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GRAND JUNCTION EXPLORATION BRANCH

GEOLOGY AND URANIUM DEPOSITS OF THE LUCERO UPLIFT VALENCIA, BERNALILLO, AND SANDOVAL COUNTIES

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ABSTRACT

The Lucero uplift in northwest New Mexico is over 1,100 square miles in area. As a result of geologic investigations and mapping during 1952, certain conclusions can be drawn.

After an uplift during late Triassic, the positive area remained low until Morrison time.

The margin of the basin was relatively constant throughtout Jurassic time.

The Jurassic pinchout is due primarily to onlap onto the positive area and secondarily, to pre-Dakota erosion.

It is believed the Lucero uplift is the result of vertical movement of blocks along deep-seated faults.

There are two known uranium localitities in the Lucero uplift, one in the northeast and the other in the west-central area. Uranium mineralization appears to be concentrated in the vicinity of the structural corners.

INTRODUCTION

The Lucero uplift covers over 1,100 square miles in northwest New Mexico (fig. 1). The Jurassic rocks outcrop as a crescent-shaped area of 300 square miles and extend from the northeast to the southwest side of the uplift. Paleozoic rocks are on the east and southeast; the Chinle formation of Triassic age forms a large valley in the middle of the uplift; and the Dakota sandstone of Cretaceous age crops out as a cuesta nearly encircling the area and is arbitrarily employed as an outline for the uplift.

A geologic map of the Lucero uplift was prepared between June 30 and September 11, 1952 to aid in the investigation of uranium in the Jurassic rocks of the area, and also some rim examination for radioactivity was accomplished. The field information was recorded on aerial photographs (scale 1:62,500) and later transferred to U. S. Soil Conservation Service planimetric maps (scale 1:31,680).

Darton (1928) prepared a geologic map of an area which included the Lucero uplift in 1928. Hunt (1936) classified the youngest Jurassic units under the general name "Morrison formation" in his geologic map which extended into the northeast corner of the Lucero uplift. Kelly and Wood (1951) divided the Jurassic into Entrada and Morrison formations on their oil and gas map which covered the eastern margin of the Lucero uplift. The southeastern part of the generalized isopach maps prepared by Craig and others (1951) include the northern portion of the Lucero uplift.

The co-operation of the Anaconda Copper Mining Company was very helpful in mapping the area. Acknowledgment is due Dr. V. C. Kelley of the University of New Mexico, R. H. Wilpolt and P. E. Melancon of the Atomic Energy Commission for their constructive criticism of the report. Discussions with A. K. Gilkey and access to the field data compiled by R. W. Duschatko, both with Columbia University, contributed materially to the report.

GEOLOGY

STRATIGRAPHY

The Jurassic formations are described in stratigraphic sections listed in the appendix.

Sedimentation

Several features of the Jurassic sedimentation in the Lucero uplift are revealed by the fence diagram (fig. 2). Formational contacts from upper Chinle to lower Morrison are generally gradational. The Jurassic sediments are usually relatively fine-grained up to the Morrison formation which consists of coarse-grained sandstones.

The Jurassic sediments thin, become finer, and more angular-grained toward the south. There the Dakota sandstone of Cretaceous age rests directly on the Chinle formation of Triassic age. The Summerville shale and Carmel mudstone units grade southward into siltstones and very fine-grained sandstones. The Bluff and Entrada sandstones, which are sweeping crossbedded units in the northern half of the uplift area, grade southward into essentially interstratified parallel-bedded; and very low-angle cross-bedded units.

The Wingate, Carmel, and Todilto formations pinch out within a mile of each other (between secs. 14 and 15). The Morrison is believed to lens out farther north due to pre-Dakota erosion.

Ten miles south (between Secs. 16 and 17) the Summerville formation and Entrada sandstone grade into the Bluff sandstone. The Bluff, a very fine-grained sandstone unit, rapidly thins out completely within several miles. All the Jurassic formations in this area merge in one general locality.

The resistant Todilto limestone forms a bench upon which the overlying gypsum member is exposed as mounds. The elevation of the top of these mounds is commonly much higher than the overlying Summerville contact. It is believed that this is the result of hydration.

A common occurrence are sandstone pipes which are generally cylindrical and sometimes stand 100 feet high. These fingers of massive sandstone usually begin in the lower Bluff sandstone and pass vertically downward through the Summerville formation. Within the pipe the typically corrugated Summerville beds are either absent or are completely distorted. At both sides of the pipe, the Summerville beds are bent down as though by drag. It is believed that the sandstone pipe represents pene contemporaneous collapse due to flowage of the underlying gypsum.

STRUCTURE

The geologic map (fig. 3) reveals that for about thirty miles, from approximately 107° 07' longitude to the McCarty syncline, the sediments dip gently west. Deformation is almost entirely restricted to a narrow fault zone extending over 125 miles from Rio Salado to Nacimiento and the San Pedro Mountains. A part of this fault zone appears on the geologic map. Within this mile-wide belt the sediments dip abruptly and steeply east. The fault zone is essentially a deep-seated vertical fault which does not extend to the surface. The west wall has moved up relative to the east and produced a monocline.

Along the east side of Mesa Gigante the fault zone consists of numerous parallel faults in the east-dipping monocline. It appears that the east walls of these faults have been displaced upward.

In the Mesa Redonda-Suwanee Peak area, about ten miles south, the fault zone contains many small faults believed to be sympathetic to the several major faults in the area.

Structural deformation is absent west of the fault zone. Here the Todilto and Dakota rims are outstanding features. The rims exhibit blocking due to fracturing in perpendicular north and east directions. The following factors suggest that the north trending fractures are the major ones:

1. The outcrop belt from near the village of Paguate to south of Old Laguna contains many north trending basic dikes and sills (Two known uranium localities in the uplift area occur within this zone).

2. The north trend along the west side of Mesa Gigante contains a plug, a large dike, and a sill.

3. The north trend, which forms the east margin of the uplift, is a zone of many north-trending faults and some volcanic activity.

As a result of this detailed study of the fracture pattern of the Zuni uplift, some thirty miles northwest of the Lucero uplift, A. K. Gilkey (1953) considered the Zuni structure as resulting from vertical uplift of blocks bounded by deep-seated faults over which the upper sediments were draped. It is believed that the Lucero uplift was the response to a similar mechanism. Evidence from both the relatively undeformed gently dipping area and the east margin fault zone, suggests uplift resulted from vertical movement of blocks along deep-seated faults.

GEOLOGIC HISTORY

A late Triassic uplift in west-central New Mexico and central Arizona caused deposition of the Shinarump conglomerate and Chinle formations and formed the Navajo highland. It is believed that recurrent vertical movement of pre-existing deep-seated faults caused the uplift of the Navajo Highland, which is a series of blocks of which the most eastern is the Lucero block. This hypothesis is based largely upon the fact that isopach and structure maps of Paleozoic and Mesozoic sedimentation show the area under consideration to be continuous with a positive area in northeastern-central Arizona. Also, the isopach contours of the positive areas are rectangular.

Movement of the various blocks was independent. This is responsible for the rapid facies changes along the Jurassic outcrop rim and the variance in conformity of contacts at different places. An unconformity was observed at the base of the Carmel along the Defiance monocline which is not present in the Lucero uplift.

