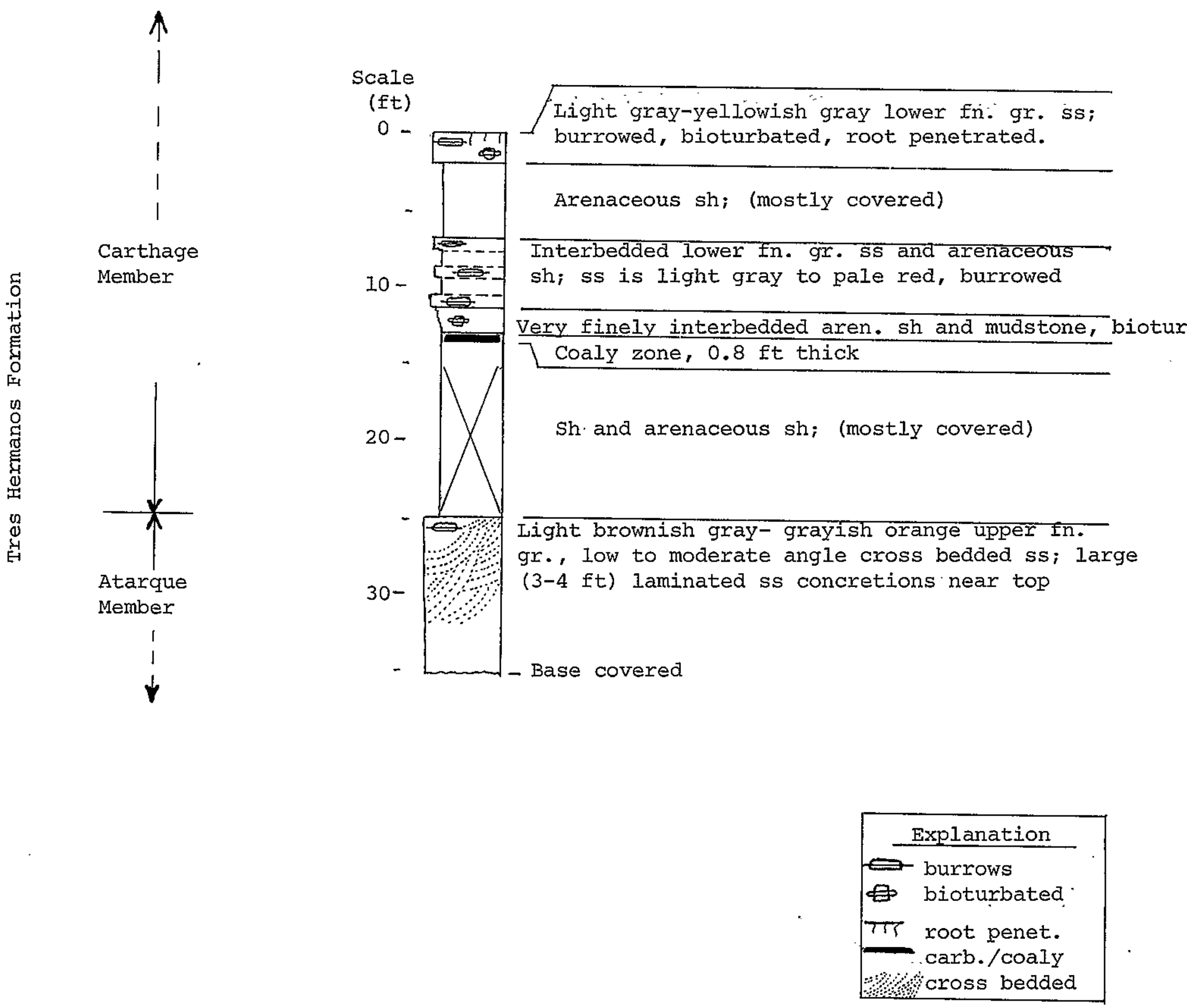


Fig. 6 Shoemaker Canyon SE stratigraphic section, lower part of Tres Hermanos Formation in SE¼ SE¼ sec. 20, T. 7N., R. 16W.



