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ALIBI FOR A MESAVERDE MISFIT—THE LA VENTANA FORMATION CRETACEOUS DELTA, NEW MEXICO

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INTRODUCTION

A delta with a source generally southeast is inferred mainly from trough cross-stratification of sandstones in the La Ventana area. In the past, a great variety of stratigraphic terms have been used in the La Ventana area leading to confusing nomenclature, so it is recommended that the term *"La Ventana Formation"* be reinstated for all strata between the Mancos Shale and the Lewis Shale in this area. The La Ventana formation cosists of continental-type sandstone, shale and coal lithosomes that formed in a deltaic environment. The classic Mesaverde Group of southwestern Colorado consists, in ascending order, of the regressive Point Lookout Sandstone and Menefee Formation and the transgressive Cliff House Sandstone, all formed as the result of shifting shorelines. This does not fit the stratigraphic pattern of time-equivalent rocks at La Ventana, which were formed by a delta with a source to the southeast (whereas the source of clastics for the classic Mesaverde Group lies to the west), but attempts to force correlations resulted in naming, for example, the La Ventana Tongue of the Cliff House Sandstone because it was expected that somewhere in the subsurface the La Ventana would be found to connect essentially with the main body of Cliff House Sandstone to which it is clearly related as part of the upper transgressive marine-sandstone sequence of the Mesaverde Group (Beaumont, Dane and Spears, 1956, p. 2160). The clearly related aspect of the La Ventana to any other rock units except those with which it is seen to interfinger at the excellent outcrops in the subject area were not recognized by the majority of workers in this area, including Dane (1936) and Silver (1951). The Beaumont *et al* 1956 correlation depended upon the La Ventana being a marine sandstone unit, but the present study finds it to be a predominantly of continental fluvial and paralic origin, except for one sandstone bed with marine fossils which occurs in the northern (seaward) part of the La Ventana area, apparently formed during a marine transgression. My main objectives are then to establish the continental nature of the La Ventana formation; to show that stream-formed trough cross beds indicate a source to the east and southeast for clastics; and to define the La Ventana formation.

A concept common to all workers in the San Juan Basin is "the great truth" for Mesaverde sedimentation, that landward was to the southwest and seaward was to the northeast; most paleogeographic reconstructions show this (e.g., Schuchert, 1955, p. 75). An east-southeast source for La Ventana formation clastics therefore calls for new interpretations and explanations of the stratigraphy.

[Editor's note: see paper by Fassett elsewhere in this volume for another interpretation of the La Ventana Sandstone.]

STRATIGRAPHIC SETTING

The La Ventana area, located in the southeastern part of the San Juan Basin (fig. 1), was mapped by Dane (1936). He included as members of the Cretaceous Mesaverde Formation in ascending order: (1) the Hosta Sandstone Member (described as a white, buff and gray soft sandstone with charcoal fragments and poorly defined horizontal bedding about 80 feet thick along the Rio Puerco; cross-bedded sandstones in the Mancos Shale below the Hosta were also noted); (2) the Allison Member and Gibson Coal Member, undifferentiated, described as 670 feet of predominantly continental shales, with coals, mostly dirty and subbituminous and sandstones up to 43 feet thick; (3) the La Ventana sandstone member, described as about 900 feet of white, gray and buff sandstones with interbedded shale and coal beds. Dane estimated the thickness at 900 feet and noted that Renick (1931, p. 45) gave a thickness of the La Ventana sandstone member in T. 19 N., R. 1 W. of 1256 feet. The present study includes measurements of considerably less total thickness for the interval from the base of the Hosta Sandstone Member to the uppermost sandstone in the La Ventana; a thickness of 850 feet was measured for that interval in T. 18 N., R. 2 W. and 573 feet was measured in T. 19 N., R. 1 W. Because almost every bed in the La Ventana area changes thickness, intertongues with other beds or pinches out laterally and because faulting complicates correlation even more, measuring sections can be very frustrating; my best estimate is that there is a maximum thickness of 1000 feet of strata between the Mancos Shale and the Lewis Shale in the La Ventana area (fig. 2).