The Lucero block was elevated during late Triassic. The relatively thin Jurassic section and the large proportion of the finer sediments suggest that this block was the least elevated of the many comprising the highland. From late Triassic until Morrison deposition, the Lucero block remained low and quiescent, contributing the fine sediments to the basin primarly during fluviatile periods. This type of sedimentation alternated with deposition of eolian sands. Though no study has been undertaken of cross-bed orientation, it is thought that much of the eolian sands in the Lucero uplift were brought in by the prevailing west winds rather than derived directly from the Lucero block. Extreme changes in climate are represented by the Todilto limestone and gypsum.

The water-laid sands of the upper Entrada are indicative of widespread fluviatile conditions which resulted in the formation of a large body of standing water in the central basin. As an arid environment set in, the balance between evaporation and inflow of alkaline waters resulted in the precipitation of limestone and gypsum which now comprise the Todilto formation.

Shortly after Morrison deposition began, uplift of the Lucero block recurred with resulting coarse sandstone units being included in the predominantly shale sequence. This uplift continued intermittently until the close of the Jurassic. There appears to have been a hiatus which removed some uppermost Morrison units. There followed regional tilting to the north and the Dakota was deposited unconformably upon the Jurassic. Though local scours along the contact zone are sometimes visible, the angular unconformity is best noted in the Dakota truncating successively older rocks southward. The Cretaceous sea moved in with repeated transgressions and regressions, leaving behind an intertonguing sequence of sandstones and shales over the entire area.

The vertical movement of blocks, which resulted in the Lucero uplift, probably began during late Cretaceous or early Tertiary time and continued slowly and recurrently until its culmination in late Tertiary.

URANIUM DEPOSITS

There are two known uranium localities in the Lucero uplift, one in the northeast and the other in the west-central part of the uplift area. Both mineralized areas lie within the Laguna Indian Reservation and were developed by the Anaconda Copper Mining Company. Anaconda has exclusive prospecting and mining rights on the Laguna Pueblo land.

The most important deposits in the uplift area is the Jackpile ore body which occurs in the Westwater sandstone member of the Morrison formation.* The ore body lies in Sec. 2, T 10 N, R 5 W and the adjoining Sec. 35, T 11 N, R 5 W. The ore body is located at the intersection of two rim directions (fig. 3); from the Jackpile one rim extends eastward and the other southward. Approximately twelve other mineralized outcrops have been reported within a two mile radius of this main ore body. Since the discovery of this ore body by an airborne radiometric survey, Anaconda has delineated about 40,000 tons of ore by dry hole and diamond drilling.

The second uranium locality, where the deposits occur in the Todilto limestone, is about 12 miles south of the Jackpile. The best deposits, which lie in Sec. 8, T 8 N, R 5 W and Secs. 27, 28, 33 and 34, T 9 N, R 5 W, are also coincident with an abrupt change in rim direction from south to east. It is suggestive that the most promising uranium mineralization in the uplift occurs on structural corners similar to the major uranium localities of the Zuni uplift which also seem to occur near a structural corner. It would seem that this phenomenon is worth consideration in future uranium prospecting.

* Since this report was written the unit containing the Jackpile ore body is considered to be in the Brushy Basin shale member of the Morrison formation. See figure 4 for details of the Morrison formation.

CONCLUSIONS

The study of the Jurassic sedimentation in the Lucero uplift, indicates that the source area which lay to the south remained low and quiescent until lower Morrison time. The Jurassic formations either merge or pinch out in the same area, which suggests that the margin of the basin remained relatively constant throughout Jurrassic time.

Deposition occurred under a climate which fluctuated between arid and semi-arid. Much of the eolian sands present are believed to have been brought in by west winds.

The Lucero uplift is part of a large positive element discernable on pre-Jurassic isopach maps. This positive element has remained fairly constant despite varying amounts of uplift in different parts.

Other uranium deposits of major significance are unlikely in the Lucero uplift. The two known uranium bearing horizons, the Todilto limestone and the Morrison formation, pinch out about the middle of the uplift area. Southeast from the south Laguna deposits the Todilto limestone becomes argillaceous and unfavorable for uranium deposition. However, the Morrison formation is more promising.

The basal sandstone unit of the Dakota is locally replaced by a black carbonaceous shale which contains some anomalies but no commercial uranium deposits.

The Paleozoic limestones along the eastern margin of the uplift and the spring deposits common in the area have been checked with no encouraging results.

A relationship between "structural corners" and uranium mineralization appears to exist. Two structural corners exist in the area northeast of the Lucero uplift, one near Jemez crater, the other west of Taos, New Mexico.

The Cochiti and Petaca mining districts are within thirty miles of these corners. These appear favorable areas for expanding the search for uranium in the northern part of the Grants district.

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DESCRIPTION OF MEASURED SECTIONS

SECTION 1: East Mesa Redonda--Section measured on the main projection on the east side of Mesa Redonda; top of section starts in Dakota sandstone in NW corner of NE¼ NE¼ Sec. 23, and continues eastward into NW¼ NW¼ Sec. 24, T.8N., R.3W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: basal, white, fine grained, rounded, well sorted, well cemented, hard, resistant; contains coarse scour zones up to 6 inches thick.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: Incomplete, 499 feet thick.		
Morrison formation: 82 feet thick.		
Recapture Creek shale member:		
7. Mudstone: purple in lower part, pale green in upper; (almost all talus-covered)................................	82	499
Bluff sandstone: 248 feet thick.		
6. Sandstone: upper unit: white to light-brown, very fine grained, subrounded, well sorted, cross stratified; with limonite specks; kaolinization in specked areas; locally, hematite nodules abundant................................	126	417
5. Sandstone: lower unit: yellow-white, very fine grained, subrounded, well sorted, parallel stratified; with cross stratified units in upper part.........	122	291
Summerville formation: 87 feet thick.		
4. Mudstone: maroon, with interbedded maroon and yellow beds of siltstone....	87	169
Todilto formation: 72 feet thick.		
3. Gypsum: white, swollen, pure...........	50	82
2. Limestone: dark gray, recrystallized, in very thin beds which give "shaly" appearance............................	22	32

	Feet	Cumulative Feet
Entrada sandstone: Incomplete, 10 feet thick.		
1. Sandstone: white, limy, very much weathered; (only top part visible)......	10	10

Valley: (covered by alluvium).