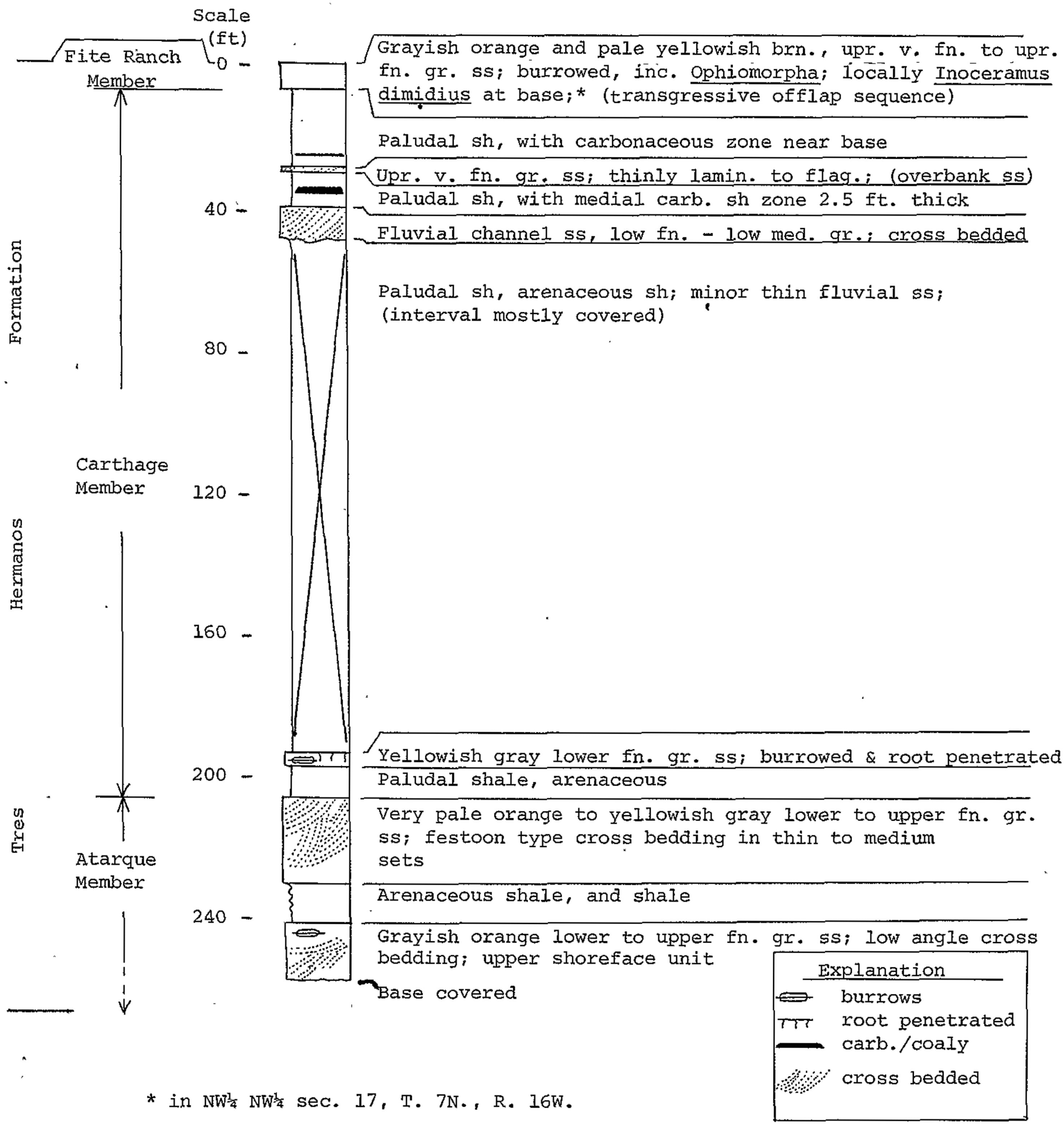
and/or carbonaceous shale (Figs. 2 and 5).

The middle part of the Carthage Member is largely shale and is poorly exposed on the quadrangle. A prominent and widespread fluvial channel complex is present near the top, however, and this sandstone is overlain by a paludal shale with carbonaceous zones. This upper carbonaceous zone is best exposed in the NE 1/4 sec. 24, T.7N., R.17W., and in adjacent sec. 19. At this locality it is 2.5 ft thick and is coaly (see Fig. 7). The carbonaceous zone is capped by a fine grained splay sandstone which is in turn overlain by a paludal shale sequence. The total thickness of the Carthage member is about 200 ft on this quadrangle.

The Carthage is overlain by the marine Fite Ranch Member of the Tres Hermanos Formation. It is a fine grained, flat to low-angle cross-bedded sandstone that locally contains Inoceramus dimidius at the base. At the measured section in the NE 1/4 sec. 24, T.7N., R.17W., it is 8 to 10 ft thick (Fig. 7); the prominent topographic knob at elevation 7,480 is capped by the Fite Ranch Sandstone and this isolated outcrop represents the southwesternmost occurrence of the member. It originally extended an unknown distance to the southwest. However, because the overlying Pescado Tongue of the Mancos Shale is only 30 ft thick and thinning quite rapidly southwestward in this area, the turn-around line for the transgression represented by the Fite Ranch Member and Pescado Tongue of the Mancos Shale, was probably no more than 10 miles away. Information regarding the position of the turn-around line

Fig. 7

Shoemaker Canyon SE stratigraphic section, Tres Hermanos Formation in the NE¼ NW¼ and N½ NE¼ sec. 24, T. 7N., R. 17W.



* in NW¼ NW¼ sec. 17, T. 7N., R. 16W.

could be gained from the subsurface in the Adams Diggings - Omega area to the southeast.

