

GEOLOGY AND COAL RESOURCES OF THE
TECHADO QUADRANGLE,
CATRON AND CIBOLA COUNTIES, NEW MEXICO

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ABSTRACT

The Techado quadrangle is located in west-central New Mexico along the eastern fringe of the Salt Lake coal field. Three formations crop out in the quadrangle. The lowermost unit is the Moreno Hill Formation of Late Cretaceous age. This is a sequence of sandstones, siltstones, claystones and coal beds deposited in meandering stream and coastal plain environments. The Moreno Hill Formation is unconformably overlain by the Eocene(?) Baca Formation. The Baca consists of coarse-grained, arkosic sandstones and conglomerates deposited by a braided stream system. Unconformably overlying the Moreno Hill and Baca Formations is the Miocene(?) Fence Lake Formation. This is a sequence of boulder conglomerates and lithic sandstones deposited in a braided stream environment.

Coal occurs in both the Lower and Upper Members of the Moreno Hill Formation. Throughout most of the Techado quadrangle, the Lower Member is too deep to yield economically minable coal deposits. However, the extreme southwest corner of the quadrangle may contain some minable coal. The Upper Member crops out throughout the Techado quadrangle but contains only thin, discontinuous coals. The poor coal development is a function of dynamic depositional environments characterized by strong fluvial influences and poor swamp development. Therefore, the Upper Member is not expected to contain minable coal deposits in the Techado region. However, to the north and northeast of the Techado quadrangle, depositional environments indicate that the coal resource potential is better.

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INTRODUCTION

The Techado 7.5 minute quadrangle is located in west-central New Mexico, approximately 13 miles north of Quemado and 26 miles south of Gallup (fig. 1). Coal occurs within the Cretaceous rocks of this region, generally referred to as the Salt Lake coal field. In the late 1970's, the New Mexico Bureau of Mines and Mineral Resources, in conjunction with the U.S. Geological Survey, began systematic mapping and preliminary resource exploration in the region. This report represents a continuation of this program and focuses primarily on the surface geology, stratigraphy and coal resources of the Techado quadrangle.

The Techado area is accessible via route 117 north from Quemado or route 36 south from Gallup. No railroads or commercial airports are present in the vicinity. Land status, shown in figure 2A, is approximately 58% private, 40% state and 2% federal. Approximately 65% of the coal rights are federally owned, 30% are owned by the state and the remainder is privately held (fig. 2B).

Regional Geology

The Techado quadrangle is situated along the southern fringe of the Colorado Plateau on the structural subdivision known as the Mogollon Slope (Fitzsimmons, 1959). Immediately to the south, the area is bordered by the Datil-Mogollon volcanic field. Strata in the Techado region are nearly flat-lying, showing