SECTION 2: 6.7 miles S.60°E. of Correo--Top of section starts in the Dakota sandstone in SE¼ NW¼ SW¼ Sec. 20, and continues SSE into SW¼ SE¼ SW¼ Sec. 20, T.8N.,R.2W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: as described in Section 1, except for light-brown color.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: Incomplete, 343 feet thick.		
Morrison formation: 129 feet thick.		
Westwater Canyon sandstone member:		
9. Sandstone: white, fine grained to very coarse grained, rounded to angular, poorly sorted, poorly cemented; with limonite..................................	5	343
Recapture Creek shale member:		
8. Mudstone: green, and white; purple in lower few feet............................	44	338
7. Sandstone: white, fine grained, rounded, well sorted, very low angled cross stratified; contains coarse sand zones..	3	294
6. Mudstone: purple.........................	37	291
5. Sandstone: similar to unit 7; with green shale seam 5 feet above base; lower few feet contains zones of coarse to very coarse sand, and small pebbles..........	13	254
4. Mudstone: purple, and light green.......	27	241
Bluff sandstone: 204 feet thick.		
3. Sandstone: upper unit: white, fine grained, subrounded, well sorted, cross stratified; locally, hematite nodules occur near top..........................	108	214
2. Sandstone: lower unit: light-tan to brown, fine to medium grained, rounded to subangular, poorly sorted, predominantly parallel stratified.............	96	106
Summerville formation: Incomplete, 10 feet thick.		
1. Mudstone and siltstone: interbedded dark red mudstone to siltstone and dark red weathering yellow-tan siltstone to very fine grained sandstone; (only top part visible)	10	10

Valley: (covered by alluvium)

SECTION 3: SE Suwanee Peak Butte--Section measured on the rim on the SE side of Suwanee Peak Butte; top of section starts in Dakota sandstone in the SW corner of SW¼ NW¼ SW¼ Sec. 1, and continues SW into the SW corner of SW¼ SE¼ Sec. 2, T.8N.,R.3W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: white, very fine grained, rounded well sorted, well cemented, hard, resistant, "clean" sandstone; coarse scour zones up to 2 inches thick; limonite coloration above 5 foot level; light-gray siltstone interbedded; strike N. 40°W., dip 7°NE.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: Incomplete, 460 feet thick.		
Morrison formation: 115 feet thick.		
Recapture Creek shale member:		
10. Mudstone: pale green, and white........	78	460
9. Sandstone: similar to unit 7...........	5	382
8. Mudstone: pale green...................	11	377
7. Sandstone: white, very fine grained, subangular to subrounded, low angle cross-stratified; with pale green mudstone from 3-7 feet above base of sandstone..	21	366
Bluff sandstone: 198 feet thick.		
6. Sandstone: upper unit: white, fine grained, rounded, well sorted, poorly cemented, cross stratified; locally hematite nodules occur near top........	124	345
5. Sandstone: lower unit: white to tan, very fine grained, subrounded, well sorted, parallel stratified and cross stratified	74	221
Summerville formation: Incomplete, 40 feet thick.		
4. Mudstone and siltstone: red, gray, interbedded; (base not visible); strike N.35°W, dip 4.5°NE...........................	40	147
Todilto formation: 35 feet thick.		
3. Gypsum: white; (spring deposits cap part of the Todilto exposure)...............	30	107
2. Limestone: light gray, platy, finely crystalline, recrystallization.........	5	77

	Feet	Cumulative Feet
Entrada sandstone: Incomplete, 72 feet thick.		
1. Sandstone: red-brown, fine grained, rounded, cross stratified; upper 15 feet bleached white; (base not visible)................................	72	72

Valley: (covered by alluvium).

SECTION 4: 4.5 miles N.9°E. from Correo Overpass to Dakota sandstone rim on SE projection of Mesa Gigante--top of section starts in Dakota sandstone in SW¼ NE¼ SW¼ Sec. 9, and continues SSE through E½ W½ Sec. 16, into NW¼ SW¼ NE¼ Sec. 21, T.9N.,R.3W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: basal, white, medium to coarse grained; with interbedded sandstones and dark shales overlying.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: 801 feet thick		
Morrison formation: 180 feet thick		
Recapture Creek shale member:		
11. Mudstone: pale green; with several thin (1-3 feet thick), tan to white, medium to coarse grained sandstone lenses included..............................	146	801
10. Mudstone: maroon........................	10	655
9. Sandstone: white to tan, medium grained.	4	645
8. Mudstone: maroon........................	20	641
Bluff sandstone: 300 feet thick.		
7. Sandstone: upper unit: gray-white, fine grained, subrounded, well sorted, moderately cemented, cross stratified......	140	621
6. Sandstone: lower unit: red-brown, fine grained, subrounded, well sorted, well cemented, parallel stratified; with some low angle, cross stratified units in the upper part......................	160	481
Summerville formation: 57 feet thick.		
5. Mudstone: red-brown; with interbedded red-brown, and white, thin (1-4 feet thick) beds of siltstone to very fine grained sandstone occurring mostly in the upper part.........................	57	321
Todilto formation: 99 feet thick.		
4. Gypsum: white, swollen....................	90	264
3. Limestone: dark gray, recrystallized; "crinkly" appearance; occurs in very thin beds (up to several inches thick)..	9	174

	Feet	Cumulative Feet
Entrada sandstone: 165 feet thick.		
2. Sandstone: white, bleached, essentially parallel stratified; upper half is very limy..............................	40	165
1. Sandstone: red-brown to orange-red, very fine grained, subrounded, well sorted, cross stratified.......................	125	125

Valley: (covered by alluvium).

TRIASSIC

Chinle formation:

Sandstones: gray, pink, and tan, coarse and medium grained; with interbedded red-brown, medium to fine grained, subrounded, low angle, cross stratified.

SECTION 5: 6 miles N.4°W. of Canoncito--Section measured on the south side of eastward projection of the rim; top of section starts in Dakota sandstone in the NW corner of SW¼ NE¼ Sec. 14, and continues SSE into NE¼ NW¼ SE¼ Sec. 14, T.11N.,R.3W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: (typical, as described in SECTION 4).		
UNCONFORMITY		
One of the few places where the angular unconformity, usually evident only on a regional scale, is observable.		
JURASSIC: Incomplete, 280 feet thick.		
Morrison formation: Incomplete, 280 feet thick.		
Westwater Canyon sandstone member:		
6. Sandstone: white, bleached, medium grained, subrounded, moderately sorted, poorly cemented, very low angle, cross stratified................	32	280
Recapture Creek shale member:		
5. Mudstone: pale green; gray near top.....	151	248
4. Sandstone: similar to unit 2............	22	97
3. Mudstone: maroon and purple............	5	75
2. Sandstone: tan, fine to medium grained, angular to round, poorly sorted, poorly cemented, low angle cross stratified; with small scour zones containing coarse grains; feldspar recognizable, less than 1%..........................	43	70
1. Mudstone: purple; with thin (6-12 inches thick), gray, dense, cryptocrystalline limestone units about 2, 12, and 22 feet above the exposed "base" of the mudstone unit, limestone unit at 22 foot level contains aragonite; with 2 foot thick white sandstone (similar to unit 2) occurring from 6 to 8 feet above the "base" of the mudstone; (base not visible)...........................	27	27

Valley: (covered by alluvium).

