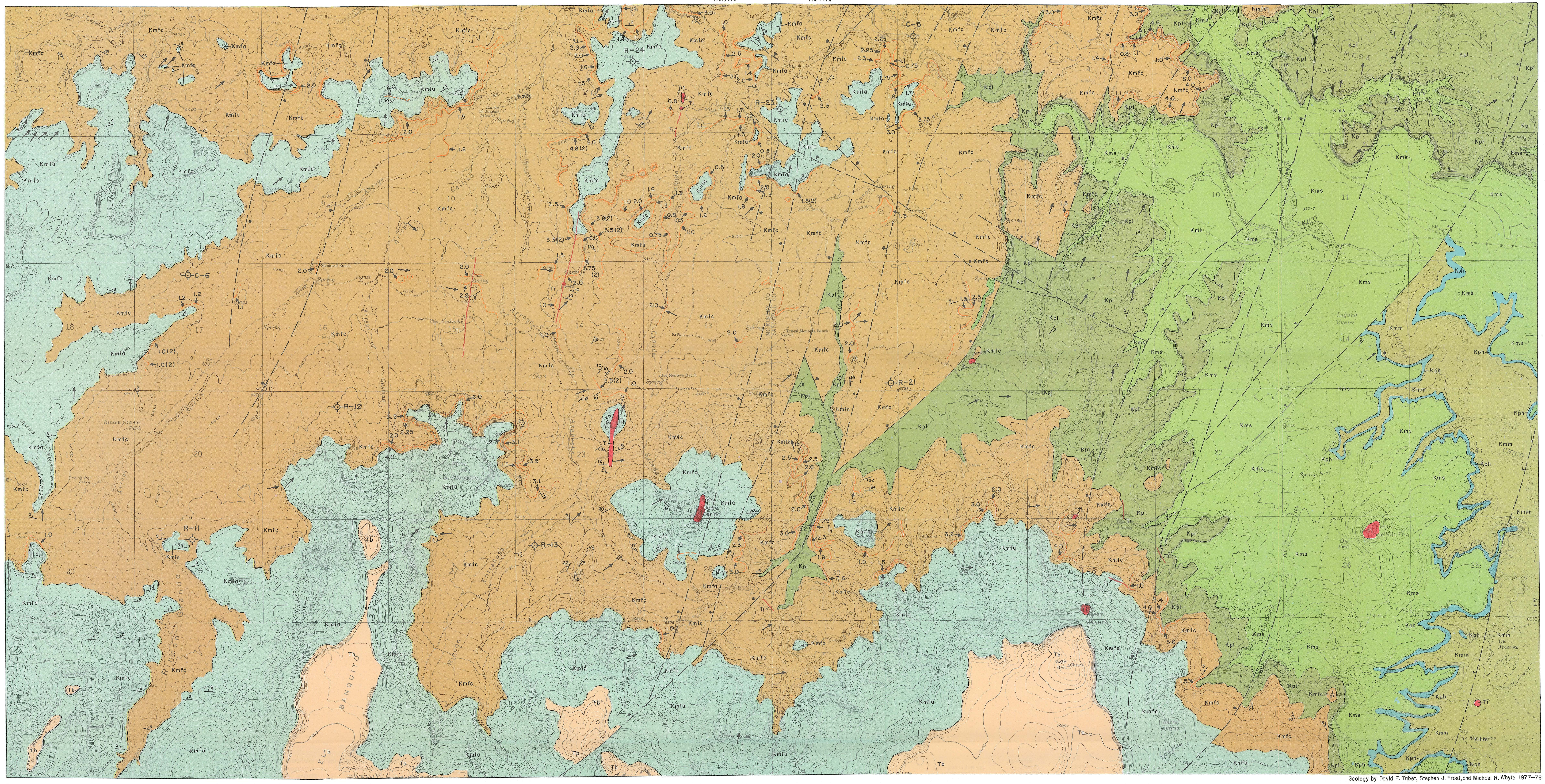
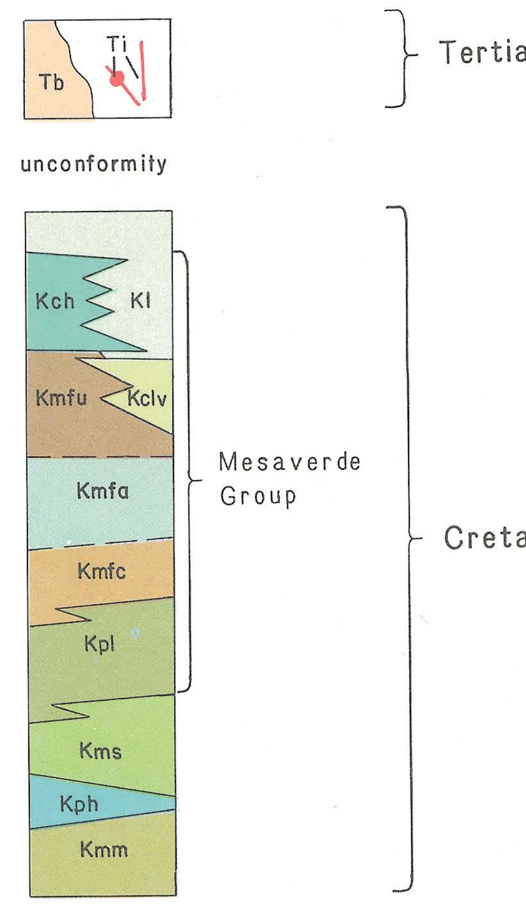