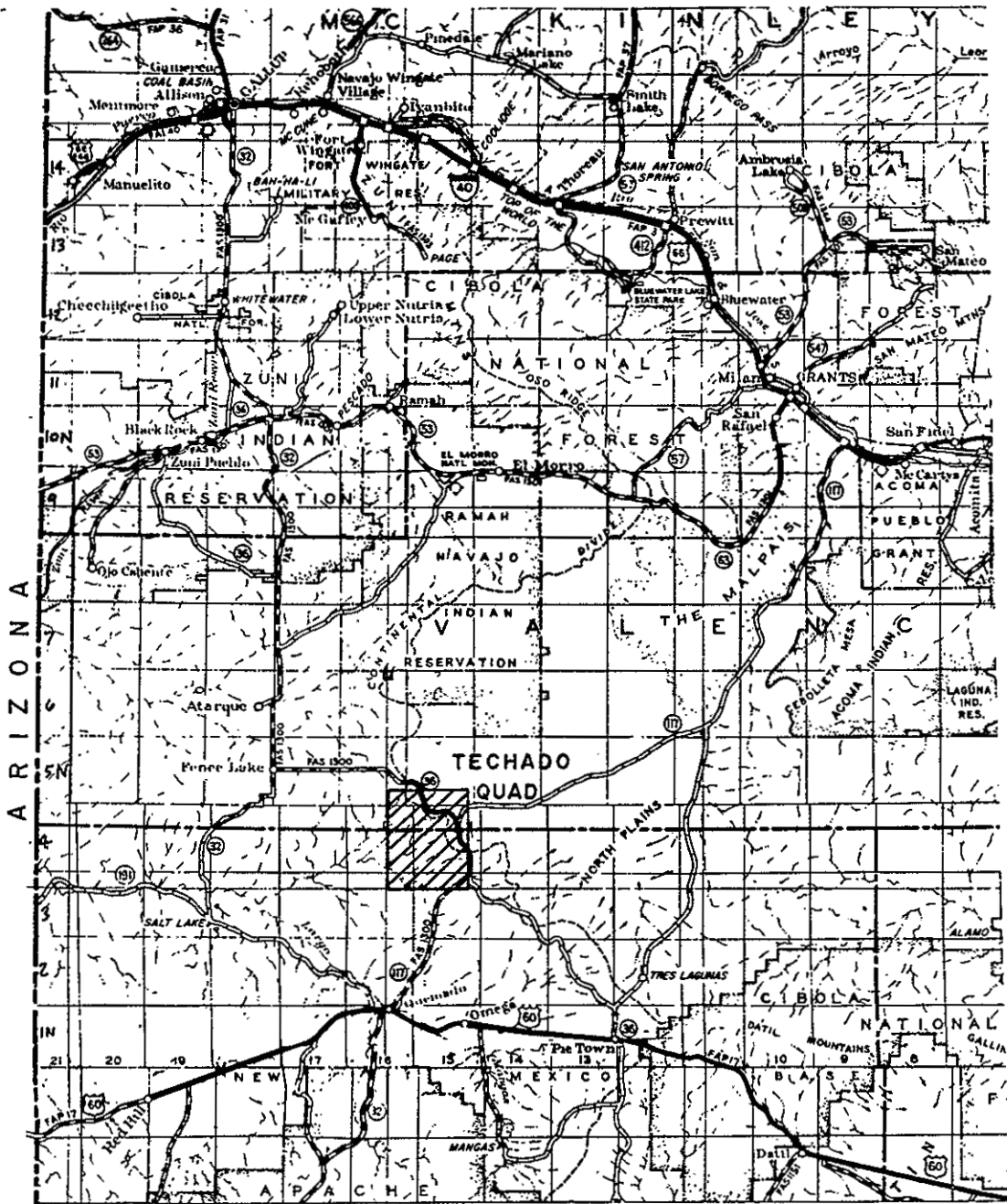


Fig. 1 - Map of west-central New Mexico showing location of Techado quad

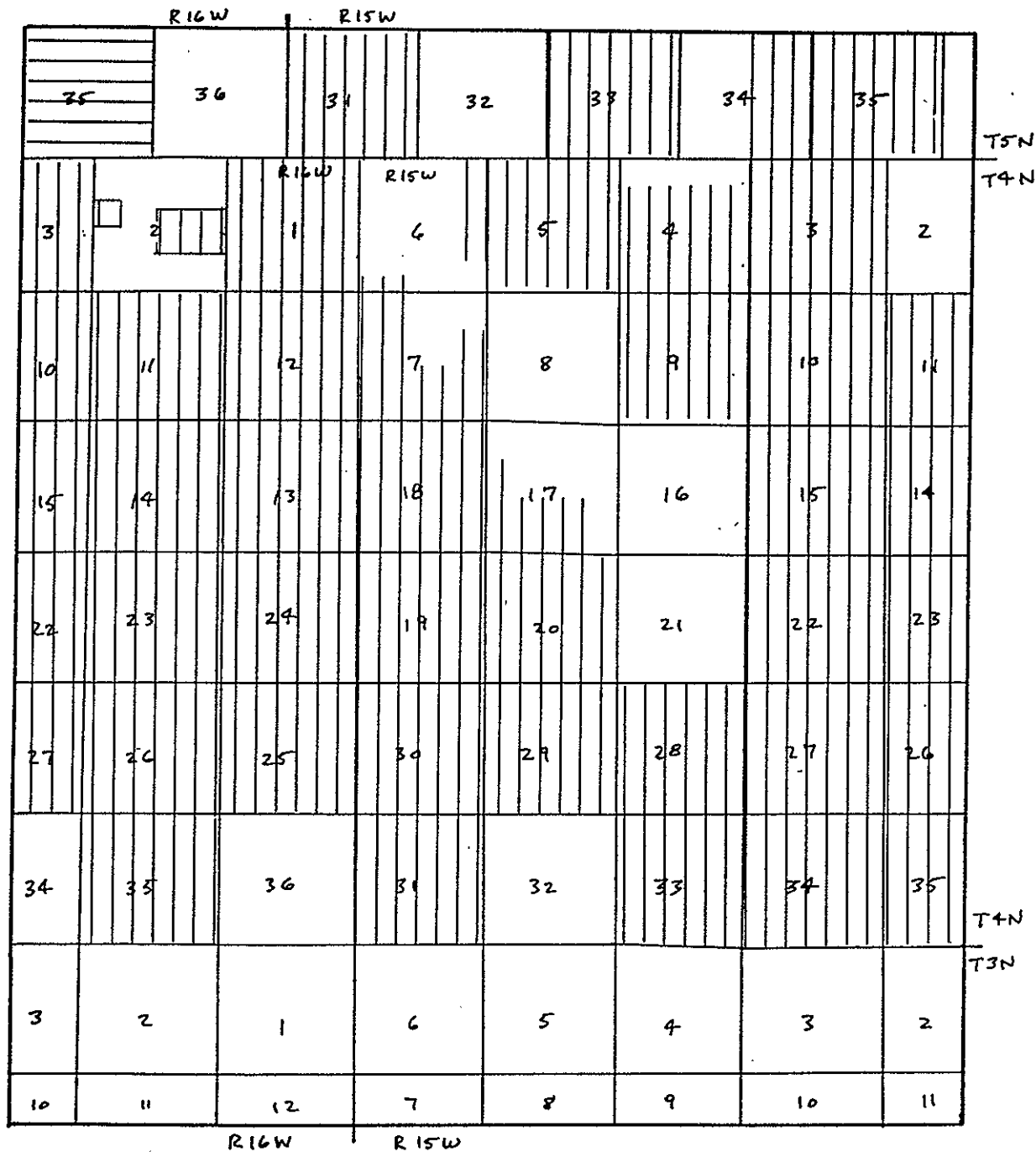
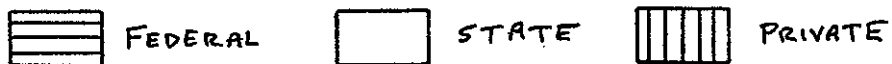


FIG 2 A - LAND OWNERSHIP IN THE TECHADO QUAD

(source: Catron & Cibola County Assessors & Bur. Land Mgmt. Surface - Minerals Mgmt. Quad NW-26)