The Fite Ranch is not a typical trangressive marine sandstone. It is of widely varying thickness locally-from 2 to 10 ft-and in places cannot even be recognized such as in the NE 1/4 sec. 34, T.7N., R.16W. Most important is the fact that it does not fine upward at the sections examined on this quadrangle. Hook, Molenaar, and Cobban (1983) have offered the explanation that it is a transgressive offlap sequence in that long stillstands of the shoreline allowed extensive progradation of sand bodies to take place. These episodes were punctuated by relatively rapid advances of the shoreline which transgressed its back barrier and/or lagoonal deposits and then assumed a stillstand in a more landward position.

The southwesternmost occurrence, (or truncation point), of the Fite Ranch Member is an erosional remnant in the NE 1/4 sec. 24, T.7N., R.17W. The overlying Pescado Tongue of the Mancos Shale has been eroded off and its southwesternmost occurrence is approximately two miles to the northeast in sec. 8 (see accompanying geologic map). The significance of these erosional truncation points is that the authors of the redefined Tres Hermanos Formation (Hook, Molenaar, and Cobban, 1983) stated that the presence of the Fite Ranch Member and/or the Pescado Tongue shall determine the area in which the Tres Hermanos nomenclature shall be used. Landward equivalents to the southwest were, as previously mentioned, designated as the Atarque Sandstone and the Moreno Hill Formation. In the present study it was considered appropriate to extend the Tres Hermanos nomenclature southwestward around the end of the topographic feature upon which the Fite Ranch truncation occurs. This carries the nomenclature throughout the Shoemaker Canyon SE quadrangle and into the eastern part of the adjacent Mesita de Yeso quadrangle; the latter quadrangle becomes the one in which the change in stratigraphic nomenclature takes place (Anderson, 1982). Where the Atarque appears in outcrops, 12 miles to the west of the Shoemaker Canyon SE quadrangle, it is of formational rank. To relate this nomenclatural change to a line rather than an area, the following has been adopted by the New Mexico Bureau of Mines and Mineral Resources; east of NM-32 and north of the Jaralosa Draw Lobe of the North Plains lava field the Tres Hermanos nomenclature will be used; west of NM-32 and south of the basalt flow the names Atarque Sandstone and Moreno Hill Formation will be used for this interval. This nomenclature change corresponds with a change in coal-field terminology. The Tres Hermanos outcrop defines the southern and southwest edge of the Gallup-Zuni coal field. Coal occurrences in the Moreno Hill Formation to the south and west are part of the Salt Lake coal field (Anderson, 1982b).

The Pescado Tongue of the Mancos Shale separates the Fite Ranch Member from the F Member of the Gallup Sandstone. The Pescado is characterized by large limestone concretions at the base and very thin, fine grained sandstones interbedded with shale in the lower one third to one half. No fossils were collected from this interval on the quadrangle. It thins in a southwesterly direction and at its southwesternmost outcrop in the E 1/2 sec. 8, T.7N., R.16W., it is about 30 ft thick. Molenaar (1973) correlated the Pescado with the lower half of the D-Cross Tongue of the Mancos Shale.

The Gallup Sandstone, at the top of the Cretaceous section in the Shoemaker Canyon SE quadrangle, is about 200 ft thick and is subdivided into the F Member at the base overlain by an unnamed coal-bearing member in the middle, and the Torrivio Member at the top.

The F member (Hook, Molenaar, and Cobban, 1983) is 45-50 feet thick in the Shoemaker Canyon SE quadrangle. It is a regressive coastal-barrier sandstone that marks a transition in the Zuni Basin from an open-water marine environment in which the underlying Pescado Tongue of the Mancos Shale was deposited to a deltaic and coastal-plain environment in which the overlying middle and upper parts of the Gallup were deposited. The lower half of the F member is flat-bedded light-gray very fine to fine-grained sandstone containing dark-gray silty and shaly partings. This part of the member is poorly exposed except for the basal 5-10 ft which commonly form weak ledges. The upper part of the member is mostly fine-grained light-gray sandstone that is somewhat more resistant than the lower part and is flat-bedded and crossbedded. In sec. 4, T.7N., R.16W., the top of the member consists of a bed about 12 ft thick of light-gray fine-grained sandstone containing numerous burrows at the top, underlain by an interval about 6 ft thick of nonresistent sandstone that is shaly and slightly carbonaceous.

The basal part of the F member also is burrowed locally. The F member grades downward into the underlying Pescado Tongue of the Mancos Shale through an interval of 5-10 ft.

The middle, coal-bearing member of the Gallup Sandstone is about 100 ft thick in the Shoemaker Canyon SE quadrangle. At the base is a fluvial channel-fill sandstone bed 30-35 feet thick that rests with a sharp erosional contact on sandstone of the F member. The fluvial sandstone is very light gray to very light yellowish-gray, mostly fine-grained becoming somewhat coarser at the base, crossbedded, and forms prominent rounded ledges and cliffs.