Dane (1936) also included the Chacra sandstone member in the Mesaverde Formation. The Chacra sandstone member crops out west of the study area; it is described as a marine sandstone 300 to 360 feet thick. Dane rejected Reeside's 1924 correlation of the Chacra with the Cliff House Sandstone, although later authors, including Dane, have agreed with Reeside, e.g., Dane and Bachman (1957). My evaluation of the Chacra sandstone member is that it represents for the most part marine beach and nearshore sand environments, with abundant *Calianassa* burrows, with land lying to the south. The beach, running essentially east-west, where the Chacra sandstone member accumulated, was interrupted to the east by the La Ventana delta.

Need to Revise Nomenclature to Reinstate the La Ventana Formation

Because of the confusing variety of references to the La Ventana sandstone member, La Ventana formation, La Ventana Tongue of the Cliff House Sandstone, La Ventana facies and because of different correlations of strata in the La Ventana area with various stratigraphic units such as the Menefee,

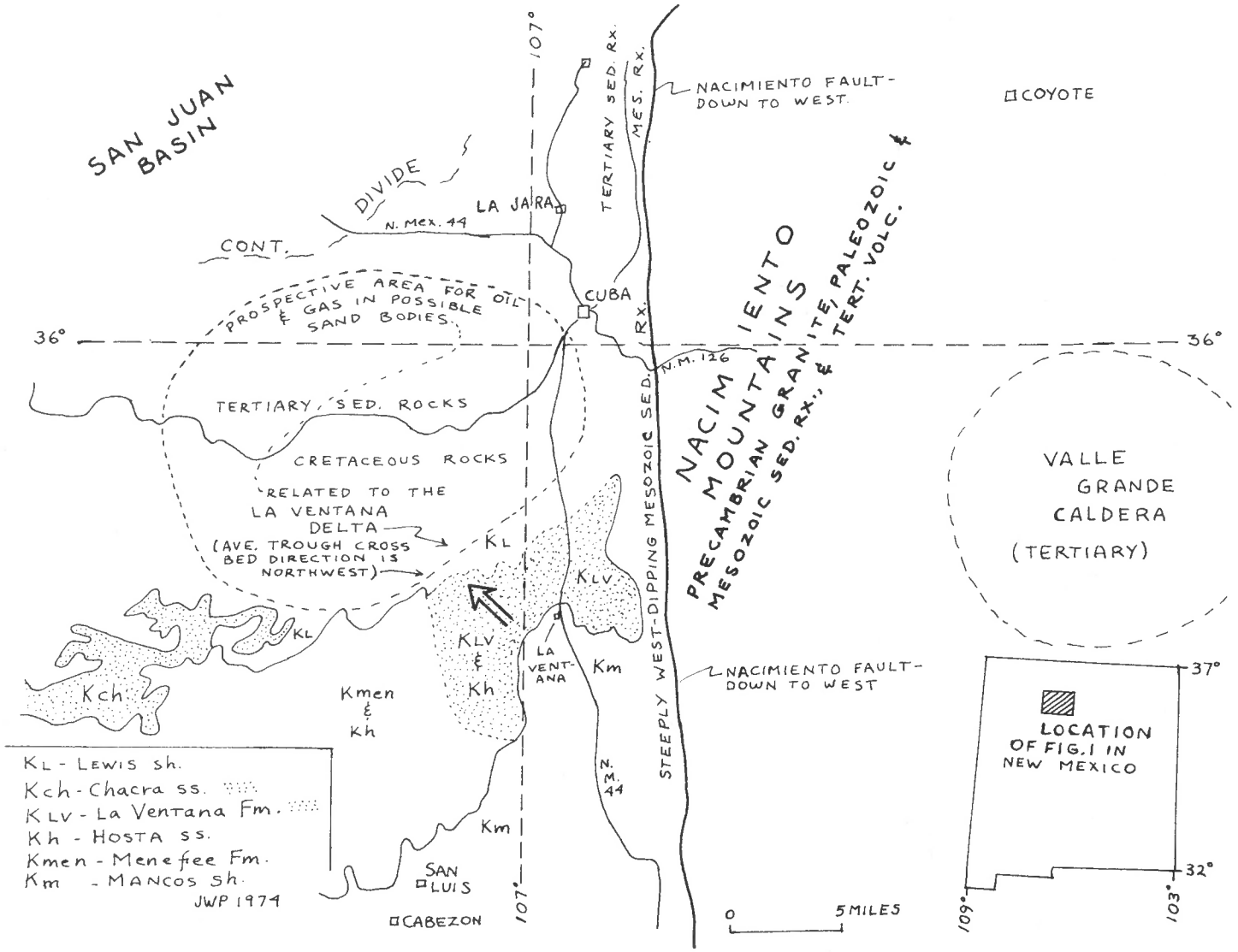

Figure 1. Index map showing the study area near La Ventana, New Mexico. Note area delineated by dashed line northwest of La Ventana which indicates the probable location of subsurface, lenticular sandstone bodies.

Allison-Gibson, Point Lookout and Cliff House Sandstones, etc., it is best to revert to a part of Dane's (1936) nomenclature which described the La Ventana sandstone member of the Mesaverde Formation as the predominantly sandy, but also coaly and thick shaly strata. In fact Dane's diagram, Plate 41, facing p. 90, redrawn as Figure 3, shows stratigraphic relationships with which the present study is in general agreement, except for the well-defined contact between the La Ventana sandstone member and the Allison Member. The Allison-La Ventana contact is really an interfingering contact; this is true of all contacts in the La Ventana area.