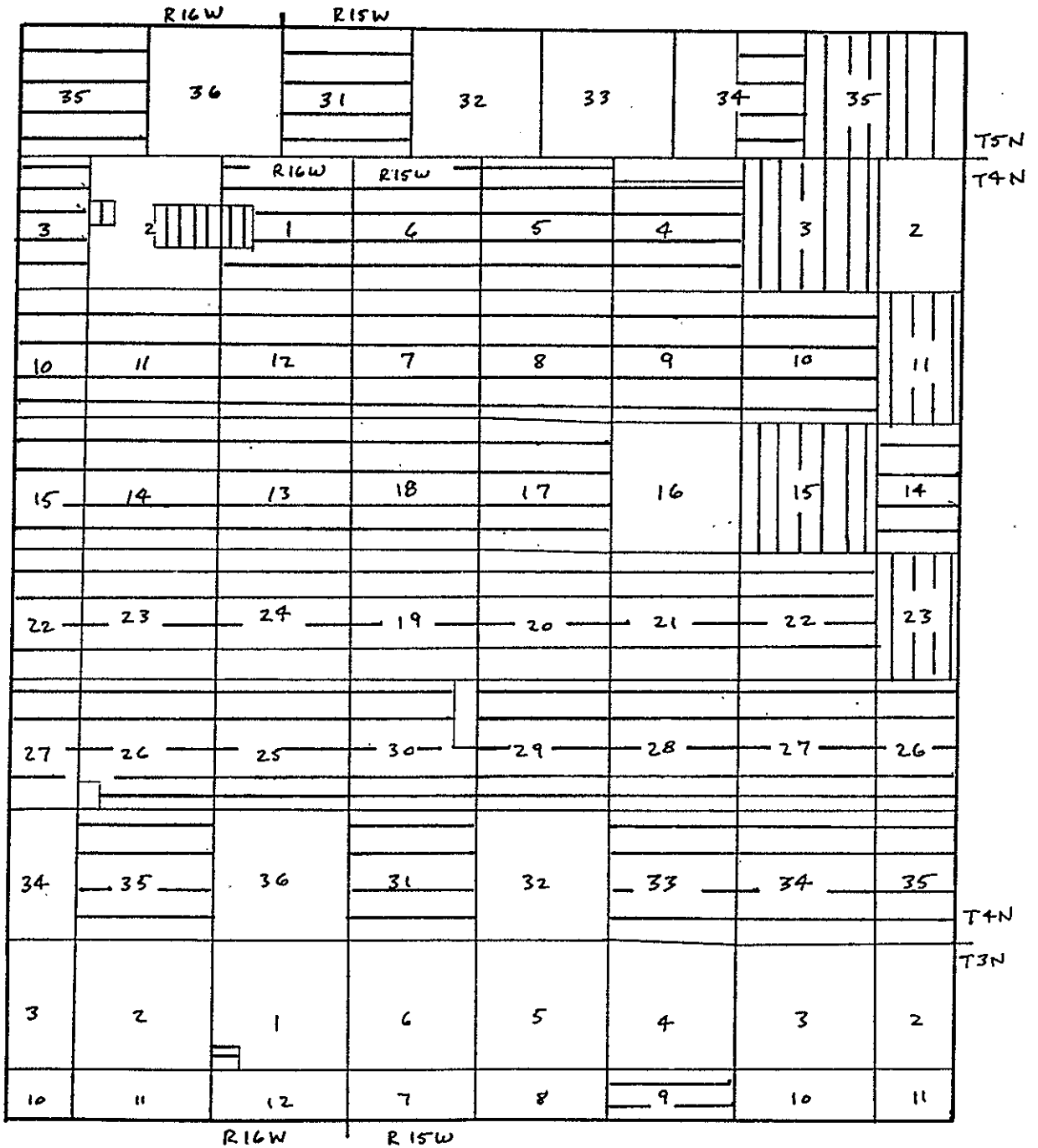


FIG 2B - COAL OWNERSHIP IN THE TECHADO QUAD

(source: U.S. Bur. Land Mgmt. Surface-Minerals Mgmt Quad NW-26)



very slight regional dips to the south and east.

Outcrops in the region are primarily Cretaceous and Tertiary sediments and Cenozoic volcanics. During the Late Cretaceous, an epihercynian sea covered much of New Mexico and the Techado area was periodically inundated. These sea-level fluctuations resulted in a complex series of interfingering marine and nearshore continental deposits belonging to Dakota Sandstone, Mancos Shale, Tres Hermanos Formation and Mesaverde Group. The Latest Cretaceous/Early Tertiary was primarily a period of erosion and non-deposition brought about by Laramide tectonic activity. This left a series of topographic basins into which coarse sandstones and conglomerates of the Baca Formation were deposited. The remainder of the geologic history has been characterized by periods of rifting and volcanism, covering much of the area with volcanics and volcanoclastics of the Datil Group and Fence Lake Formation.

STRATIGRAPHY

Three formations crop out in the Techado quadrangle. All are continental deposits of sandstone, siltstone, claystone and conglomerate. The oldest units belong to the Moreno Hill Formation of Late Cretaceous age. These are unconformably overlain by the Eocene(?) Baca Formation which, in turn, is unconformably overlain by the Miocene(?) Fence Lake Formation. Figure 3 is a generalized stratigraphic column of the area.