Geology by David E. Tabet, Stephen J. Frost, and Michael R. Whyte 1977–78

CORRELATION OF UNITS



DESCRIPTION OF MAP UNITS

Ti Tb **Tertiary volcanics**—Tb, *basalt flows capping Mesa Chivato;* Ti, *basalt dikes and plugs related to Mt. Taylor volcanic center*

Kl **Lewis Shale**—*Light- to dark-gray silty shale interbedded with Cliff House Sandstone*

Kch Kclv **Cliff House Sandstone**—*Gray or tan, fine-grained, even-bedded to crossbedded sandstone. Main body of Cliff House,* Kch, *dies out rapidly to northeast as lower La Ventana Tongue,* Kclv, *appears; La Ventana consists of several tongues.*

Kmfu Kmfa Kmfc **Menefee Formation**—Kmfu, *upper coal-bearing member, intertongues with La Ventana Tongue of Cliff House;* Kmfa, *Allison Member, predominantly fine to medium crossbedded sandstone and tan to light-gray shale;* Kmfc, *Cleary Member, gray to dark-brown carbonaceous shale, tan sandstone, and coal*

Kpl Kph **Point Lookout Sandstone**—*Tan to brown, fine-grained, even-bedded to crossbedded sandstone; interbedded with shale near base. The Hosta Tongue,* Kph, *is separated from the main body of the Point Lookout Sandstone,* Kpl, *by the Satan Tongue of the Mancos Shale*

Kms Kmm **Mancos Shale**—*Light- to dark-gray silty shale with a few thin sandstone or limestone beds or limestone concretions. The Satan Tonuge,* Kms, *is separated from the Mulatto Tongue,* Kmm, *by the Hosta Tongue of the Point Lookout Sandstone*

Strike and dip of beds

Axis of trough crossbedding

Coal bed, dashed where approximate, dotted where inferred (measurement in ft)

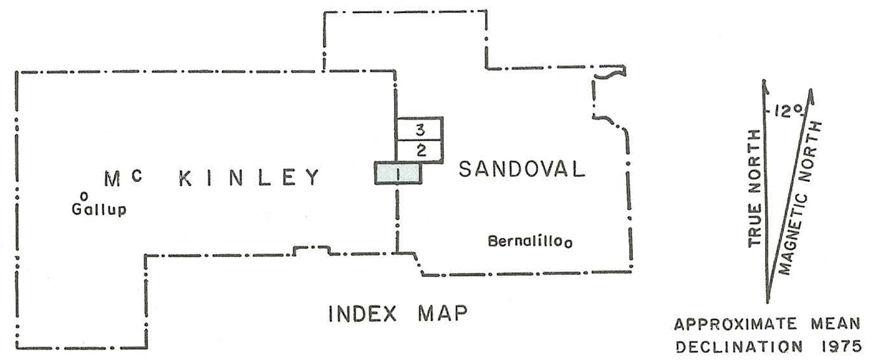
Coal mine or prospect

Burned coal bed

Fault, dashed where approximate or concealed (ball on downthrown side)