A variable sequence of fluvial and paludal rocks comprises the rest of the coal-bearing member. Included in the sequence are dark-gray silty and sandy claystone, fissile brown carbonaceous shale, light-gray siltstone, and light-gray and light yellowish-gray crossbedded and ripple-marked sandstone. Dark reddish-brown ferruginous concretions are common in some of the shale and claystone beds. Present in the quadrangle are at least four beds of coal separated by intervals a few inches to several feet thick of shale, claystone, and sandstone. Individual coals commonly are 1-2 feet thick, thickening locally where two or more beds merge. The lowest of the coals rests directly on, or within a few inches of the basal fluvial sandstone. The two next higher coals contain identifying partings 0.2-0.4 ft thick of grayish-white claystone. The partings are thin beds of altered volcanic ash, and they are useful in correlating the coals in an area of several square miles in this part of the Zuni Basin.

The Torrivio Member of the Gallup Sandstone (named the Torrivio Sandstone Member by Molenaar, 1973) is about 40-50 feet thick. It crops out only in the extreme northeastern corner of the quadrangle where it consists of ledge-forming grayish-red fine- to coarse-grained crossbedded feldspathic sandstone. Molenaar (1973) describes the unit as a channel-fill sandstone complex deposited by low-gradient braided streams.

Coal Resources

Coal in the Shoemaker Canyon SE quadrangle is classed as high volatile bituminous C, based on the analyses of samples of fresh coal from a bed in the Gallup Sandstone a few miles northwest of the quadrangle (Sears, 1925, p. 50). Table 1 shows the analyses of two samples of weathered coal from a coal bed in the Gallup Sandstone exposed in a road cut about a mile north of the Shoemaker Canyon SE quadrangle. The analyses show ash contents of 6.7 to 10.1 percent, respectively, and sulfur contents of 0.6 percent for the weathered coal, which is slightly less than the values reported by Sears (1925, p. 50) for the fresh coal from about the same horizon. Heat values of 9017 and 9471 BTU/lb on the as-received basis for the weathered coal (table 1) compare with an average of about 11000 BTU/lb for the fresh coal as reported by Sears (1925, p. 50). The weathered condition of the coal probably accounts for the low heat values reported on table 1.

Estimated resources of bituminous coal in the Shoemaker

Canyon SE quadrangle total 1.4 million short tons. Table 2 lists the resources by township according to thickness and reliability categories established by the U.S. Bureau of Mines and the U.S. Geological Survey (1976). The estimates are based on coal-bed measurements made at five places in the northeastern part of the quadrangle in sec. 34, T.8N., R.16W., and in secs. 3 and 4, T.7N., R.16W. All the beds for which resources are estimated are in the coal-bearing member of the Gallup Sandstone. Coal beds and lenses in the Carthage Member of the Tres Hermanos Formation are too thin and discontinuous for resource estimates.

Acknowledgements

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Table 1.—Analyses of coal from a bed in the Gallup Sandstone exposed in a road cut in the SE¼ NE¼ sec. 33, T. 8 N., R. 16 W., Cibola Co., New Mexico.

[In percent. Forms of analysis: A, as received; B, moisture free; C, moisture and ash free. Analyses by the U.S. Department of Energy, Feb. 18, 1980]

Laboratory no.	Form of analysis	Proximate				Ultimate					Heating value (British thermal units)
		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	
K98773	A	10.6	36.7	42.6	10.1	0.6	4.7	54.7	1.1	28.8	9017
	B	—	41.0	47.7	11.3	0.7	3.9	61.2	1.2	21.7	10085
	C	—	46.3	53.7	—	0.8	4.4	69.0	1.4	24.5	11365
K98772	A	11.3	37.0	45.0	6.7	0.6	4.9	57.7	1.2	29.0	9471
	B	—	41.7	50.7	7.6	0.6	4.1	65.0	1.4	21.4	10673
	C	—	45.1	54.9	—	0.7	4.4	70.3	1.5	23.1	11548

Description of samples: K98773, chip sample, upper bench 0.6 ft thick above a light-gray claystone parting; K98772, chip sample, lower bench 1.4 ft thick below a light-gray claystone parting.

Table 2.—Estimated coal resources in the Gallup Sandstone, Shoemaker Canyon SE quadrangle, Feb. 1, 1983.

[In thousands of short tons. All values rounded. 1,800 short tons/acre ft used in the calculations]

Township and range	Thickness of coal in bed						Total in the township
	1.2-2.3 ft thick			2.3-3.5 ft thick			
	Measured	Indicated	Total	Measured	Indicated	Total	
T. 8 N., R. 16 W.	120	180	300	95	—	95	400
T. 7 N., R. 16 W.	440	140	580	370	20	390	970
Totals, rounded	560	320	860	470	20	490	1,400