The evidence cited below for a source to the southeast for La Ventana clastics helps to explain why these strata have been difficult to correlate with the stratigraphic scheme for the rest of the San Juan Basin, which probably had westerly and southwesterly source areas. Sears, Hunt and Hendricks (1941, p. 108) and Weimer (1970, p. 27) also show west and southwest sources. Maps of Upper Cretaceous paleoenvironments in the *Geologic Atlas of the Rocky Mountain Region* (Mallory, 1972, Figures 37, 39, 40, 44 and 45, pp. 216-222) show land areas as sources of detrital sediments only to the west and southwest. The chances are that sediment influx from a southeastern land source would not coincide with that from other land areas, and that only major regional sea level fluctuations would make their effect felt simultaneously both in the La Ventana delta area and throughout the greater San Juan Basin environs. Probably the Hosta Sandstone Member and Main sandstone member (named below) of the La Ventana formation record such a major regression and transgression, respectively.

It is my intention to reject most of the correlations that have been made in the La Ventana area because all of the sedimentary units between the Mancos and Lewis shales are true lithosomes, in the sense of having intertonguing relationships with adjacent rock masses of different lithology, as described by Krumbein and Sloss (1953, p. 301), and are best defined genetically as deltaic strata belonging to a single formation (the La Ventana formation), which in turn belongs to the Mesaverde Group.