SECTION 6: 10.6 miles N.19°W. of Correo--Section measured in gully on west side of south-facing slope; top of section begins in Dakota sandstone in N½ NW¼ NE¼ NW¼ Sec. 14, and continues slightly east of south into SE¼ NW¼ SE¼ NW¼ Sec. 14, T. 10N.,R.4W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: basal, white, very fine grained, subrounded to subangular, well sorted, well cemented, parallel stratified, vitreous; interbedded sandstone and dark shale overlying.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: Incomplete, 457 feet thick.		
Morrison formation: 438 feet thick.		
Westwater Canyon sandstone member:		
13. Sandstone: white, medium to coarse grained, angular to subrounded, poorly sorted, poorly cemented, very low angle cross stratified; with some feldspar; about 40% kaolinization..............	59	457
Recapture Creek shale member:		
12. Mudstone: pale green; with several thin (up to 6 inches thick) gray, cryptocrystalline limestone beds included...	62	398
11. Sandstone: gray-white, very fine grained, angular to subrounded, poorly sorted, moderately cemented, low angle cross stratified; with less than 1% kaolinization............................	11	336
10. Mudstone: pale green; with lowest 6 feet being maroon.....................	24	325
9. Sandstone: gray-white, fine grained, subrounded, poorly sorted, moderately cemented, low angle cross stratified; with coarse, angular, poorly sorted sandstone in scour zones throughout...	21	301
8. Mudstone: pale green..................	52	280
7. Sandstone: gray-white, medium grained, subrounded, moderately cemented, moderately sorted, very low angle cross stratified and parallel stratified; very limy, very hard, very well cemented basal 1 foot................	11	228

	Feet	Cumulative Feet
6. Mudstone: pale green; with 1 foot thick, gray, arenaceous limestone 22 feet above base and several thinner limestone beds higher up in the mudstone.............	49	217
5. Sandstone: gray-white, medium grained, rounded to subrounded, moderately sorted, moderately cemented; with basal 4 feet a gray, fine to medium grained, subangular to subrounded, very well cemented, very limy sandstone; with several sill-like tongues of diabase up to 4 inches thick intruding the middle part................	17	168
4. Mudstone: maroon in lower part, grading into pale green in upper part.........	11	151
3. Sandstone: white, medium to fine grained subrounded to rounded, moderately sorted, parallel stratified and cross stratified; some feldspar recognizable; upper 30 feet is all cross stratified, and contains sandstone "concretions" and limonite nodules, and is underlain by thin seam of mudstone..............	108	140
2. Mudstone: purple; with thin (6-12 inches thick), blue-gray, dense, cryptocrystalline limestone which contains white, and black calcite crystals, and clusters of aragonite.........................	13	32
Bluff sandstone: Incomplete, 19 feet thick.		
1. Sandstone: white, fine grained, well sorted, clean, cross stratified; (only top part visible)...............	19	19

Valley: (covered by alluvium).

SECTION 7: 2 miles N.15°W. of Old Laguna--Section measured on the south end of a N-S elongated butte; top of section begins in Dakota sandstone in NW¼ NW¼ NW¼ Sec. 28, and continues SE to center Sec. 28, then continues SW into NW¼ NE¼ SW¼ Sec. 28, T.10N.,R.5W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: basal, gray to white, fine grained, rounded, well sorted, clean, hard, vitreous; with limonite staining; with interbedded sandstone and dark shale overlying.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: Incomplete, 432 feet thick.		
Morrison formation: 387 feet thick.		
Westwater Canyon sandstone member:		
19. Sandstone: white, very fine to medium grained, subrounded, moderately sorted, ill-defined low angle cross stratified; with much kaolinization; with lenses of coarse to very coarse grained, angular poorly sorted sandstone..............	103	432
Recapture Creek shale member:		
18. Mudstone: green and gray..............	21	329
17. Sandstone: tan, subrounded, fine grained, well sorted, low angle cross stratified	21	308
16. Mudstone: pale green....................	7	287
15. Sandstone: gray-white, very fine grained, subrounded, well sorted, silicified; with 1 foot thick crystalline limestone at base; with scour pockets of very coarse grained to pebbly, angular, poorly sorted, silicified sandstone and dinosaur bone fragments...............	10	280
14. Mudstone: green; with 1 foot thick gray, cryptiocrystalline limestone beginning 25 feet above the base of the mudstone	65	270
13. Sandstone: gray-white, fine grained, rounded, well sorted, hard; (thin, green mudstone seams divide sandstone into 3 units which all thin to nothing within 200 feet laterally)....................	10	205
12. Mudstone: pale green..................	27	195

		Feet	Cumulative Feet
11.	Sandstone: gray-white, fine grained, subangular, well sorted, silicified......	4	168
10.	Mudstone: pale green..................	16	164
9.	Limestone: gray, cryptocrystalline....	1	148
8.	Mudstone: purple, and light green.....	11	147
7.	Sandstone: yellow-brown, fine to very fine grained, subangular to subrounded, moderately sorted, poorly cemented, low angle cross stratified; with limonite coating grains, and less than 1% kaolinization; with lavender, finely crystalline, limestone lense (several hundred feet long, up to 2 feet thick) about 20 feet above the base of the sandstone............................	65	136
6.	Mudstone: pale green..................	5	71
5.	Limestone: gray, cryptocrystalline; with aragonite seams and clusters..........	2	66
4.	Mudstone: pale green; with 1 foot thick sandstone in middle..................	10	64
3.	Limestone: lavender, cryptocrystalline	1	54
2.	Mudstone: purple, shaly...............	8	53
Bluff sandstone:	Incomplete, 45 feet thick.		
1.	Sandstone: yellow-white, very fine grained, subrounded, well sorted, moderately cemented, cross stratified; (only top part visible)...............	45	45

Valley: (covered by alluvium).

SECTION 8: SE Projection of Wheat Mountain Mesa--Section measured on southern end of SE projection of Wheat Mountain Mesa, 1 mile NNW of Laguna; top of section begins in Dakota sandstone in NE$\frac{1}{4}$ SE$\frac{1}{4}$ NE$\frac{1}{4}$ Sec. 31, and continues SSE into center W$\frac{1}{2}$ SW$\frac{1}{4}$ Sec. 32, T.10N.,R.5W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: basal, white, fine grained, rounded, well sorted, clean, hard; with interbedded sandstone and dark shale overlying; basic sill occurs from 11 to 21 feet above base.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: Incomplete, 439 feet thick.		
Morrison formation: 409 feet thick.		
Westwater Canyon sandstone member:		
12. Sandstone: tan to white, channel deposit, with lenses of fine grained, rounded to subrounded, well sorted sandstone, and lenses of coarse grained to pebbly conglomeratic, rounded to subrounded, moderately sorted sandstone; predominant seam of light green mudstone up to 6 inches thick at 35 foot level; throughout the sandstone are light green mudstone stringers, seams, and clay galls; upper 30 feet is generally more fine grained, and has fewer coarse lenses...........	132	439
Recapture Creek shale member:		
11. Mudstone: light green; with 1 foot thick chalk gray, cryptocrystalline limestone from 32 to 33 feet above base; with 4 foot thick, white, fine grained, rounded, well sorted, parallel stratified (?) sandstone from 37 to 41 feet; with 1 foot thick purple, cryptocrystalline limestone from 53 to 54 feet; upper 4 feet of mudstone is purple............................	58	307
10. Sandstone: tan to white, fine to coarse grained, angular to rounded, poorly sorted, low angle cross stratified....	25	249
9. Mudstone: gray; with 1 foot thick limestone about 43 feet above base........	59	224

		Feet	Cumulative Feet
8.	Sandstone: white, very fine grained, subrounded, well sorted, low angle cross stratified........................	5	165
7.	Mudstone: white to pale green..........	51	160
6.	Sandstone: white, very fine to fine grained, subangular to subrounded, moderately sorted, parallel stratified; with light colored mudstone and siltstone interbedded......................	11	109
5.	Shale: purple; with thin lenses of sandstone................................	32	98
4.	Sandstone: tan, very fine grained, subrounded, well sorted, parallel stratified, limy............................	26	66
3.	Limestone: blue-gray, dense; with calcite crystals.......................	2	40
2.	Shale: red; with claystone (?).........	8	38
	Bluff formation: Incomplete, 30 feet thick.		
1.	Sandstone: yellow-white to tan, fine to very fine grained, subrounded, well sorted, cross stratified; (only top part visible)........................	30	30

Valley: (covered by alluvium).