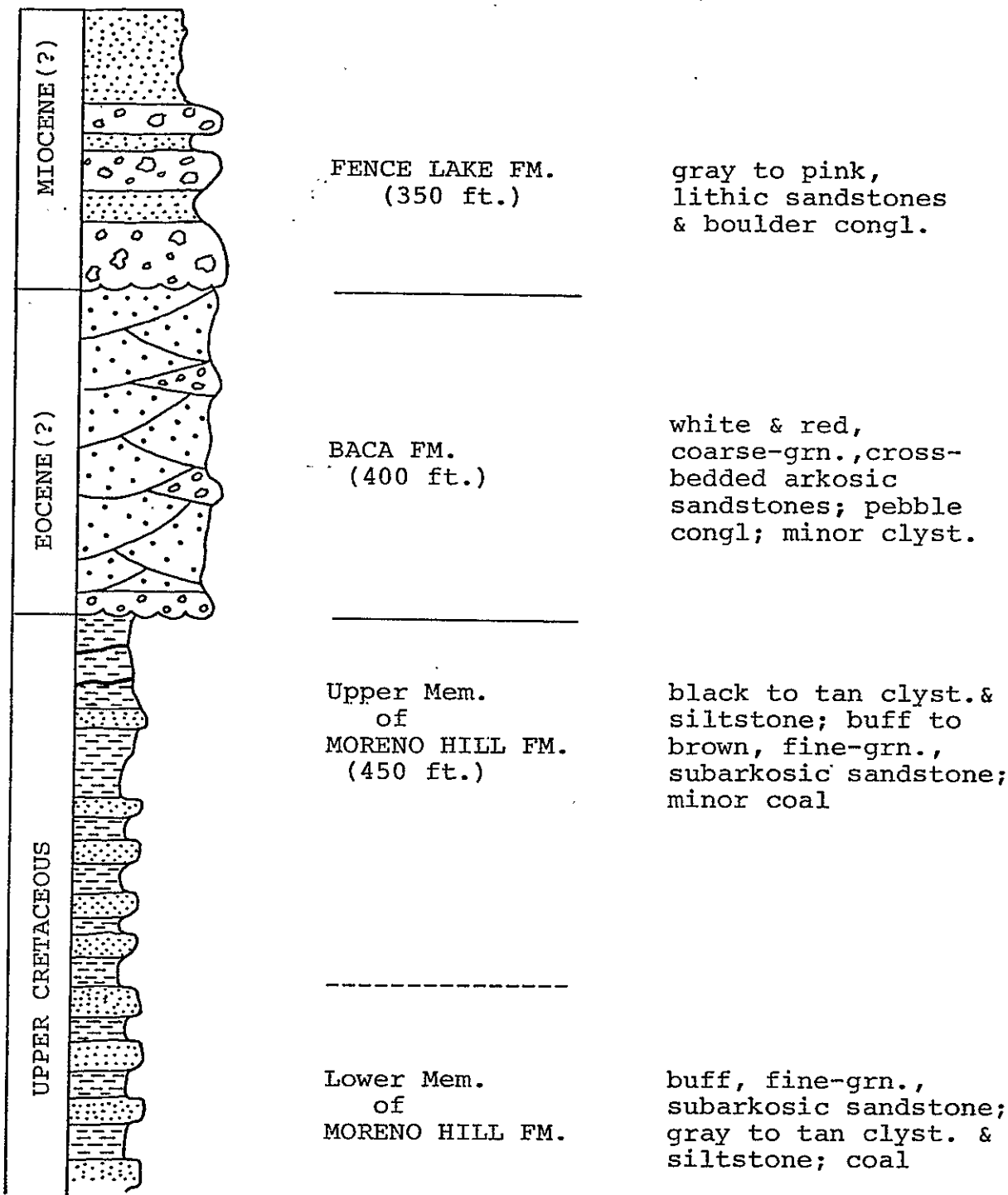


FIGURE 3 - Generalized stratigraphic column for the Techado quadrangle

Moreno Hill Formation

The oldest exposures in the Techado quadrangle are a series of sandstones, siltstones, claystones and coals belonging to the Moreno Hill Formation. The formation represents westward equivalents of Tres Hermanos, Gallup Sandstone and Crevasse Canyon Formations (Molenaar, 1983a & b; Hook et al, 1983; McLellan, 1983). Estimating from the ages of its eastward equivalents, the formation is probably Turonian in age (Molenaar, 1983a). The Moreno Hill Formation is divisible into three members: Lower, Middle and Upper.

Lower Member

The only outcrops of the Lower Member are in the extreme southwest corner of the Techado quadrangle (plate 1). Because of sparse exposure, the reader is referred to Campbell (1981) for a detailed description of the unit in the adjacent Cerro Prieto quadrangle. Campbell (1981) describes the member as a 350 foot sequence of fluvial sandstones interbedded with floodplain deposits of claystone, siltstone and coal. Sandstones are laterally persistent ledge-formers, generally 10 to 20 feet thick and usually trough cross-bedded. They are mainly buff- to brown-colored, fine-grained, well sorted and rounded, composed primarily of quartz with some feldspar. Mudrocks are gray to black, often carbonaceous and may grade laterally into coarser grained deposits. Coal occurs in three zones in the Lower

Member. Within these zones, the thickness and extent of the coal beds varies significantly; however, coal beds may reach up to 12 feet in thickness and maintain continuities of thousands of feet.

The few outcrops of the Lower Member present in the Techado quadrangle consist predominantly of buff to brown, fine-grained, fluvial sandstones. Interbedded with these are lenticular beds of gray to tan claystone and siltstone. No coal was observed in outcrop.

Middle Member

The Middle Member does not crop out in the Techado quadrangle. To the west in the Cerro Prieto quadrangle, Campbell (1981) describes the member as a distinctive, 40 to 80 foot thick, braided stream deposit consisting of coarse-grained, subangular to subrounded quartz and feldspar, lacking any matrix. The unit generally occurs in trough cross-bedded channels with no interbedded mudrocks.

The Middle Member should occur in the vicinity of Hubbell Draw (plate 1). The absence of the unit requires either: (1) faulting, (2) the unit was eroded, or (3) the unit was not deposited in this area. There is no evidence of faulting in this area. Furthermore, the hard, resistant nature of the Middle Member, makes it unlikely the entire unit would be eroded before other sediments. It is suggested therefore, that the unit pinches out west of the Techado quadrangle.

Upper Member

The majority of Upper Cretaceous rocks in the Techado quadrangle belong to the Upper Member of the Moreno Hill Formation. The member ranges from 0 to 450 feet thick with the thickest accumulations occurring in the central and northeastern parts of the quadrangle. Much of the member has been removed, a result of pre-Baca, pre-Fence Lake and Recent erosion. The Upper Member is composed of a series of sandstones, siltstones and claystones deposited in meandering stream environments.

Sandstones occur as lenticular beds generally in the range of 5 to 15 feet thick. These are often channel-shaped deposits that grade laterally and upward into finer-grained rocks. Lateral continuity of beds is poor, generally a few hundred to a thousand feet. Sandstones usually exhibit trough or low-angle planar cross-bedding. Erosional features such as clay rip-up and scoured surfaces are common. Color of the sandstones ranges from gray and buff to brown and occasionally red. Mineralogically, most are subarkosic sandstones, containing mainly quartz with lesser feldspar and some rock fragments. They are generally fine-grained, subrounded and moderately sorted. The geometry of the sand bodies, lithologic associations, sedimentary structures, mineralogy and texture indicate that the sandstones are primarily channel and crevasse splay deposits of a meandering stream environment.

Interbedded with the sandstones are lenticular deposits of

claystone and siltstone. Colors range from black, brown and red to lighter shades such as tan, green and gray. These deposits are often carbonaceous and may contain rootlets, plant fragments or minor coal stringers. The mudrock sequences contain some coal and shaly coal beds. These beds are always poorly developed and are characteristically thin, wavy and discontinuous. Maximum thicknesses measured for coal and shaly coal were 12 and 17 inches, respectively; maximum continuity was estimated to be 750 feet. The general lithologies and stratigraphic associations indicate these mudrock/coal sequences represent overbank and poorly developed paludal deposits.