Contact, dashed where approximate

Well



Scale 1:24,000 — 0 – 1 mi; 0 – 1 km — Contour interval 20 ft

Coal geology of Torreon Wash area, southeast San Juan Basin, New Mexico

by D.E. Tabet and S.J. Frost, 1979

INTRODUCTION

1 The Torreon Wash area basically consists of a series of three north-sloping, sandstone-capped mesas, each one stepping successively up to the north. From south to north these mesas are formed by the Point Lookout Sandstone, the sandy middle member of the Menefee Formation, and the Cliff House Sandstone. The intermittent Chico Arroyo and Torreon Wash, two main tributaries of the Rio Puerco, traverse the area from west to east and north to south respectively. The area has been deeply dissected by these two main washes and their tributaries. In the southern part of the area extensive erosion has exhumed various volcanic necks around the lava-capped Mesa Chivato. At 8,091 ft above sea level, Mesa Chivato is the highest point in the area; Chacra Mesa in the north is the second highest point, reaching 7,078 ft. The lowest point is along the Chico Arroyo in the south at 5,940 ft above sea level.

2 NM-197 connecting Cuba and Crownpoint passes through the northwest corner of the area and NM-44 runs north-south 9 mi from the eastern edge of the area. Federal, county, utility, and ranching concerns maintain numerous dirt roads providing good access to the whole area. Torreon, comprising a trading post, mission school, and various Indian houses and hogans on part of the Eastern Navajo Reservation, is the only sizable development in the area; Cuba, 30 mi to the northeast, is the closest major town.

3 Various workers have studied all or part of the Torreon Wash project area. Dutton (1885), who conducted the first reconnaissance examination through the Torreon Wash area, outlined the geology and emphasized the volcanic rocks. Schrader (1906) and Gardner (1909, 1910) traced the Upper Cretaceous coal-bearing rocks around the San Juan Basin south from Durango, Colorado, and east from Gallup, New Mexico, and described selected coal exposures. Hunt (1936) and Dane (1936) made more detailed examinations of the coal beds in the southern part of the San Juan Basin and attempted to correlate some of the thicker beds in an effort to classify the coal resources on public land. Shomaker and others (1971) included some general information about the study area in their discussion of low-sulfur strippable coal resources for the entire San Juan Basin. Beaumont and Shomaker (1974) gave a short summary of the geology and deep-coal resources of the Cuba–La Ventana–Torreon area, and the deep-coal resources of the area were discussed at length in Shomaker and Whyte (1977). Mannhard (1976) measured two stratigraphic sections of the La Ventana Tongue of the Cliff House Sandstone and associated Menefee Formation through part of the Torreon Wash area and discussed the sedimentology of these rocks.

4 ACKNOWLEDGMENTS—Several people provided information that was essential to understanding the stratigraphy and coal geology of the Torreon Wash area. Howard Nickelson, formerly supervising mining engineer with the U.S. Geological Survey Conservation Division Office in Farmington, New Mexico, allowed access to the expired coal-lease and prospect files for the study area. Ray N. Warren of Pioneer Nuclear, Incorporated, Albuquerque, New Mexico, Dennis G. Storhaug of Tenneco Oil Company, Denver, Colorado, and Thomas Drought, agent for the H. P. Drought Company, San Antonio, Texas, all kindly released drill-hole information for use in this report. Certainly most important to the completion of this project was the funding provided by the U.S. Geological Survey, Conservation Division, under grant number 14-08-0001-448, and the cordial working relationship that developed with Marvin Millgate, Wayne Lambert, and Norman Wingard of the Conservation Division.

REGIONAL STRATIGRAPHY

5 The Torreon Wash area strata comprise Upper Cretaceous marine and nonmarine rocks that have locally been intruded and/or overlain by Tertiary volcanic rocks related to the Mount Taylor center to the southwest. Coal is found in the Menefee Formation, which is composed of the basal coal-bearing Cleary Member, the middle Allison Member (a sandy unit essentially devoid of coal), and an upper unnamed coal-bearing member. In the southern part of the area, the Menefee Formation lies conformably on the Point Lookout Sandstone; to the east and northeast it intertongues with the La Ventana Tongue of the Cliff House Sandstone, and to the northwest it is overlain by the Cliff House Sandstone.