SECTION 9: 7.5 miles N.30°E. of Acoma--Section measured on the north side of rim projection; top of section starts in Dakota sandstone in SE¼ SW¼ NE¼ Sec. 19, and continues SE into NW¼ NE¼ SE¼ Sec. 19, T.9N.,R.6W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: white, very fine grained, subrounded, well sorted, well cemented, hard, vitreous.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: Incomplete, 536 feet thick.		
Morrison formation: 89 feet thick.		
Recapture Creek shale member:		
7. Mudstone: light green, and light gray.	11	536
6. Sandstone: white, fine grained, subangular, well sorted, poorly cemented, low angle cross stratified; with scour zones up to 4 inches thick containing very coarse grained, angular sandstone; kaolinized throughout................	29	525
5. Mudstone: light green and purple......	27	496
4. Sandstone: gray, very coarse to coarse grained, angular, poorly sorted, poorly cemented, very low angle cross stratified; grades upward into white, very fine grained, subangular, well sorted, moderately cemented, very low angle cross stratified sandstone...........	22	469
Bluff sandstone: 329 feet thick.		
3. Sandstone: upper unit: gray to very light brown, fine grained, subrounded, well sorted, moderately cemented, cross stratified; with patches of limonite-stained sandstone; with hematite nodules sparsely distributed near top at places........................	129	447
2. Sandstone: lower unit: tan, very fine grained, subrounded, well sorted, moderately cemented, predominantly parallel stratified; with low angle cross stratified units averaging 5 feet thick interbedded, especially near top	200	318

	Feet	Cumulative Feet
Summerville formation: Incomplete, 118 feet thick.		
1. Mudstone: dark red-brown; with interbedded, white, very fine grained, subrounded, well sorted, massive sandstone in beds from 3-60 inches thick; upper 30-40 feet of formation is predominantly bedded sandstone units with thin mudstone interbedded; (base not visible).......	118	118

Valley: (covered by alluvium).

SECTION 10: 3.3 miles N.35°W. of Acoma--Section measured on the slope immediately SW of the road which ascends the escarpment; top of section starts in Dakota sandstone in SE$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ Sec. 7, and continues SE into NW$\frac{1}{4}$ SW$\frac{1}{4}$ NW$\frac{1}{4}$ Sec. 8, T.8N., R.7W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: typical; with interbedded black shale; basal unit is black shale;		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: Incomplete, 203 feet thick.		
Morrison formation: 173 feet thick.		
Recapture Creek shale member:		
9. Sandstone: white, medium grained, subrounded, well sorted, moderately cemented, low angle cross stratified; with angular, coarse grained sand to pebbles in scour pockets up to several inches thick..................	9	203
8. Mudstone: pale green; with 1 foot thick sandstone bed beginning 25 feet and 31 feet above the base..................	43	194
7. Sandstone: white, fine grained, subrounded, well sorted, moderately cemented, low angle cross stratified; with less than 1% kaolinization.......	11	151
6. Mudstone: pale green and purple.......	17	140
5. Sandstone: white, fine grained, subrounded well sorted, well cemented, in lower part, grading upward into argillaceous siltstone; with coarse sand to pebbles of subangular quartz, and less than 5% feldspar grains scattered throughout, mostly in scour pockets...............	9	123
4. Mudstone: purple, grading upward into pale green; with a 1 foot thick gray cryptocrystalline limestone bed beginning 30 feet above the base...........	64	114
3. Sandstone: white, very fine grained, subrounded, well sorted, moderately cemented low angle cross stratified............	4	50
2. Mudstone: purple......................	16	46
Bluff sandstone: Incomplete, 30 feet thick.		
1. Sandstone: gray, cross stratified; (only top part visible)....................	30	30

SECTION 11: 4.3 miles S.35°W. of Mesita--Section measured about 200 feet SW of road and parallel to it; top of section starts in Todilto formation in NE¼ NW¼ NE¼ Sec. 34, and continues SE into SW¼ NE¼ NE¼ Sec. 34, T.9N., R.5W.

	Feet	Cumulative Feet
JURASSIC: Incomplete, 199 feet thick.		
Todilto formation: 27 feet thick.		
6. Limestone: blue gray, "crinkled," highly folded in upper part, lower part platy; caps bench; upper part of formation eroded..............................	27	199
Entrada sandstone: 72 feet thick.		
5. Sandstone: bleached white, very fine to fine grained, rounded to subrounded, well sorted, poorly cemented, cross stratified...........................	25	172
4. Sandstone: light red-brown, very fine to fine grained, subrounded to subangular, moderately sorted, moderately cemented, low angle cross stratified............	47	147
Carmel formation: 75 feet thick.		
3. Siltstone: rusty red, very small scale cross stratified; with interbedded bleached, pale green to white siltstone to mudstone...........................	55	100
2. Mudstone?: red, and pale green, irregularly "banded," baked, with 3 foot thick sill occurring at top...........	20	45
Wingate sandstone: Incomplete, 25 feet thick.		
1. Sandstone: gray, very fine grained, baked; with medium sized grains scattered throughout; (base not visible)........	25	25

SECTION 12: 7.3 miles S.40°W. of Mesita--Section measured on south end of mesa on bench and in re-entrant of lower escarpment; top of section starts in Bluff sandstone in S½ NE¼ NE¼ Sec. 7, and continues SSW into SW¼ SE¼ NE¼ Sec. 7, T.8N., R.5W.

	Feet	Cumulative Feet
JURASSIC: Incomplete, 462 feet thick.		
Bluff sandstone: Incomplete, 78 feet thick.		
9. Sandstone: lower unit; gray, fine grained subrounded, well sorted, moderately cemented, low angle cross stratified; with less than 1% kaolinization; (top unit eroded)...........................	78	462
Summerville formation: 143 feet thick.		
8. Sandstone: gray to tan, very fine grained, subangular, well sorted, well cemented, parallel stratified units 2-5 feet thick; with red mudstone "breaks" up to several inches thick between sandstone units.......................	69	384
7. Mudstone: red; with interbedded white and light green mudstone and sandstone lenses near top of unit................	74	315
Todilto formation: 39 feet thick.		
6. Gypsum: white..........................	15	241
5. Limestone: light to dark gray, recrystallized; lower part platy, upper part more massive and highly con torted and folded	24	226
Entrada sandstone: 113 feet thick.		
4. Sandstone: bleached yellow, low angle cross stratified........................	33	202
3. Sandstone: red-brown, very fine grained, rounded to subrounded, well sorted, low angle cross stratified............	80	169
Carmel formation: 70 feet thick.		
2. Siltstone: red, in beds averaging 1 foot thick; with interbedded red mudstone; upper 1/3 of formation mostly siltstone; lower 2/3 mostly mudstone.............	70	89
Wingate sandstone: incomplete, 19 feet thick.		
1. Sandstone: light rusty red, very fine grained, with medium to coarse grained, rounded to subrounded smoky quartz grains scattered throughout; spotted bleaching; lower ½ is a red siltstone............	19	19

TRIASSIC
Chinle formation: purple and dark red mudstone at top.