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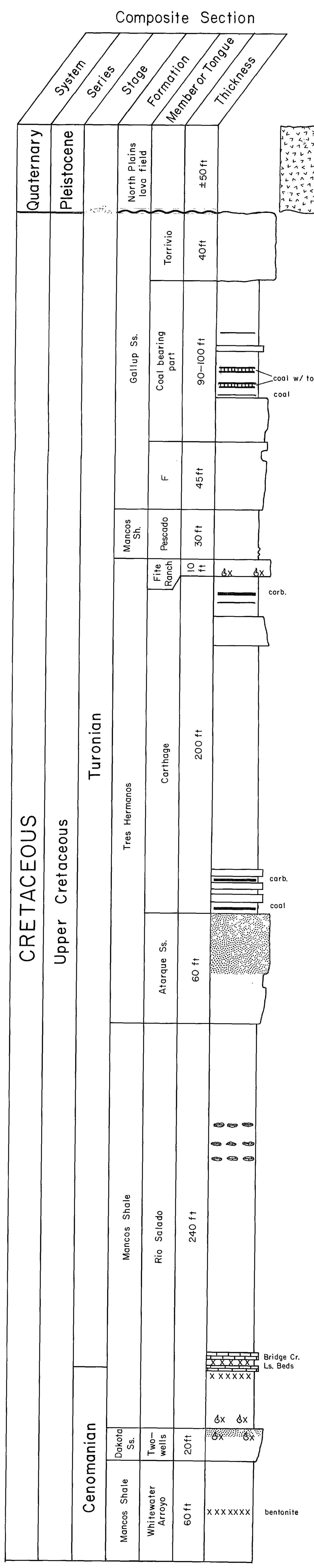
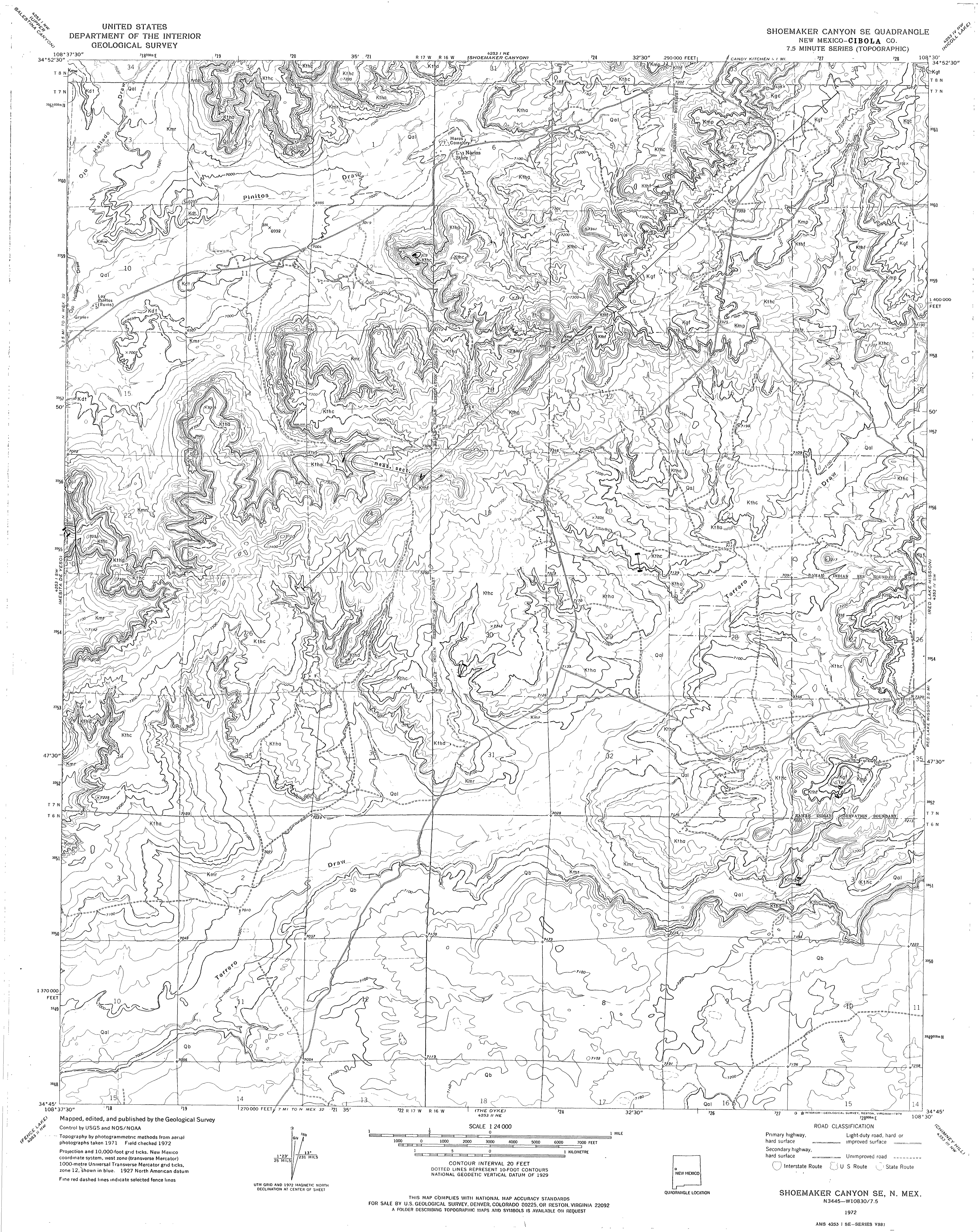
Township	Range	Section	Parcel	Patent or action number	Railroad Grant	Homestead or other private	State of New Mexico	Indian trust, tribal, or withdrawn	Rights reserved to U.S. Government
8N	16W	31	All	LI-NM13-1001					All minerals
		32	All	1223641			X		Ditches and canals
		33	All	LI-NM13-1001					All minerals
		34	All	1052199		X			All minerals,ditches and canals
		35	All	567459	X				-none-
8N	17W	34	All	30730023			X		All minerals, ditches and canals
		35	All	LI-NM13-1001					All minerals
		36	All	1223640			X		Ditches and canals
7N	16W	2	All	1223704			X		Ditches and canals
		3	All	PLO 2198				X	All minerals
		4	All	30660179				X	All minerals, ditches and canals
		5	All	PLO 2198				X	All minerals
		6	NE¼	30650200		X			Oil,gas,coal;ditches and canals
			NW¼	491234		X			Coal, ditches and canals
			SW¼	470978		X			Coal, ditches and canals
			SE¼	955305		X			All minerals, ditches and canals
		7	All	PLO 2198				X	All minerals
		8	NE¼	1042054				X	Ditches and canals
			NW¼	1042214				X	Ditches and canals
			SW¼	1042215				X	Ditches and canals
			SE¼	1042213				X	Ditches and canals
		9	All	PLO 2198				X	All minerals
		10	All	1077253		X			All minerals, ditches and canals
		11	All	PLO 2198				X	All minerals
		14	NW¼	954638				X	Ditches and canals
			SW¼	954637				X	Ditches and canals
		15	N½	SF064554					Surface and minerals
			S½	PLO 2198				X	All minerals
		16	All	1223703		X			Ditches and canals
		17	All	PLO 2198				X	All minerals
		18	NE¼	1042216				X	Ditches and canals
			NW¼	1042055				X	Ditches and canals
			SW¼	1042217				X	Ditches and canals
			SE¼	1095018				X	Ditches and canals
		19	All	PLO 2198				X	All minerals
		20	NE¼	1043513				X	Ditches and canals
			NW¼	1043514				X	Ditches and canals
			SW¼	1043515				X	Ditches and canals
			SE¼	1043512				X	Ditches and canals
		21	All	PLO 2198				X	All minerals
		22	N½	1096622		X			Ditches and canals
			SW¼	965304				X	Ditches and canals
			SE¼	965305				X	Ditches and canals
		23	All	PLO 2198				X	All minerals
		26	NW¼	1037496				X	Ditches and canals
			SW¼	1037493				X	Ditches and canals
		27	All	PLO 2198				X	All minerals
		28	NE¼NE¼	30660179		X			All minerals
			NW¼NE¼	934208				X	Ditches and canals
			N½NW¼	934208				X	Ditches and canals
			SW¼NW¼	934208				X	Ditches and canals
			SE¼NW¼	IL-175			X		Ditches and canals
			W½SW¼	IL-175			X		Ditches and canals
			W½SE¼	934207				X	Ditches and canals
			E½SW¼	934207				X	Ditches and canals
			E½SE¼	934213				X	Ditches and canals
			S½NE¼	934213				X	Ditches and canals
		29	All	PLO 2198				X	All minerals
		30	NE¼	1043510				X	Ditches and canals
			NW¼	1043511				X	Ditches and canals
			SW¼	1095019				X	Ditches and canals
			SE¼	1043185				X	Ditches and canals