Mancos Shale

6 Two tongues of the Mancos Shale, the Mulatto and the Satan, are exposed in the southeastern part of the Torreon Wash area in parts of T. 16 N., R. 4 W. and T. 17 N., Rs. 3 and 4 W. These shales are the lowermost Upper Cretaceous rocks exposed in the area. They consist of medium-gray, silty, laminated marine shale. The lower Mulatto and upper Satan Tongues are separated by distal sands of the Hosta Tongue of the Point Lookout Sandstone. The Hosta Tongue thickens to the southwest. The main body of the Point Lookout Sandstone conformably overlies the Satan Tongue.

Point Lookout Sandstone

7 The regressive marine Point Lookout Sandstone has an alternating sand-shale transitional lower contact with the Satan Tongue of the Mancos Shale. The contact between these two units is characterized by a series of sand beds and intervening shales in which the sand beds increase gradually in thickness upward until only a massive cliff-forming sand exists. For the sake of mapping, this contact was drawn where sand predominates over shale. The Point Lookout crops out in a belt that runs southwestward through the southern part of T. 17 N., R. 3 W. and T. 17 N., R. 4 W. This belt turns sharply south midway through the latter township and extends southward through the central part of T. 16 N., R. 4 W. along the east edge of Mesa Chivato.

8 Outcrops of Point Lookout Sandstone are very pale orange to light gray for the most part, although exposures may be very light gray to white toward the top. Bedding toward the base of the unit is generally less than 3 ft thick and has planar lamination; bedding toward the top is thicker and has cross-lamination.

9 Sand grains in the Point Lookout are subangular to subrounded and vary from very fine to fine grained. A general increase in grain size occurs from the base to the top of the formation (Shetiwy, 1978). Quartz is the dominant mineral in the Point Lookout Sandstone, especially in the finer grained sandstones. Detrital grains of chert, feldspar, rock fragments, and organic debris are more common in the coarser sandstones of the upper Point Lookout (Sabins, 1964). Body fossils are not common in the Point Lookout although the trace fossil *Ophiomorpha* may be common in places.

10 Examination of well logs from the Torreon Wash area shows that the thickness of the Point Lookout Sandstone ranges from 75 to 260 ft. The Point Lookout thickens and thins in a systematic way to form a series of west-northwest-trending ridges and troughs.

Menefee Formation

11 The Menefee Formation consists of interbedded shales or mudstones, siltstones, sandstones, and coals. The three members of the Menefee mapped in the Torreon Wash area were essentially divided on the basis of the presence or absence of coal. In ascending order these members are the coal-bearing Cleary Member, the sandy Allison Member, and an upper unnamed coal-bearing member, formerly considered part of the Allison Member. The upper coal member underlies or intertongues with the Cliff House Sandstone and includes the Hogback Mountain tongue of Shomaker and Whyte (1977). The Hogback Mountain tongue was defined as one or more Menefee tongues that are laterally (to the south) equivalent and in part enclosed by the La Ventana Tongue of the Cliff House Sandstone.

12 These three members represent the gradational succession of depositional environments from a coastal swamp to a floodplain and back to a coastal swamp. Because the succession is gradational, the contacts between units are gradational and not easily defined and so they are dashed on the maps. The contact between the Cleary and Allison members is drawn at the base of a thick, cliff-forming channel-sandstone sequence that overlies the uppermost major coal horizon of the Cleary. The upper contact of the Allison Member with the overlying upper coal member is not well defined. This contact is drawn where coals and brown to black carbonaceous shales, rarely found in the Allison Member, once again begin to predominate over drab-gray and tan mudstones.

13 CLEARY MEMBER—The basal Cleary Member of the Menefee Formation has a conformable, transitional contact with the underlying Point Lookout Sandstone. This unit, composed of paludal deposits, is generally 200-300 ft thick. The Cleary Member crops out in a northeast-trending belt running through most of T. 16 N., R. 5 W., the west half of T. 16 N., R. 4 W., the southern part of T. 17 N., R. 4 W., and the central part of T. 17 N., R. 3 W.

14 Lithologically the Cleary Member is dominated by finer grained paludal deposits composed of silt-clay-sized particles and abundant organic debris. At various horizons, more commonly in the lower half of the Cleary, organic debris accumulated to form coal beds. Occasional lenticular channel sandstone deposits and related splay and levee sandstone deposits make up a minor portion of the Cleary Member. These sands increase in abundance toward the top of the unit. Iron-rich concretionary layers or nodules composed of siderite are often associated with organic-rich shales or mudstones. Abundant plant impressions and fragments ranging up to sections of logs are found along bedding planes, but no macroinvertebrate fossils are found. The random orientation of the plant debris and the occasional presence of an upright stump indicate that most of the organic debris accumulated in place. The coal is characterized by medium bands of vitrain with bits of amber along horizontal cleats.