SECTION 13: 9.5 miles S.47°W. of Mesita--Section measured on SE side of main rim projection; top of section starts in Bluff sandstone in NW¼ NE¼ NE¼ Sec. 14, and continues ESE into SW¼ NW¼ NW¼ Sec. 13, T.8N., R.6W.

	Feet	Cumulative Feet
JURASSIC: Incomplete, 403 feet thick.		
Bluff sandstone: Incomplete, 37 feet thick.		
7. Sandstone: gray, very fine grained, subangular to subrounded, well sorted, well cemented, low angle cross stratified; (upper unit eroded).............	37	403
Summerville formation: 139 feet thick.		
6. Siltstone: red, interbedded with red, very fine grained sandstone units 2-6 feet thick; with red mudstone "breaks" up to 4 inches thick between the units.	139	366
Todilto formation: 28 feet thick.		
5. Limestone: light to dark gray, recrystallized, "crinkly"; lower part platy, upper part more massive and contorted by folding..........................	28	227
Entrada sandstone: 95 feet thick.		
4. Sandstone: bleached white, otherwise similar to unit 3 below................	24	199
3. Sandstone: red-brown, fine grained, rounded to subrounded, well sorted, low angle cross stratified............	71	175
Carmel formation: 70 feet thick.		
2. Mudstone: red, interbedded with red siltstone...........................	70	104
Wingate sandstone: incomplete, 34 feet thick.		
1. Sandstone: red-brown, fine grained, rounded, well sorted, cross stratified; with medium to coarse grained, rounded, smoky quartz grains scattered throughout and occurring in layers up to 1 inch thick...........................	34	34

TRIASSIC

Chinle formation:

Mudstone: purple, white, and dark red; with purple shaly siltstone beds ½-1 foot thick occurring in upper 40 feet; only top part of Chinle is visible.

SECTION 14: SW Petoch Butte--Section Measured on NW side of main talus slope on the SW side of Petoch Butte; top of section starts in Dakota sandstone in SE¼ NE¼ SE¼ Sec. 31, and continues SW into NE¼ SW¼ SE¼ Sec. 31, T.8N., R. 6W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: white, very fine grained, rounded, well sorted, well cemented, subvitreous.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: 471 feet thick.		
Bluff sandstone: 153 feet thick.		
7. Sandstone: white to tan, fine grained, subrounded, well sorted, moderately cemented, friable, low angle cross stratified............................	153	471
Summerville formation: 87 feet thick.		
6. Sandstone: gray, very fine grained, subrounded, well sorted, moderately cemented, parallel stratified, in beds averaging 3 feet thick; with interbedded red and cream-white mudstone up to 4 inches thick; upper part has massive sandstone units, and lower part has thin bedded sandstone units; at about the middle of the formation is a 7 foot thick mudstone unit....................	87	318
Todilto formation: 3 feet thick.		
5. Limestone: gray-white, coarsely recrystallized, "crinkly"; occurs in beds 2-3 inches thick; with sandy shale "breaks" up to 1 inch thick between the limestone beds.......................	3	231
Entrada sandstone: 160 feet thick.		
4. Sandstone: gray, very fine grained, subrounded, well sorted, well cemented, cross stratified, bleached............	46	228
3. Sandstone: red-brown, very fine to fine grained, subangular to rounded, moderately sorted, moderately cemented, cross stratified; with rounded, smoky quartz grains as in Carmel and Wingate below..	114	182

	Feet	Cumulative Feet
Carmel formation: 32 feet thick.		
2. Sandstone: rusty red, very fine grained, subangular, moderately sorted, poorly cemented; with interbedded thin red mudstone; the sandstone units contain medium to coarse grained, rounded smoky quartz grains as in Wingate below; (upper 1/3 of Carmel is 75% sandstone, lower 2/3 is 25% sandstone)...........	32	68
Wingate sandstone: incomplete, 36 feet thick.		
1. Sandstone: orange-red, fine to medium grained, rounded to subrounded, moderately cemented, wedge-shaped cross stratified; with well rounded to subrounded, well sorted, medium grained smoky quartz grains occurring in layers up to ½ inch thick................................	36	36

TRIASSIC

Chinle formation:

Mudstone: white, purple, and dark red; (only upper part of formation is visible).

SECTION 15: 4.8 miles S.25°W. of Petoch Butte--Section measured on north side of large alcove; top of section starts in Dakota sandstone in SE¼ SW¼ SE¼ Sec. 23, and continues ESE into SW¼ SE¼ SE¼ Sec. 23, T.7N., R.7W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: gray, conglomeratic.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: 564 feet thick.		
Bluff sandstone: 230 feet thick.		
4. Sandstone: pink tan, very fine grained, subangular, well sorted, well cemented, low angle cross stratified; with kaolinization interstitially.............	230	564
Summerville formation: 98 feet thick.		
3. Sandstone: white, very fine grained, subangular sandstone to siltstone, interbedded with gray, fine grained, subrounded, well sorted sandstone, and pink siltstone, all occurring in units 6-10 feet thick........................	96	334
Entrada sandstone: 238 feet thick.		
2. Sandstone: white, very fine grained, subrounded, well sorted, moderately cemented, cross stratified, grading upward into a fine to very fine grained, well cemented, cross stratified sandstone; kaolinization throughout.......	208	238
1. Sandstone: white, very fine grained, subrounded to subangular, well sorted, moderately cemented, very low angle cross stratified and parallel stratified; with medium to coarse grained, subrounded to rounded smoky quartz grains................................	30	30
TRIASSIC		
Chinle formation:		
Upper 40 feet is a red, very fine grained, subangular to subrounded, moderately sorted, well cemented sandstone with fine to coarse grained, angular to rounded smoky quartz grains scattered throughout; purple and red mudstone underlies the sandstone.		

SECTION 16: 2.3 miles N.40°W. of Wilson's Ranch--Section measured on north-facing slope of large projection of rim; top of section starts in Dakota sandstone in SW¼ NW¼ NE¼ Sec. 19, and continues NNE in SW¼ NW¼ NE¼ Sec. 19, T.6N., R.6W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: basal, tan, conglomeratic.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: 283 feet thick.		
Bluff sandstone: 100 feet thick.		
12. Sandstone: gray to white to tan, moderately cemented, cross stratified.......	100	283
Summerville formation: 19 feet thick.		
11. Sandstone: gray-green, very fine grained, knobby; with red streaks in lower part...	2	183
10. Sandstone: white, medium grained.........	4	181
9. Sandstone: Gray, coarse (?) grained, massive; gradational with unit 8.........	2	177
8. Sandstone: white, medium grained.........	4	175
7. Sandstone: gray, conglomeratic, massive..	1	171
6. Mudstone: red-brown......................	1	170
5. Siltstone: white, conglomeratic..........	2	169
4. Mudstone: red-brown......................	3	167
Entrada sandstone: 164 feet thick.		
3. Sandstone: gray, conglomeratic........	8	164
2. Sandstone: gray, fine grained, moderately cemented, cross stratified............	150	156
1. Sandstone: gray, conglomeratic........	6	6
TRIASSIC		
Chinle formation:		
Upper 50 feet is red mudstone.		