Looking at the Upper Member as a whole, one can see an upward transition towards more stable, lower energy environments. The member is underlain by coarse, braided stream deposits of the Middle Member. The lower portions of the Upper Member are predominantly continuous, channel sandstones; interchannel deposits are relatively minor. These represent relatively high energy, low sinuosity meandering stream deposits. Conversely, finer-grained interchannel sediments, including swamp deposits, compose the majority of the upper portions. These are relatively low energy, coastal plain sediments cut by a few high sinuosity meandering stream channels. Thus, the sediments record a change from braided stream to meandering stream to coastal plain environments. The indications are that these are landward facies changes, brought about by an ensuing transgression. This observation is an important factor in predicting coal resources.

Baca Formation

Unconformably overlying the Moreno Hill Formation is the Eocene(?) Baca Formation. The Baca Formation occurs throughout much of the eastern third of the Techado quadrangle. The formation is thickest in the southeastern part of the quadrangle where it may be as much as 400 feet thick. The unit thins and pinches out to the west and north (plate 1). The pinch-out is due to both depositional thinning and pre-Fence Lake Formation erosion.

The Baca is composed primarily of white and red sandstones. These occur as a sequence of stacked and multilateral channel-shaped deposits with a few interbedded lenses of claystone, siltstone and conglomerate. Sandstones are usually trough cross-bedded and exhibit abundant erosional features. Sandstones are arkosic to subarkosic in composition, containing mainly quartz and feldspar with some rock fragments. Matrix is normally absent or low. Texturally, most are coarse- to very coarse-grained, angular to subangular, with moderate sorting. Claystone and siltstone lenses are usually red, gray or tan. These occur sparingly and are of limited extent. Conglomerate beds occur frequently. Pebbles are well rounded pieces of chert, quartzite, petrified wood, sandstone, claystone and minor igneous rocks, all generally less than 3 inches in diameter. Conglomerate beds are especially prolific along the base of the Baca where they can usually be used to draw the contact with the Moreno Hill Formation.

Based on overall shape of the deposits, stratigraphic profile, sedimentary structures and lithologies, it is evident the Baca Formation was deposited in a braided stream environment.

Fence Lake Formation

Unconformably overlying the Baca and Moreno Hill Formations is the Miocene(?) Fence Lake Formation. The lower contact is erosional and highly undulating with a general westward dip of 2 to 4 degrees. The formation is present in the north-central and northwest parts of the Techado quadrangle (plate 1). It is thickest in the northwest at Cerro Blanco (plate 1) where it is roughly 350 feet thick. The unit pinches out eastward, primarily due to depositional thinning.

The Fence Lake Formation consists of white, gray and pink lithic sandstones, conglomeratic sandstones and conglomerates. Sandstones occur as thick sequences of channel-shaped deposits exhibiting abundant, but variable cross-bedding. Sandstones are fine- to medium-grained, subrounded and moderately sorted. They contain quartz with abundant rock fragments, mafic minerals and feldspar. Sandstones are extremely calcareous and usually very friable. Though similar to Baca sandstones, Fence Lake sandstones can usually be distinguished by their highly calcareous nature, finer grain size and abundant lithic fragments.

Conglomerates range from a few scattered pebbles within sandstones to thick beds of boulder conglomerate. Conglomerates contain some pieces of chert, quartzite, sandstone, rhyolite or andesite, however, the bulk of the gravels are huge (0.5-3.0 feet diameter), rounded boulders of vesicular basalt. These large, basaltic boulders allow Fence Lake conglomerates to be easily distinguished from those of the Baca Formation. At Cerro Blanco, conglomerate beds were estimated to make up 15 to 25 percent of the Fence Lake Formation, occurring mostly in the lower portions. In most areas, a boulder conglomerate marks the base of the Fence Lake Formation. However, because of the weak and friable nature of the conglomerate beds, it is very often not exposed.

Fence Lake sediments were deposited in a fluvial environment, probably related to a post-Oligocene, northwest-trending alluvial fan system (McLellan et al, 1982).

Quaternary Alluvium

The low-lying areas and many of the high terraces are covered by a blanket of Recent alluvium. The alluvium may reach a maximum thickness of 60 feet and was mapped where it totally obscures bedrock. No distinctions were made between various types of alluvium.

Igneous Rocks

Three intrusive plugs and a series of en echelon dikes occur in the Techado quadrangle. The plugs are basalt and cut the Miocene(?) Fence Lake Formation in the northeast quarter of the Techado quadrangle. They bear a striking resemblance to the basalt boulders of the Fence Lake Formation and may represent one of the sources of these boulders. A series of en echelon dikes trends northwesterly through the Techado quadrangle. This is part of the dike system that runs from Pie Town to Fence Lake and has been discussed by Laughlin et al. (1979) and Campbell (1981). It is an olivine basalt dated at 27 million years B.P. (Laughlin et al., 1979). The dike is overlain by Fence Lake Formation (plate 1), thus providing a maximum age for the Fence Lake.

STRUCTURE

Geologic structure in the Techado quadrangle is simple. Strata are either flat-lying or dip gently eastward at 2 to 5 degrees. A few normal faults were observed in the quadrangle. Most are small, with displacement on the order of a few tens of feet. A large normal fault with slightly more than 100 feet of displacement, occurs east of Cerro Blanco (plate 1). The general structure is illustrated in the cross-sections on plate 2.