		31	All	PLO 2198				X	All minerals
		32	All	1223704			X		Ditches and canals
		33	All	PLO 2198				X	All minerals
		34	NE¼	1095015				X	Ditches and canals
			NW¼	1095014				X	Ditches and canals
			SW¼	1095016				X	Ditches and canals
			SE¼	1095017				X	Ditches and canals
		35	All	PLO 2198				X	All minerals
7N	17W	1	All	670394	X				Ditches and canals
		2	All	1223704			X		Ditches and canals
		3	All	670394	X				Ditches and canals
		10	NE¼	905129		X			Ditches and canals
			NW¼	1105323		X			All minerals, ditches and canals
			SW¼	905125		X			Ditches and canals
			SE¼	1105323		X			All minerals, ditches and canals
		11	All	670394	X				Ditches and canals
		12	NE¼	1078497	X				Ditches and canals
			NW¼	905128		X			Ditches and canals
			S½	1104718		X			All minerals, ditches and canals
		13	All	670394	X				Ditches and canals
		14	E½	1078497	X				Ditches and canals
			E½W½	30660015		X			Oil,gas,coal; ditches and canals
			W½W½	1078497	X				Ditches and canals
		15	All	670394	X				Ditches and canals
		22	All	1052426		X			All minerals, ditches and canals
		23	All	670394	X				Ditches and canals
		24	All	1067470	X				Ditches and canals
		25	All	670394	X				Ditches and canals
		26	N½	1078497	X				Ditches and canals
			NWSW¼	1105323		X			All minerals, ditches and canals
			S½SW¼	1105323		X			All minerals, ditches and canals
			SW¼SE¼	1105323		X			All minerals, ditches and canals
			NE¼SW¼	905122		X			Ditches and canals
			N½SE¼	905122		X			Ditches and canals
			SE¼SE¼	905122		X			Ditches and canals
		27	All	670394	X				Ditches and canals
		34	All	1067470	X				Ditches and canals
		35	All	916727	X				Ditches and canals
		36	All	1123703			X		Ditches and canals
6N	16W	2	NW¼	986677				X	Ditches and canals
			E½SW¼	1223974			X		Ditches and canals
		3	All	670394	X				Ditches and canals
		4	N½	1081582		X			All minerals, ditches and canals
			SE¼	1081582		X			All minerals, ditches and canals
			N½SW¼	1081582		X			All minerals, ditches and canals
			SE¼SW¼'	1081582		X			All minerals, ditches and canals
			SW¼SW¼	IL 158			X		All minerals, ditches and canals
		5	All	670394	X				Ditches and canals
		6	NE¼NE¼	1088664		X			All minerals, ditches and canals
			S½NE¼	1088664		X			All minerals, ditches and canals
			SE¼NW¼	1088664		X			All minerals, ditches and canals
			S½	1088664		X			All minerals, ditches and canals
			NW¼NE¼	648510		X			Ditches and canals
			N½NW¼	648510		X			Ditches and canals
			SW¼NW¼	648510		X			Ditches and canals
		7	All	670394	X				Ditches and canals
		8	All	1056136	X				Ditches and canals
		9	All	670394	X				Ditches and canals
		10	All	1056136	X				Ditches and canals
		11	All	670394	X				Ditches and canals
		14	All	1056136	X				Ditches and canals
		15	All	670394	X				Ditches and canals
		16	All	1223973			X		Ditches and canals
		17	All	670394	X				Ditches and canals
		18	All	1056136	X				Ditches and canals
6N	17W	1	All	670394	X				Ditches and canals