SECTION 17: 5.5 miles S.70°W. of Wilson's Ranch--Section measured on second cliff exposure west of fence; top of section starts in Dakota sandstone in NW¼ SE¼ SW¼ Sec. 3, T.5N., R.7W.

	Feet	Cumulative Feet
CRETACEOUS		
Dakota sandstone:		
Sandstone: tan, conglomeratic.		
UNCONFORMITY		
Angular unconformity evident on regional scale; locally not obvious.		
JURASSIC: 36 feet thick		
Bluff sandstone: 36 feet thick.		
1. Sandstone: white, very fine grained, angular, well sorted with faint parallel stratification, grading downward into white, massive siltstone..............	36	36
TRIASSIC		
Chinle formation:		
Upper part is rusty red, massive mudstone or siltstone with faint parallel stratification.		

SECTION 18: 5.8 miles S.22°W. of Wilson's Ranch--Section measured in small alcove; top of section starts in Dakota sandstone in SE corner of Sec. 24., T. 5N., R.7W.

CRETACEOUS

Dakota sandstone:

Sandstone: tan, conglomeratic.

UNCONFORMITY

Angular unconformity evident on regional scale; locally not obvious.

TRIASSIC

Chinle formation:

Upper part is red mudstone.

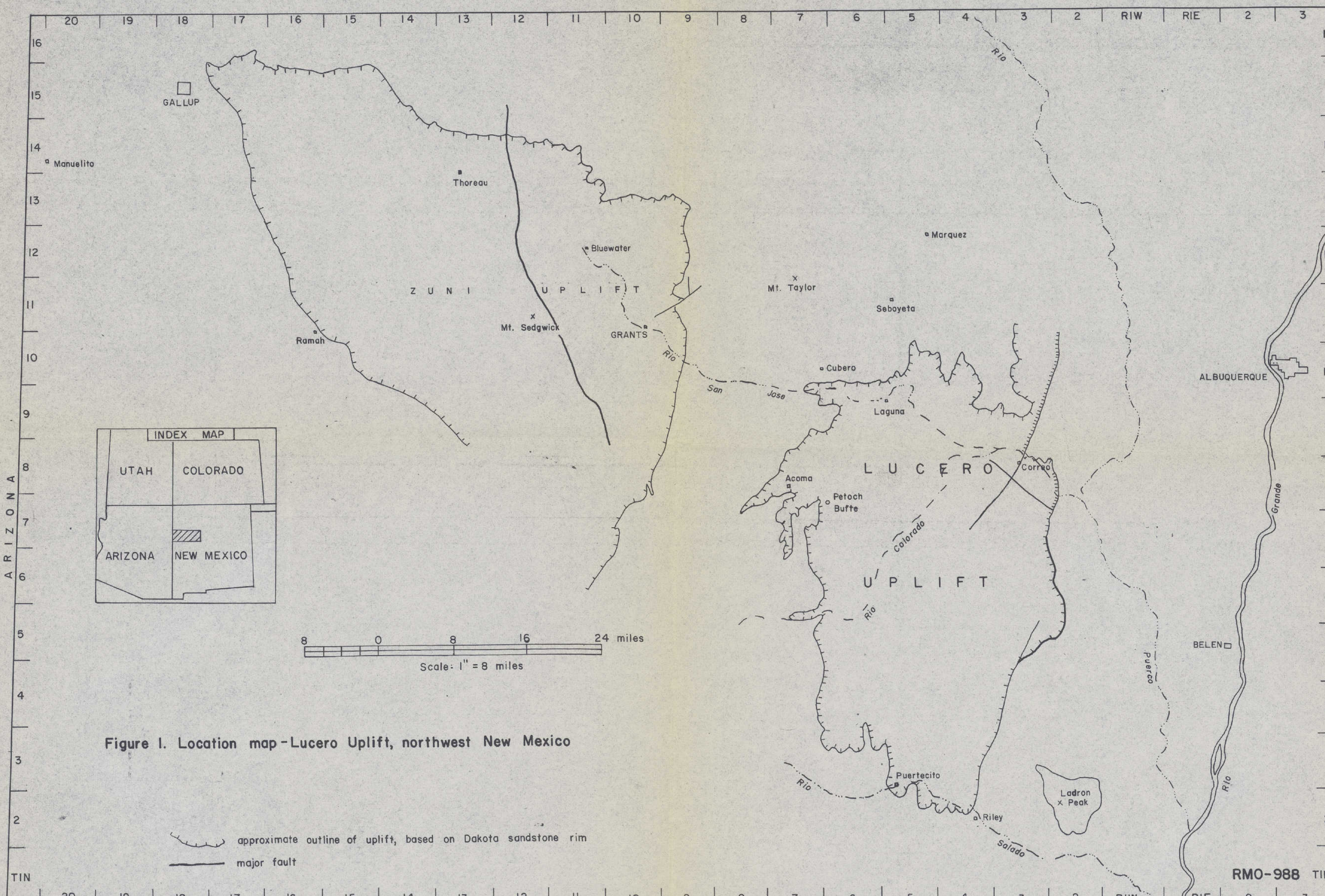
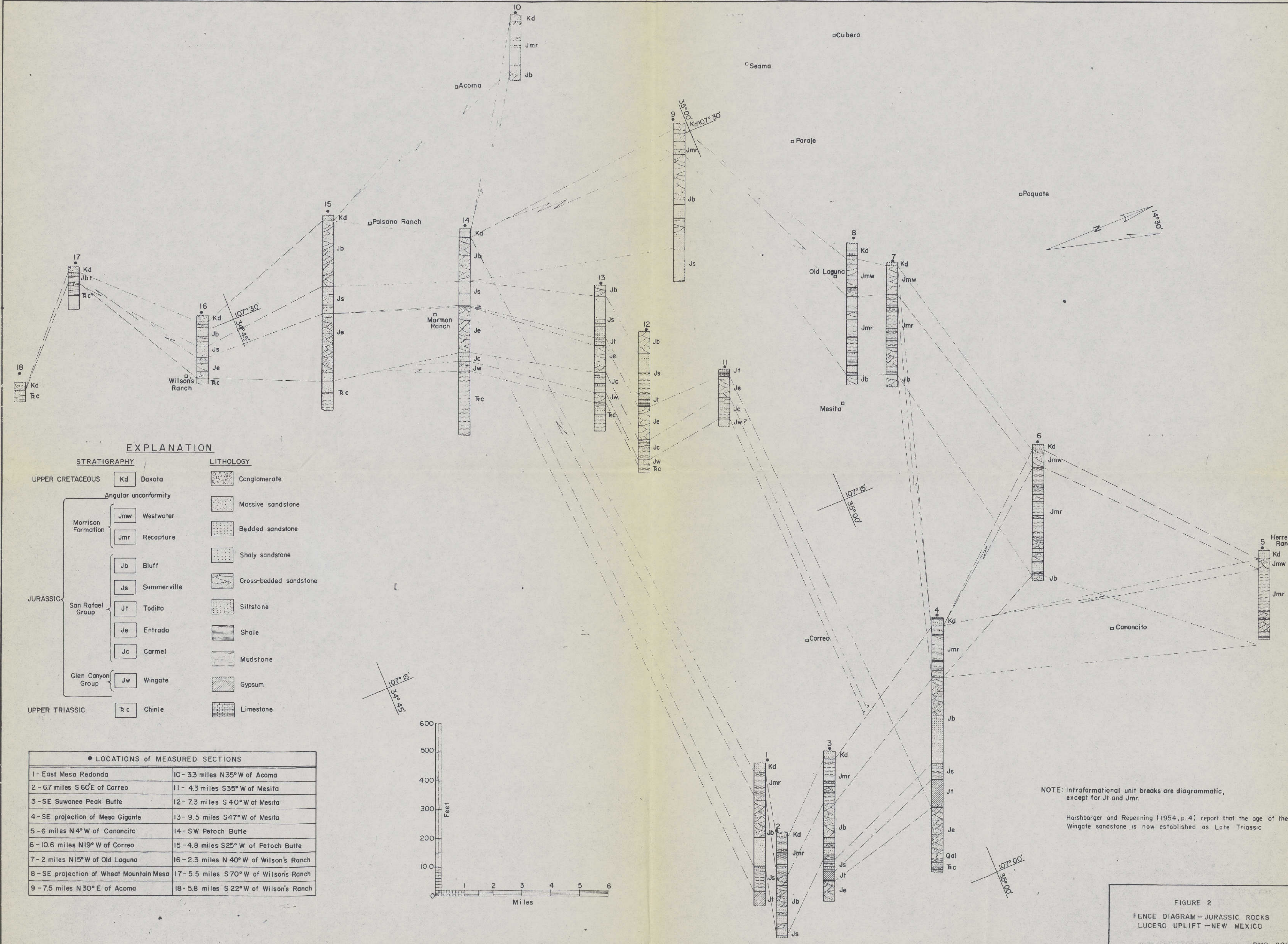