COAL RESOURCES

Potentially minable coal deposits occur within the Moreno Hill Formation. The greatest potential lies within the Lower Member. This member outcrops sparingly in the Techado quadrangle and no coal beds were observed. However, data from the adjacent Cerro Prieto quadrangle (Campbell, 1981) allows some inference into the resource potential of the Techado quadrangle. The upper, or Rabbit zone is present in the northwest part of the Cerro Prieto quadrangle where it occurs about 20 feet below the Middle Member and contains coal beds up to 12 feet thick (Campbell, 1981). However, in the eastern portions of the Cerro Prieto quadrangle, the zone is absent in both outcrop and drillholes. Thus, until further data is acquired, it is unlikely, yet uncertain, that the zone exists in the Techado quadrangle. If present, it represents a good, near surface resource possibility in the southwest portion of the quadrangle. The middle, or Cerro Prieto zone, occurs about 150 feet below the top of the Lower Member and contains coal beds up to 9.5 feet thick (Campbell, 1981). This zone has been penetrated by drilling along the eastern part of the Cerro Prieto quadrangle (Campbell, 1981). With dips ranging from 0 to 4 degrees east, available data indicates that the middle coal zone would project into the southwest corner of the Techado quadrangle at depths between 200 and 500 feet. No data is available on the lower, or Antelope zone. This zone occurs about 250 feet below the top of

the Lower Member and therefore would be well over 500 feet deep in the Techado quadrangle.

Thus, Hubbell Draw and the area to the south (plate 1) present reasonably good exploration targets. Coal should be present in the Cerro Prieto zone, although it will be somewhat deep. In addition, there is a slight chance of intersecting coal in the Rabbit zone, should it re-appear in this area.

Thin coals and carbonaceous claystones were observed in the Upper Member of the Moreno Hill Formation, mainly near the top of the unit. Invariably, these are too poorly developed to be economically recovered. Earlier discussion points out that this is a function of depositional environments. Sediments of the Upper Member were deposited in fluviially dominated meandering stream and coastal plain environments - environments too dynamic for stable swamp formation. Upward in the section, there is a transition toward more stable peat-forming environments; however, the degree of stability required for thick coal deposits was never achieved. Thus, based on surface exposures and depositional environments, the Upper Member has poor coal resource potential in the Techado quadrangle. On the other hand, depositional environments indicate that the coal resource potential will improve both upward in section and north-northeastward toward the paleoshoreline. This indicates good coal potential should exist in Upper Moreno Hill equivalents (Crevasse Canyon Formation) to the north and northeast of Techado

(fig. 4). Unfortunately, most of this region is overlain by Quaternary basalt. This thick basalt cover and the lack of transportation facilities make the area unattractive to current prospecting.

CONCLUSIONS

The Techado region contains Late Cretaceous and Tertiary clastic sediments belonging to the Moreno Hill, Baca and Fence Lake Formations. The Moreno Hill Formation is a sequence of buff to brown, fine- to medium-grained, subarkosic sandstones, tan to black, claystones and siltstones and minor coals. These were deposited as channel and overbank deposits in meandering stream and coastal plain environments. The Baca Formation consists of white and red, coarse, arkosic sandstones and conglomerates lying unconformably upon Cretaceous sediments. The Fence Lake Formation consists of lithic sandstones and conglomerates lying with angular unconformity upon Baca and Moreno Hill deposits. Both the Baca and Fence Lake Formations were deposited in Tertiary braided alluvial basins.

Coal occurs within paludal sediments of the Lower and Upper Members of the Moreno Hill Formation. The Lower Member holds some potential for minable coal deposits in the extreme southwest portion of the Techado quadrangle. Throughout the remainder of the quadrangle, the member is too deep to be a viable exploration

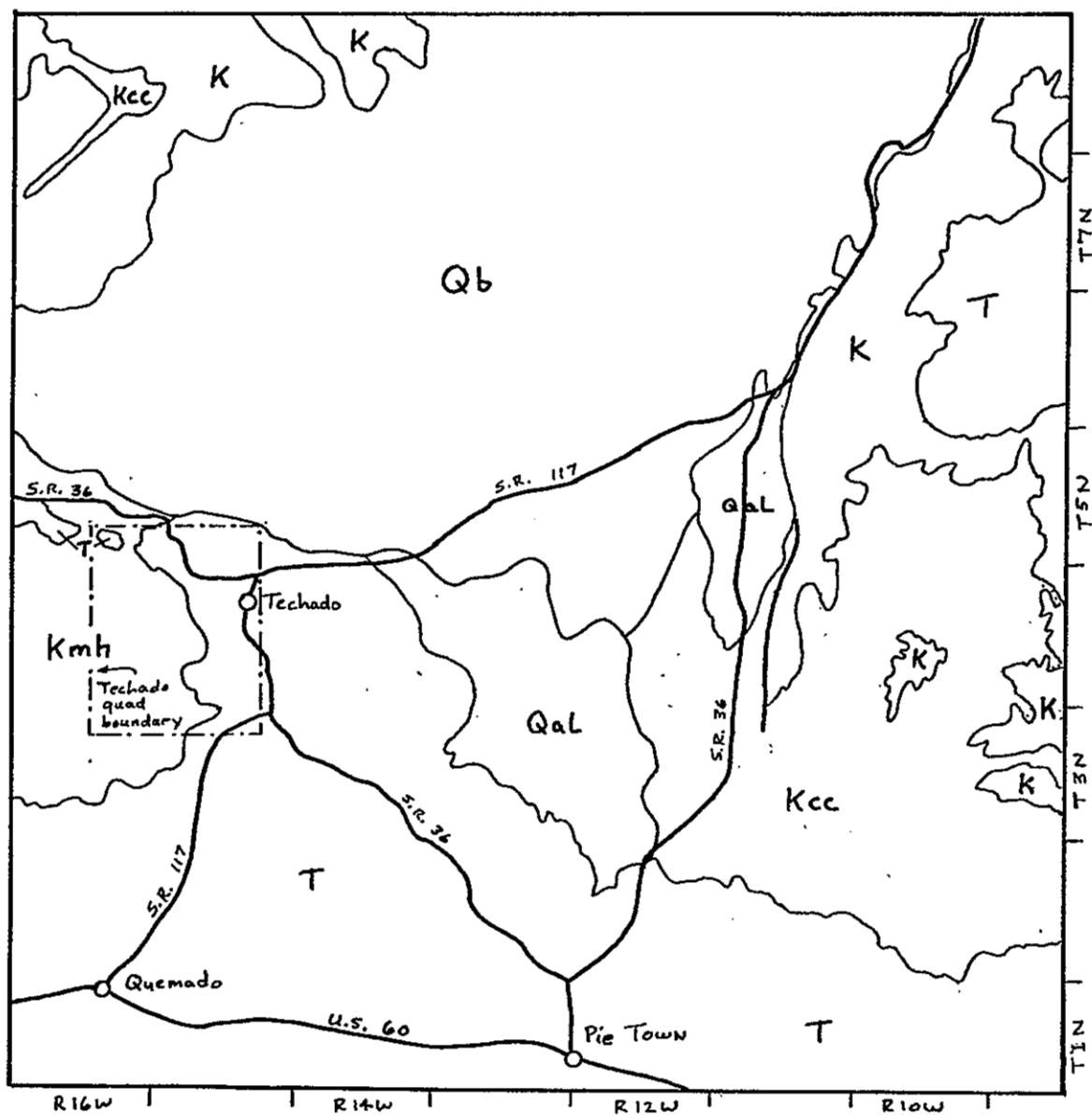


FIGURE 4 - Depositional environments indicate improved coal resource potential in areas north and northeast of the Techado quadrangle.