15 ALLISON MEMBER—The Allison Member, composed of channel sandstones and barren silty mudstones and shales, overlies the Cleary Member with an irregular but conformable contact. This unit crops out mainly in the northern third of T. 17 N., R. 3 W. and the northern half of T. 17 N., R. 4 W. Small areas of exposures occur in the southern parts of the two northern townships and cap the higher mesas of the two southern townships. The Allison is roughly 400–550 ft thick.

16 Unlike the Cleary Member, rocks of the Allison Member are composed primarily of sand-silt-sized particles and very little organic debris. Directly above the Cleary, the basal part of the Allison consists of a 200-ft-thick, multistory sequence of stacked channel sandstones. Above this basal sequence, channel-sand units are common but do not occur in thick, stacked sequences. The channel-sand units are characterized by sharp scour bases containing numerous clay clasts and wood fragments. A major part of these units has large sets of high-angle cross-stratification. The cross-sets generally decrease upward in size and thickness, then change to trough cross-sets and finally to ripple lamination. Grain size in the channel units decreases generally upward from medium to very fine sand. In cross section the channel sandstones are thick lenticular units with a flat upper surface and a concave (upward) lower surface.

17 Laterally associated with the thick channel-sand units are thin (usually less than 3-ft) tabular bodies of fine, silty sand. These bodies commonly have ripple lamination and numerous root tubes along the upper surface and represent splay and levee deposits marginal to the channels and extending into the floodplain deposits.

18 The floodplain deposits interstratified with the channel and marginal channel deposits are light-gray or tan silty claystones and shales. These claystones and shales contain little organic material, probably as a result of an oxidizing, well-drained depositional environment. Locally thin coals and some brown humic shales occur, but they generally compose less than 5 percent of the Allison Member.

19 UPPER MEMBER—The upper unnamed member composes as much as 650 ft of the Menefee Formation. It has a gradational lower contact with the Allison Member and intertongues and is overlain by sand bodies of the the Cliff House Sandstone. The upper member is lithologically similar to the Cleary Member. Most of the thicker coal beds occur in the upper part of the upper member between sandstone tongues of the La Ventana Tongue of the Cliff House Sandstone. The upper coal member thins somewhat to the west, grading laterally into the Allison Member.

Cliff House Sandstone

20 The Cliff House Sandstone proper and the stratigraphically lower La Ventana Tongue of the Cliff House overlie and intertongue with the Menefee Formation in T. 18 N., Rs. 3 and 4 W. Lack of detailed mapping or stratigraphic data caused earlier workers (Dane, 1936; Shomaker and others, 1971; and Beaumont and Shomaker, 1974) to postulate that the Menefee Formation in this area is directly overlain by the Lewis Shale. Thin marine sandstones of the Cliff House are found between the Menefee Formation and the Lewis Shale at all exposures. The stratigraphy in this area is particularly complicated because only thin lenses of Cliff House extending seaward (northeast) and thin lenses of the La Ventana extending landward (southwest) are found overlying most of the Menefee. The Lewis Shale, which intertongues with the thin Cliff House sands, pinches out rapidly to a knife edge at Chacra Mesa in sec. 30, T. 18 N., R. 4 W.

21 LA VENTANA TONGUE—The La Ventana within the Torreon Wash area consists of several laterally persistent lenses of marine sandstone up to 40 ft thick that are interstratified with paludal deposits of the upper Menefee member. The uppermost lens of La Ventana separates the Menefee from the Lewis Shale through T. 18 N., R. 3 W. and the eastern half of T. 18 N., R. 4 W. The lower La Ventana lenses, which occur in T. 18 N., R. 3 W., thin and intertongue with the Menefee Formation to the southwest and thicken toward the main buildup of the La Ventana to the northeast.

22 The La Ventana sandstone lenses are characterized by sharp, generally planar to slightly undulatory upper and lower contacts with the brown humic shales or coals of the upper Menefee. Load deformational structures and some reworked clasts of Menefee lithology are found along the lower contacts of these lenses. Internally, horizontal to very low angle, planar cross-stratification may also be present. Iron-oxide-stained, knobby-walled *Ophiomorpha* trace fossils are sparse to very abundant and a key indicator of marine conditions for the La Ventana sands. The quartzose sands composing the La Ventana units are tan to light gray, fine to very fine grained, and moderately well sorted.