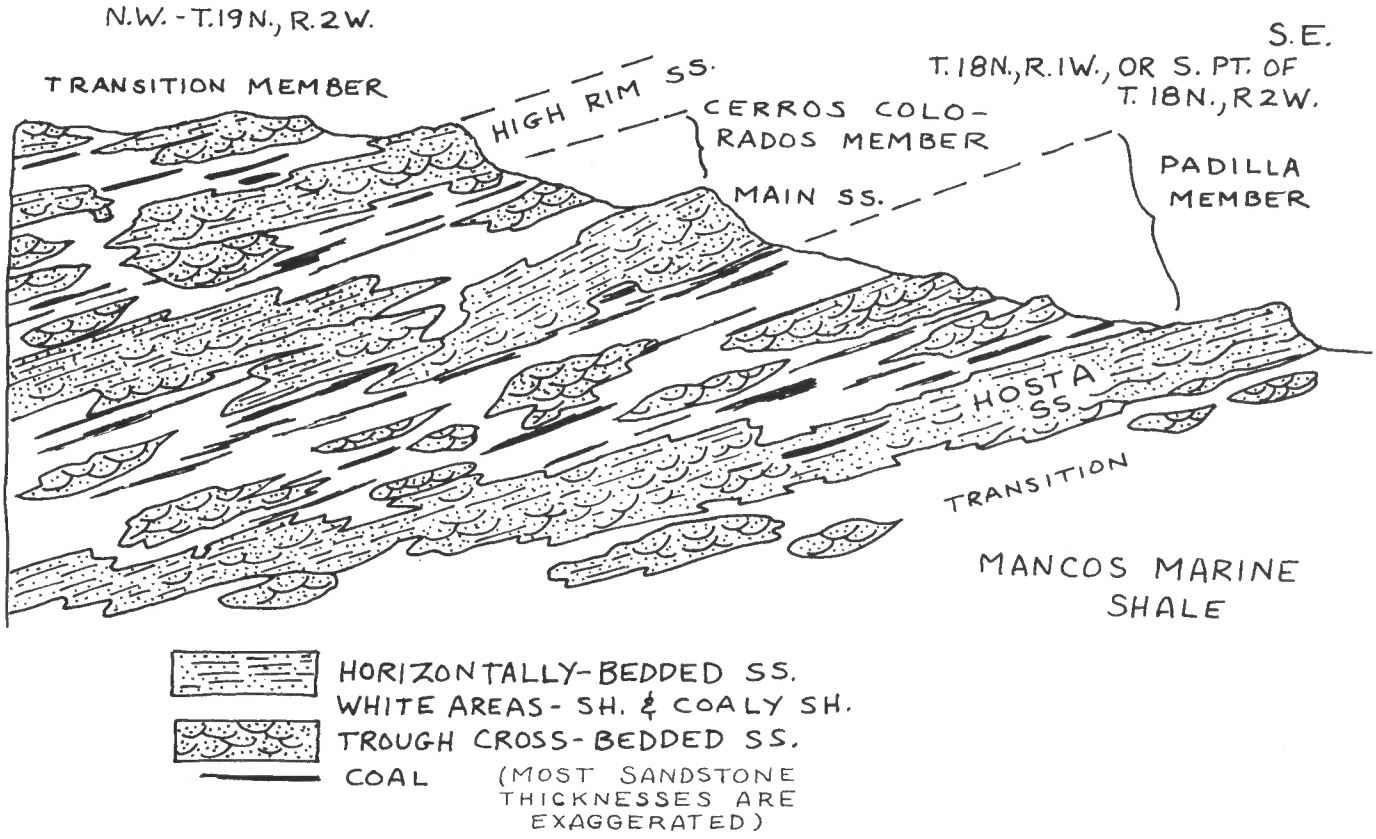

Figure 2. Composite, diagrammatic cross section of the La Ventana formation at La Ventana, New Mexico. Cross section is not to scale but shows approximately 1000 feet of strata over a map distance of 6 to 8 miles.

Nature and Definition of the La Ventana Formation

Because of the intertonguing relationship of all of the strata in the La Ventana area, between the Mancos Shale at the base of the section which intertongues with the Hosta Sandstone Member, to the Lewis Shale which intertongues with the strata above the Hosta, I consider all of the sandstone, shale and coaly beds between the Mancos and the Lewis in the La Ventana area to be the La Ventana formation. The unity of the formation resides in its origin as an extensive pile of sediments derived from deltaic distributaries and their included marsh, pond and channel sedimentary facies; the result of a northwesterly-flowing river joining the Cretaceous sea immediately to the north and northwest of the map area of Figure 4. For convenience in mapping, the La Ventana formation is subdivided into members shown on Figure 2. From the base upward these are: the Hosta Sandstone Member, the most extensive of the La Ventana lithosomes. Dane (1936, p. 95) noted cross-bedded sandstones interbedded with shale, sandy shale and sandstone with abundant small plant fragments in the upper 56 feet of the Mancos Shale immediately below the Hosta Sandstone Member. The present study found some of these to be trough cross-bedded sandstones. The Padilla member (new unit) is named for the old Padilla camp in Sec. 32, T. 19 N., R. 1 W., where these beds are well exposed. Figure 5 shows trough cross-beds in a white sandstone along with a hewn-wood trough near the Padilla cabin. The Main sandstone member (new unit), which is the thickest (about 200 feet maximum) sandstone in the La Ventana area caps La Ventana Mesa and helps support the prominant southeast-facing cliff shown by a hachured line in T. 18 N., R. 2 W. on Figure 4. This unit contains some marine fossils in its northern extension (see section on fossils below). The Cerros Colorados member (new unit) is named for good exposures in the southwest part of T. 18 N., R. 2 W. (although the member is thicker in the southeast part of T. 19 N., R. 2 W.). The High Rim sandstone member (new unit) caps the prominent cliff at Colorados, Section 15, T. 18 N., R. 2 W. The Transition member (new unit) grades into the Lewis Shale to the north and into the Allison-Gibson or Menefee to the west. All of these members intertongue with adjacent members.