Qal-Quaternary alluvium
 Qb-Quaternary basalt
 T-Tertiary undifferentiated
 Kcc-Crevasse Canyon Fm.
 Kmh-Moreno Hill Fm.
 K-Cretaceous marine deposits:
 Gallup Ss, Mancos Sh,
 Dakota Ss - undiff.
 (base adapted from Dane & Bachman, 1965,
 Geologic Map of New Mexico)

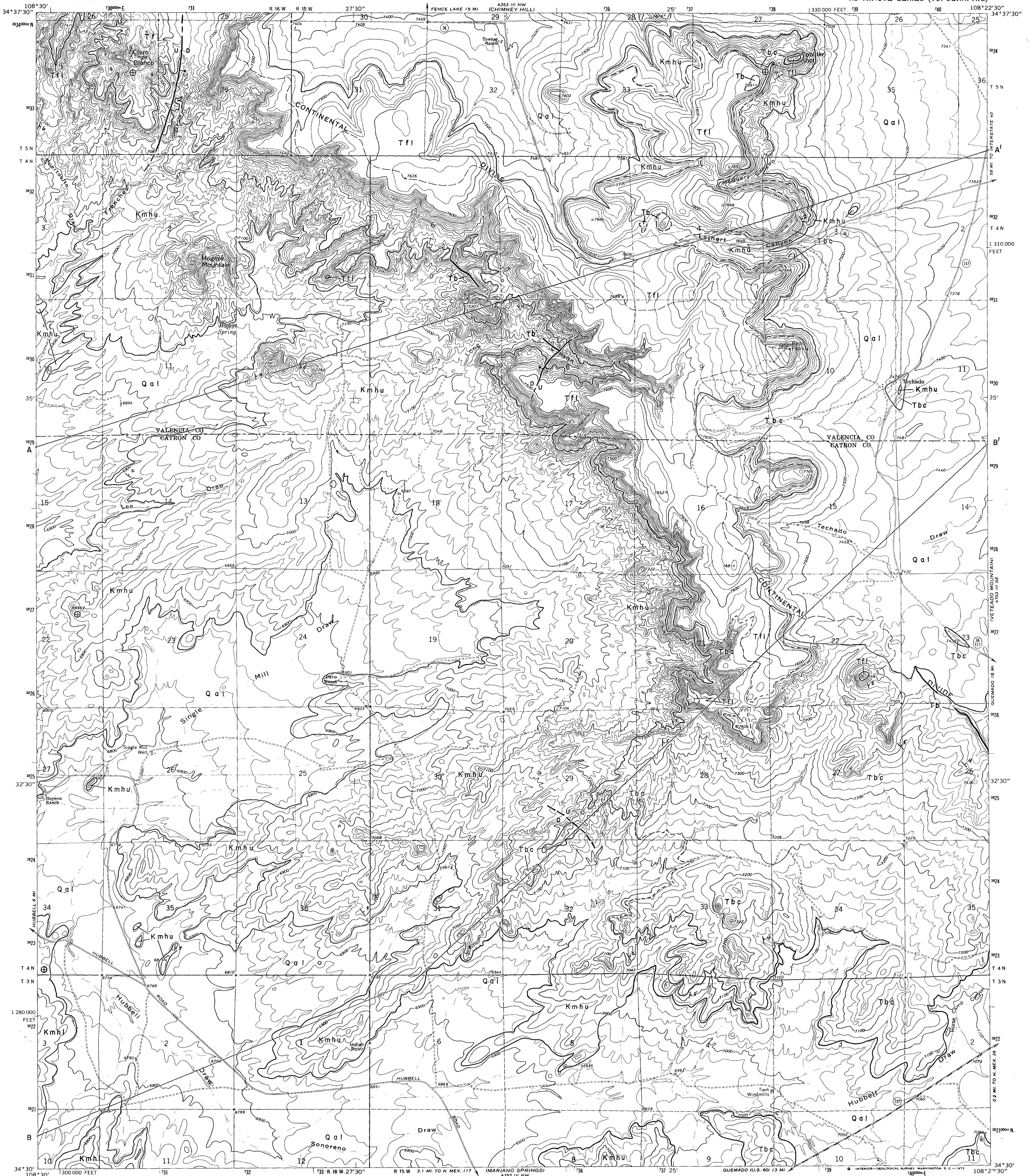
target. The Upper Member is at or near the surface throughout most of the quadrangle; however, due to unfavorable depositional environments, coal beds are scarce and poorly developed. Thus, on the whole, the Techado quadrangle has little coal resource potential. However, the stratigraphy and depositional environments of the Upper Moreno Hill indicate that the coal resource potential is improving both upward in section and northeastward towards the paleoshoreline. Thus, Upper Moreno Hill equivalents to the north and northeast of the Techado quadrangle are more likely to contain coal resources.