Figure 1. Location map-Lucero Uplift, northwest New Mexico



● LOCATIONS of MEASURED SECTIONS	
1 - East Mesa Redonda	10 - 3.3 miles N35°W of Acoma
2 - 6.7 miles S60°E of Correo	11 - 4.3 miles S35°W of Mesita
3 - SE Suwanee Peak Butte	12 - 7.3 miles S 40°W of Mesita
4 - SE projection of Mesa Gigante	13 - 9.5 miles S47°W of Mesita
5 - 6 miles N4°W of Canoncito	14 - SW Petoch Butte
6 - 10.6 miles N19° W of Correo	15 - 4.8 miles S25° W of Petoch Butte
7 - 2 miles N15°W of Old Laguna	16 - 2.3 miles N 40°W of Wilson's Ranch
8 - SE projection of Wheat Mountain Mesa	17 - 5.5 miles S 70°W of Wilson's Ranch
9 - 7.5 miles N30° E of Acoma	18 - 5.8 miles S 22°W of Wilson's Ranch

FIGURE 2
FENCE DIAGRAM — JURASSIC ROCKS
LUCERO UPLIFT — NEW MEXICO

FIGURE 3
GEOLOGIC MAP OF THE LUCERO UPLIFT, WEST-CENTRAL NEW MEXICO

Mapped by Arthur Mirsky and William L. Chenoweth July-September, 1952

Base map from USDA Soil Conservation Service quadrangles

RMO-988

NEW MEXICO 198

RMO-988

NEW MEXICO-200

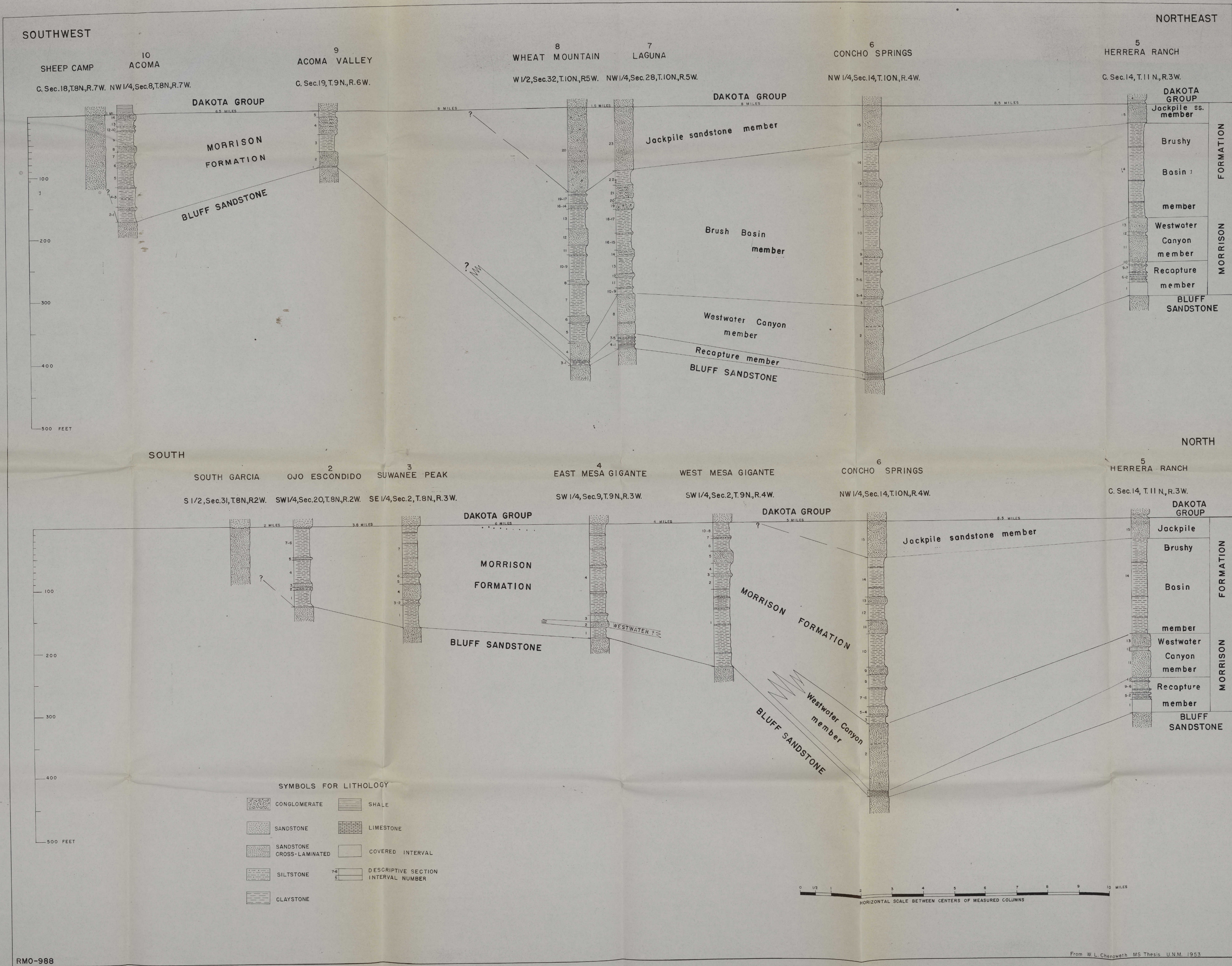


Figure 4. Graphic sections and correlation of the Morrison Formation in the southeastern part of the San Juan Basin.