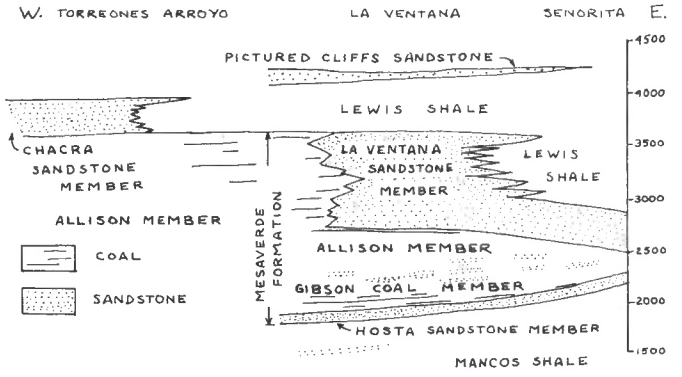

Figure 3. Schematic cross section modified from Dane (1936). Changes needed to fit concept of this paper are to substitute La Ventana formation for Mesaverde Formation and change member names as shown in Figure 2.

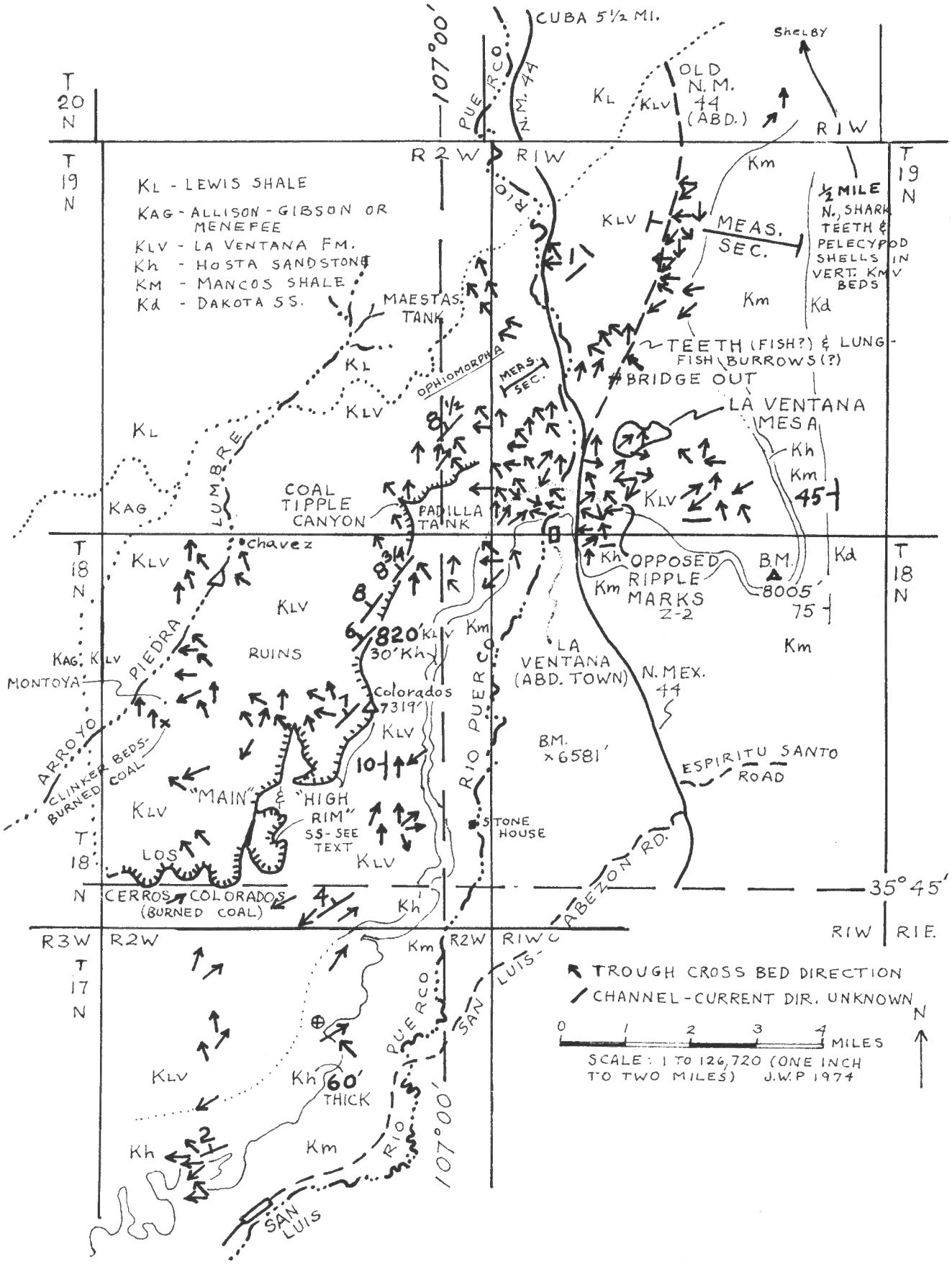

Figure 4. Geologic map of the La Ventana delta area showing trough cross-stratification paleocurrent directions through the 1000 feet of La Ventana strata.

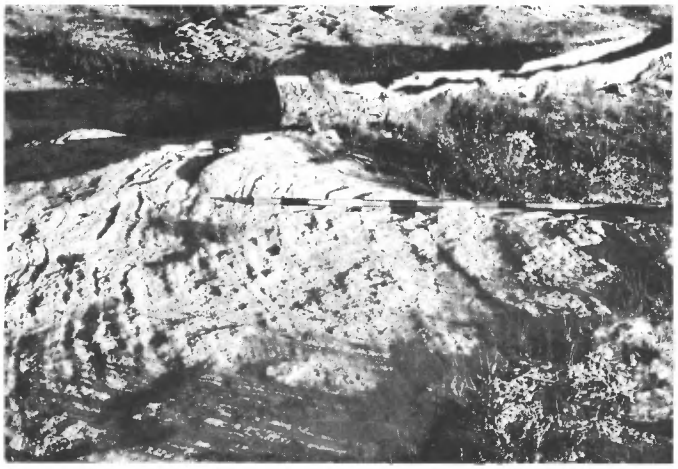

Figure 5. Hand-hewn and cross-stratified trough, Padilla camp, Sec. 32, T. 19 N., R. 1 W. Staff with divisions in decimeters points in dip direction.

Figure 6. Ophiomorpha *in High Rim sandstone member, northern part of La Ventana area.*

Evidence for the Delta

Although most of the clastic material for the Mesaverde rocks of the entire Rocky Mountain area was undoubtedly brought to the sea by rivers, no clear set of deltaic features is found in the San Juan Basin area Mesaverde except the La Ventana formation, where as early as 1950 the road log committee (C. B. Read, Chairman) of the New Mexico Geological Society noted striking foreset beds (in sandstone) in the southeast quarter of Section 20, T. 19 N., R. 1 W., along the old route of New Mexico Highway 44 (Kelley, 1950, p. 20). Such foreset beds are rare in the La Ventana area, but channel sandstones are abundant, and many outcrops show coaly shales, shaly sandstones and planar-cross-bedded sandstones interfingering with trough and festoon cross-bedded sandstones. These facies are believed to represent inter-distributary swamps; flood plains and natural levees; point bar and bar-finger sand deposits; and channel-fill sands, respectively, of a paleodelta. Trough cross-stratified sandstones are more numerous than the planar variety, so relatively straight channels, rather than meanderine ones, probably prevailed, using the criteria of Moore (1966, p. 96).