2	NE¼NE¼	1223974			X	Ditches and canals
	W½,NE¼	1223974			X	Ditches and canals
	W½	1223974			X	Ditches and canals
	W½SE¼	1103924		X		All minerals, ditches and canals
	NE¼SE¼	1103924		X		All minerals, ditches and canals
	SE¼NE¼	1103924		X		All minerals, ditches and canals
	SE¼NE¼	1223974			X	Ditches and canals
3	All	670394	X			Ditches and canals
10	N½	1095069		X		All minerals, ditches and canals
	S½NW¼ofSW¼	1095069		X		All minerals, ditches and canals
	SW¼SE¼	1095069		X		All minerals, ditches and canals
	N½SE¼	758926(original)		X		Ditches and canals
	NE¼SW¼	905130(supplemental)		X		Ditches and canals
	SE¼SE¼	30680015		X		Oil,gas,coal;ditches and canals
11	All	670394	X			Ditches and canals
12	All	1078908	X			Ditches and canals
13	All	670394	X			Ditches and canals
14	All	1067470	X			Ditches and canals
15	All	670394	X			Ditches and canals

Plate 1





DESCRIPTION OF MAP UNITS

Qal Alluvial deposits undifferentiated; clay, silt, sand and gravel in arroyos, floodplains and on gentle slopes.

Qcl Colluvium, landslide mass, or toreva blocks.

Qb Basalt flows; originating from centers to east in the North Plains lava field; olivine tholeite in composition with K-Ar age of 1.41 m.y. (Laughlin, Brookins, Damon, and Shafiqullah, 1979).

Kgt Torrivio Member of Gallup Sandstone (Upper Cretaceous); ledge forming grayish red, fine to very coarse grained, crossbedded, feldspathic sandstone; present only in extreme northeast corner of the quadrangle; unit ranges up to 40 ft thick locally.

Kgc Coal-bearing member of Gallup Sandstone (Upper Cretaceous); at base is a 30-35 ft thick fluvial channel sandstone that rests with sharp erosional contact on the F member; above is variable sequence of fluvial and paludal rocks including dark gray silty-sandy claystone, fissile brown carbonaceous shale, light gray siltstone, and light yellowish gray cross-bedded and ripple marked sandstone; ferruginous concretions common in shale and claystone beds. Contains four coal beds ranging up to 2 ft in thickness; lowest coal rests on basal fluvial sandstone; two next higher coals contain distinctive grayish-white claystone (tonstein) partings 0.2-0.4 ft thick Coal-bearing member about 100 ft thick.

Kgf F member of Gallup Sandstone (Upper Cretaceous); light gray, very fine to fine grained sandstone; lower part contains dark gray silty and shaly partings; upper part somewhat more resistant, with more distinct crossbedding, and numerous burrows; grades downward into the Pescado Tongue of the Mancos Shale through an interval of 5-10 ft; total thickness of unit about 50 ft.

Kmp Pescado Tongue of Mancos Shale (Upper Cretaceous); light to medium gray and brownish gray marine shale; contains large (up to 2 ft in diameter) limestone concretions near the base, and very thin fine-grained sandstone beds in lower half; unit about 30 ft thick.