23 CLIFF HOUSE SANDSTONE, MAIN BODY—The main body of the Cliff House Sandstone in this area was originally named the Chacra Sandstone by Dane (1936) for Chacra Mesa, which it caps, extending westward from T. 18 N., R. 4 W. The name Chacra was dropped by Beaumont, Dane, and Sears (1956) in favor of the name Cliff House, when more work showed the continuity of this sandstone around the San Juan Basin. The name Chacra Tongue has been informally used for the portion of the Cliff House that caps Chacra Mesa (Shomaker and others, 1971; Beaumont and Shomaker, 1974; Beaumont and others, 1976; and Shomaker and Stone, 1976). We prefer to use the term Cliff House until further work and formal naming clearly warrant the use of a different name.

24 Dane (1936) measured 310 ft of Cliff House Sandstone on Chacra Mesa in T. 18 N., R. 4 W. This thick, cliff-forming unit undergoes radical changes just a short distance to the northeast. Surface exposures show a rapid seaward (northeast) thinning of the Cliff House and a significant increase in intertonguing with the marine Lewis Shale. Within the space of 3 mi, from Chacra Mesa northeastward to near the Torreon Trading Post, the Cliff House changes from a 310-ft-thick sandstone to an interval composed of upper marine sandstone approximately 45 ft thick, a medial tongue of Lewis Shale roughly 165 ft thick, and a lower marine sandstone up to 25 ft thick.

25 The quartzose sands of the Cliff House are tan to light gray, very fine grained, well cemented with occasional carbonaceous shale laminae. Sorting in these sands is generally poor to fair. Hollenshead and Pritchard (1961) list an average petrographic description from Cliff House core samples taken from 19 wells scattered across the San Juan Basin: quartz, 60 percent; feldspar, 10 percent; rock fragments, 5 percent; clay, 5 percent; and calcareous cement, 15 percent.

Lewis Shale

26 Marine Lewis Shale overlies the uppermost La Ventana sandstone tongue in the northeast part of the Torreon area and interfingers with the main Cliff House Sandstone in the northwest. Good exposures of the Lewis Shale are sparse and it was not studied in great detail. The Lewis generally consists of gray to olive-gray, silty shale with common thin interbeds of silty sandstone. A persistent fossiliferous, thin, calcareous, silty sandstone occurs about 40 ft above the uppermost La Ventana sand in T. 18 N., R. 3 W. The Lewis contains numerous gastropods, bivalves, and ammonites, including *Placenticeras intercalare*. Thickness varies considerably over the area and generally thickens to the north and east from the Chacra Mesa area.

Tertiary igneous rocks

27 Tertiary igneous rocks related to the Mount Taylor volcanic center intrude and overlie the Upper Cretaceous rocks of the Torreon Wash area. A series of thick columnar-jointed basaltic flows caps Mesa Chivato in the south. Abundant basaltic rubble forms talus along the northern slopes of the mesa, obscuring the underlying Cretaceous rocks. Erosion has exposed several basaltic necks or plugs (such as Bear's Mouth and Cerro Parido) around the northern end of Mesa Chivato. Some smaller plugs are associated with north-south- trending dikes in the southwestern part of the area in T. 16 N., R. 5 W. A series of en echelon dikes extends from T. 16 N., R. 5 W. through T. 17 N., R. 4 W., and into T. 18 N., R. 5 W. to the edge of Chacra Mesa. The dikes are generally 1 ft thick or less, yet can be traced along strike over a considerable horizontal distance. These igneous rocks have had little or no metamorphic effect on the enclosing strata.

GEOLOGIC STRUCTURE

28 The structure of the Torreon Wash area is basically a gentle northwest-dipping block. The regional orientation of the strata has a northeasterly strike and a dip of 4-5 degrees to the northwest. Dips greater than 5 degrees are generally the result of primary depositional slopes or disturbances along faults. Complicating the general picture of the northwest-dipping block are a series of northeast-trending normal faults, usually with the east side of the fault raised relative to the west side. These faults have relatively small amounts of displacement, generally only a few tens of feet, with a maximum displacement of 150