The rocks at La Ventana are characterized by: (1) few fossils overall; (2) very few heavy mineral bands in the sandstones (although heavy and dark minerals are commonly disseminated throughout the sandstones; (3) carbonaceous debris and some shale-pebble conglomerates; (4) occasional current and very scarce symmetrical ripple marks; and (5) sandstones with predominantly trough cross-stratification, although horizontal bedding and planar cross-bedding are also present. Potter (1967) discusses evidence for alluvial sandstones of many types, including deltaic ones; many of the sedimentary features listed above fit his criteria. A few rock units, namely the Main and High Rim sandstones, contain *Ophiomorpha* (fig. 6) usually considered nearshore marine sandy beach indicator, the burrow of the shrimp *Callianassa*), but this apparently only records brief marine transgressions from the north or northwest, and no other indisputable beach indicators are evident. *Ophiomorpha* is found only in the north and northwesterly part of the area; all the rest of the La Ventana formation appears to be completely continental. The presence of barrier-bar sandstone complexes at La Ventana has been suspected, but diagnostic features such as bays or lagoons, washover fans, heavy mineral bands and other beach features are absent. The possibility of barrier-bar sandstones in the subsurface northwest of the La Ventana area is a distinct possibility, however, and such sand bodies might serve as oil and gas traps.

Stream-Direction Indicators

Trough cross-stratification (McKee and Weir, 1953) is the predominant type of cross-bedding of the sandstones at La Ventana; festoon cross-beds, a variety of the trough type, in which each succeeding trough truncates other troughs, are common at La Ventana. Most of the kinds of cross-stratification shown by Allen (1955, p. 115) apparently occur at La Ventana, but his larger and smaller trough cross-stratified sets, which he considers to be formed in river channels by migration of asymmetrical ripple marks, predominate. Reineck and Singh (1975, p. 269) say that the most common sediment structure found in deltaic distributary mouth bar deposits is trough cross-bedding.

High and Picard (1974) state that troughs are the best cross-stratification type of paleocurrent indicators, compared with other types of cross-stratification. The arrows that show paleocurrent directions on Figure 4 are for the most part average directions from measurements of many trough cross-beds in a particular area; only measurements considered reliable are shown. Some channel sandstones were observed which gave clear indication of channel direction in either of two ways 180° apart, but the current direction was unknown. These are shown as lines without arrowheads on Figure 4. Figures 7-9 show cross-stratified sandstones of the La Ventana formation.

A Gypsum-Coal Association Puzzle

Bedded gypsum, unquestionably in place, occurs in the eastern part of Section 17, T. 19 N., R. 1 W., near a coal seam about five feet thick. The gypsum beds are thin (1-2 centimeters) and lenticular, although some layers occur over several tens of feet and conform to the bedding of the shale

Figure 7. Festoon cross-strata in Padilla member, sec. 11, T. 18 N., R. 2 W. View south toward Cabezon Peak.

Figure 8. Festoon cross-stratification in light tan and white sandstone of the High Rim sandstone member in sec. 14, T. 18 N., R. 2 W. Iron stake (center) is 6 ft long.

Figure 9. Small-scale trough cross-stratification in Transition member where La Ventana formation intertongues with Lewis Shale near Maestas Rock tank (sec. 13, T. 19 N., R. 2 W.).

beneath the coal. In view of the coals, coaly shales and trough cross-bedded sandstones that are associated with the gypsum, an evaporite bed even of limited extent seems unlikely, nor does the gypsum appear to be a secondary, ground-water-formed layer. Perhaps the explanation is that the gypsum is the result of rapid erosion of the Jurassic Todilto Formation, which has thick gypsum beds, from a nearby uplifted and eroded eastward or southerly source during the Late Cretaceous. (Todilto gypsum crops out to the south of La Ventana at the present.)