BIBLIOGRAPHY

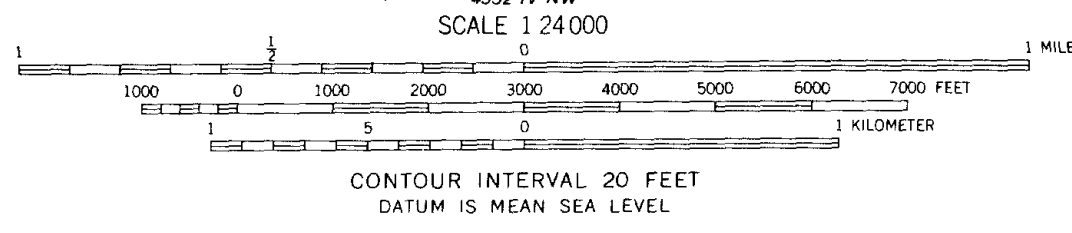
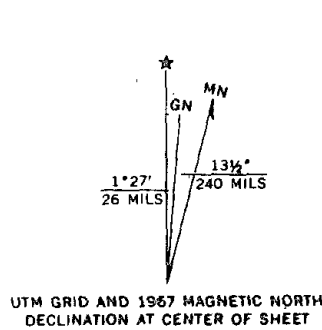
- Campbell, F., 1981, Geology and coal resources of Cerro Prieto and The Dyke quadrangles: N. Mex. Bur. Mines Min. Res., Open File Rept. 144, 44 pp.
- Fitzsimmons, J.P., 1959, Structure and geomorphology of west-central New Mexico: N. Mex. Geol. Soc., Guidebook 10, pp. 112-116
- Hook, S.C., Molenaar, C.M. and Cobban, W.A., 1983, Stratigraphy and revision of nomenclature of Upper Cenozoic to Turonian (Upper Cret.) rocks of west-central New Mexico: N. Mex. Bur. Mines Min. Res., Circ. 185, pp. 7-28
- Laughlin, A.W., Brookings, D.G., Damon, P.E. and Shafiqullah, M., 1979, Late Cenozoic volcanism of the Central Jemez Zone, Arizona and New Mexico: Isochron West, no. 25, pp. 5-8
- McLellan, M., Haschke, L., Robinson, L., Carter, M.D. and Medlin, A., 1982, Fence Lake Formation (Tertiary), west-central New Mexico: N. Mex. Geol., v.4, no.4, pp. 53-55
-
- ___, 1983, Middle Turonian and younger Cretaceous rocks, northern Salt Lake coal field, Cibola and Catron Counties, N. Mex.: N. Mex. Bur. Mines Min. Res., Circ. 185, pp. 41-47

Molenaar, C.M., 1983a, Major depositional cycles and regional correlations of Upper Cretaceous rocks; southern Colorado Plateau and adjacent areas, pp. 201-223, IN Reynolds, M.W. and Dolly, E.D., (eds.), Mesozoic paleogeography of west-central U.S.: Soc. Econ. Paleo. Min., Denver, 391 pp.

_____, 1983b, Principal reference section and correlation of Gallup Sandstone, northwestern New Mexico: N. Mex. Bur. Mines Min. Res., Circ. 185, pp. 29-40



Mapped, edited, and published by the Geological Survey
Control by USGS and USC&GS
Topography by photogrammetric methods from aerial
photographs taken 1966. Field checked 1967
Polyconic projection 1927 North American datum
10,000-foot grid based on New Mexico coordinate system,
west zone
1000-meter Universal Transverse Mercator grid ticks,
zone 12, shown in blue
Fine red dashed lines indicate selected fence lines



LEGEND
Qal = Quaternary alluvium Kmhu = Cret. Upper Moreno Hill Fm.
Tb = Tertiary basalt Kmhl = Cret. Lower Moreno Hill Fm.
Tfi = Tert. Fence Lake Fm.
Tbc = Tert. Baca Fm. ⊕ = horizontal strata

GEOLOGIC MAP OF THE TECHADO QUADRANGLE, WEST-CENTRAL NEW MEXICO

by: Brian Arkeil, N.M.B.M.R.
1984

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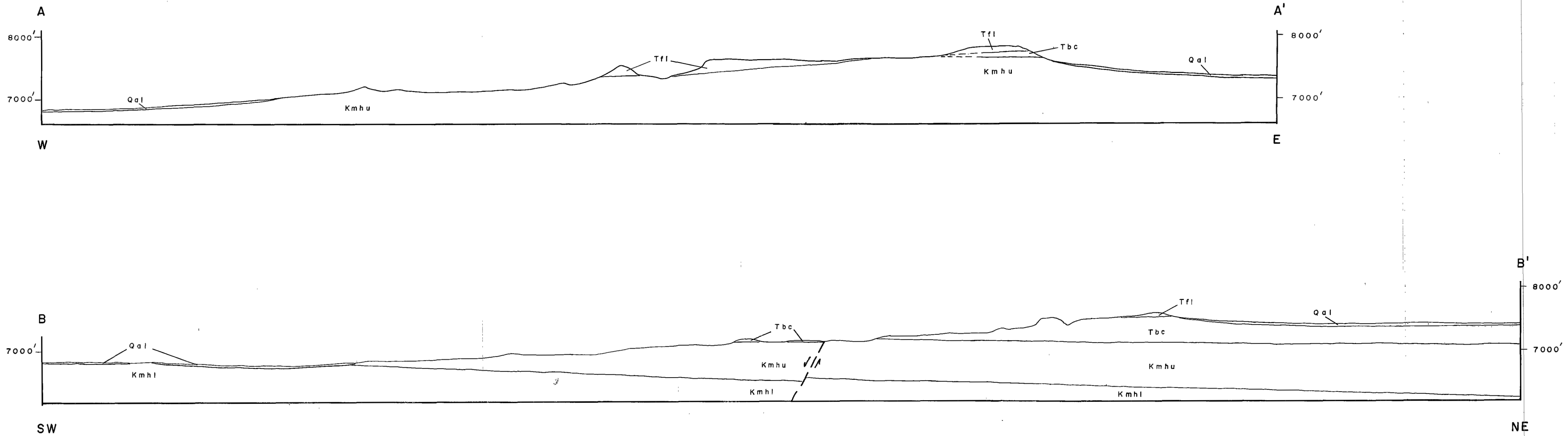


PLATE 2: CROSS-SECTIONS

Vertical Scale 1" = 2000' (1:24,000)

Horizontal Scale 1" = 1000'

2 X Vertical Exaggeration