Kthf Fite Ranch Member of Tres Hermanos Formation (Upper Cretaceous); yellowish gray to grayish orange, upper very fine to upper fine-grained sandstone; lower part commonly bioturbated and contains Inoceramus dimidius; upper part coarser grained, flat to low angle crossbedded, and burrowed. Unit varies from 2 to 10 ft in thickness.

Kthc Carthage Member of Tres Hermanos Formation (Upper Cretaceous); paludal shale and mudstone, carbonaceous shale with minor coal, and fluvial channel sandstone. Shales are gray to light olive gray; carbonaceous zone 4-6 ft above base locally has up to 1.6 ft of coal in 2 beds separated by 0.2 ft thick white claystone. Maximum thickness on quadrangle-200 ft.

Ktha Atarque Sandstone Member of Tres Hermanos Formation (Upper Cretaceous); grayish orange to very pale orange, very fine to upper fine grained marine sandstone; coarsens upward; well indurated, generally massive, cliff former; burrows present in lower and middle parts; fossiliferous-small bivalves, in middle part; upper part strongly crossbedded predominantly of trough type and is contrasted by its lighter color. Maximum thickness on quadrangle about 60 ft.

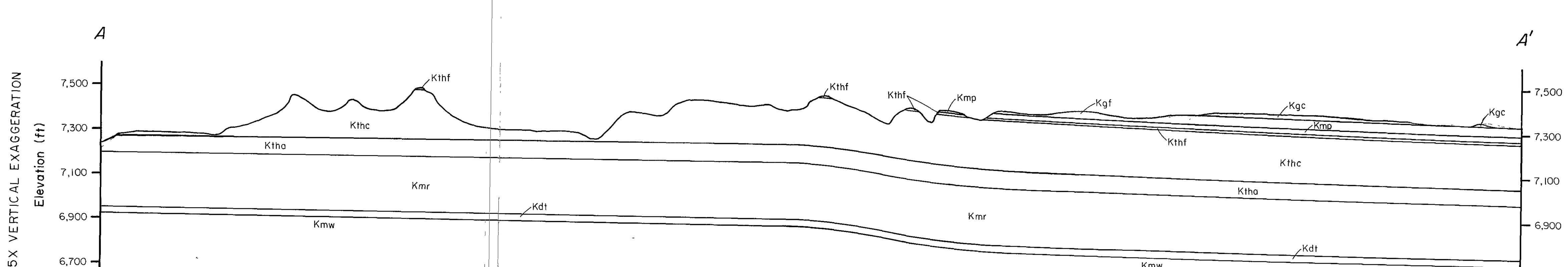
Kmr Rio Salado Tongue of Mancos Shale (Upper Cretaceous); medium to dark gray and brownish gray marine shale, silty shale, calcareous shale and calcarenite, with thin interbedded sandstone at the very top; weathers to gentle or moderately steep slopes which are generally covered by colluvium, talus, or landslide debris; base not exposed; calcarenite beds and calcareous shale with an underlying zone containing abundant Pycnodonte newberryi (Stanton) occur about 35 ft above the base; calcareous zone is Greenhorn Limestone (Bridge Creek Member) equivalent; upper 100 ft of the tongue contains numerous limestone concretion zones; associated with the concretions locally are the ammonites Mammites depressus, Mammites nodosoides, Proplacenticeras cuminsi, and Neoptychites cephalotus; also found in this association are Ostrea sp., various bivalves, Turritella and other gastropods. Thickness of tongue estimated at 240 ft.

Kdt Twowells Tongue of Dakota Sandstone (Upper Cretaceous); yellowish gray to pale olive, very fine to upper fine grained, shallow water marine sandstone; lower part very fine grained, commonly burrowed and bioturbated, with these features continuing into the middle, shaly part; upper part is crossbedded in thin sets and/or wavy bedded with thin shale interbeds; locally fossiliferous in all parts, but mainly middle and upper; fossils consist of Pycnodonte kellumi, and small (relative to those in the Paguate Tongue) Exogyra levis; also found locally in association with these is Exogyra trigeri (Coquand). Maximum thickness on quadrangle estimated at 20-22 ft.

Kmw Whitewater Arroyo Tongue of Mancos Shale (Upper Cretaceous); gray to medium dark gray marine shale; slope former, base not exposed; near the middle is a 15 inch thick white to orange weathering bentonite bed not well exposed in this area; selenite cyrstals common; the relatively large oyster Exogyra trigeri is locally abundant; estimated thickness of unit is 60 ft.

MAP SYMBOLS

- Contact, dashed where approximate or inferred
- Fault, U = upthrown, D = downthrown
- Strike and dip of beds
- Measured section referred to in text
- Base of principal coal in Kgc



GEOLOGY AND COAL RESOURCES OF THE SHOEMAKER CANYON SE QUADRANGLE CIBOLA COUNTY, NEW MEXICO

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES OPEN-FILE REPORT 172

by ORIN J. ANDERSON and WILLIAM J. MAPEL

1983

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