Cone-in-Cone Limestones

At several localities limestone beds occur in the La Ventana formation. They are lenticular (100 feet or less in lateral extent), thin (1-2 inches to a maximum of 6 inches thick), and always show well-developed cone-in-cone structure (fig. 10). No fossils have been found in these clayey limestone beds (18.5% clay, 81.5% $CaCO_3$) which suggests small freshwater ponds in which marly limestone formed. Cone-in-cone limestone beds can be seen in Coal-Tipple Canyon in Secs. 13 and 36, T. 19 N., R. 2 W. However, outcrops of these units are poor in that the weathered limestone is either scattered about on the surface, or in an arroyo bottom. The cone-in-cone structure probably resulted from initial compaction, or formed later when the rocks were tilted basinward.

FOSSILS

Leaf fossils (fig. 11) were found as impressions in sandstones just north of the town of La Ventana and in ironstone concretionary beds among shales and coaly shales in several localities, but best in Sec. 9, T. 19 N., R. 1 W. *Ophiomorpha*, the burrows of the shrimp, *Calianassa* and concentrations of pellets (fig. 12) are locally common in the Main and High Rim sandstone members in the northern part of the area. Broken pelecypod shells are found rarely in the Main sandstone member in the northern part of the La Ventana area.

An intriguing fossil (?) occurs in the northeast corner of Sec. 20, T. 19 N., R. 1 W., where many large (up to 2 feet long and 0.5-1.0 foot in diameter) tubular brown pipe- and gourd-shaped cavities occur in the Main sandstone member; many

Figure 10. Cone-in-cone limestone bed exposed in arroyo in sec. 36, T. 19 N., R. 2 W.

Figure 11. Plant fossils in ironstone concretions (sec. 9, T. 19 N., R. 1 W.). Willow, ginkgo and magnolia(?) are tentatively identified.

appear to have had an entry passage and a living chamber (fig. 13). A careful search revealed tooth and bone fragments generally near intraclasts of flat, rounded claystone up to 1 inch in diameter associated with the features. A fish scale was found embedded in the wall of one of them. These structures may be only concretions; could they be lungfish burrows?

On the Niel Shelby ranch at San Pablo, T. 20 N., R. 1 W., shark teeth and abundant pelecypod shells are found in undifferentiated Mesaverde sandstone beds associated with coals and dark shales. Clam shell impressions are found in the lower part of the Hosta Sandstone Member in Sec. 2, T. 18 N., R. 1 W. A few elongate *Ostrea* occur in the upper part of the Hosta in Sec. 5 of the same township.

ECONOMIC CONSIDERATIONS

Figure 1 shows an outline of the area considered prospective for stratigraphic traps for oil and gas in offshore bars and distributary sandstones.

Figure 12. Fecal pellets(?) or castings made up of 2 mm spheres accreted into balls about 2 cm in diameter, associated with Ophiomorpha *(perhaps represent excavated* Callianassa *burrows?). In High Rim sandstone member, Sec. 4, T. 18 N., R. 2 W. Decimeter divisions on staff.*

Figure 13. Lungfish (?) burrow in Main sandstone member, Sec. 20, T. 19 N., R. 1 W. Decimeter divisions on staff.

THE TOWN AND THE WINDOW, LA VENTANA

According to the late Joe Marchetti, the storekeeper at La Ventana during the coal-boom days of the 1920's and 1930's, the La Ventana window was a natural arch in the Hosta Sandstone in Sec. 5, T. 18 N., R. 1 W. (where a rest area on Highway 44 is presently located), but was dynamited by the coal miners when La Ventana was a "boom" town (no "pun"). The town prospered while a Santa Fe Railroad spur from the north was operating, but the change to oil-fired engines rapidly turned La Ventana into a ghost town.

ACKNOWLEDGEMENTS

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