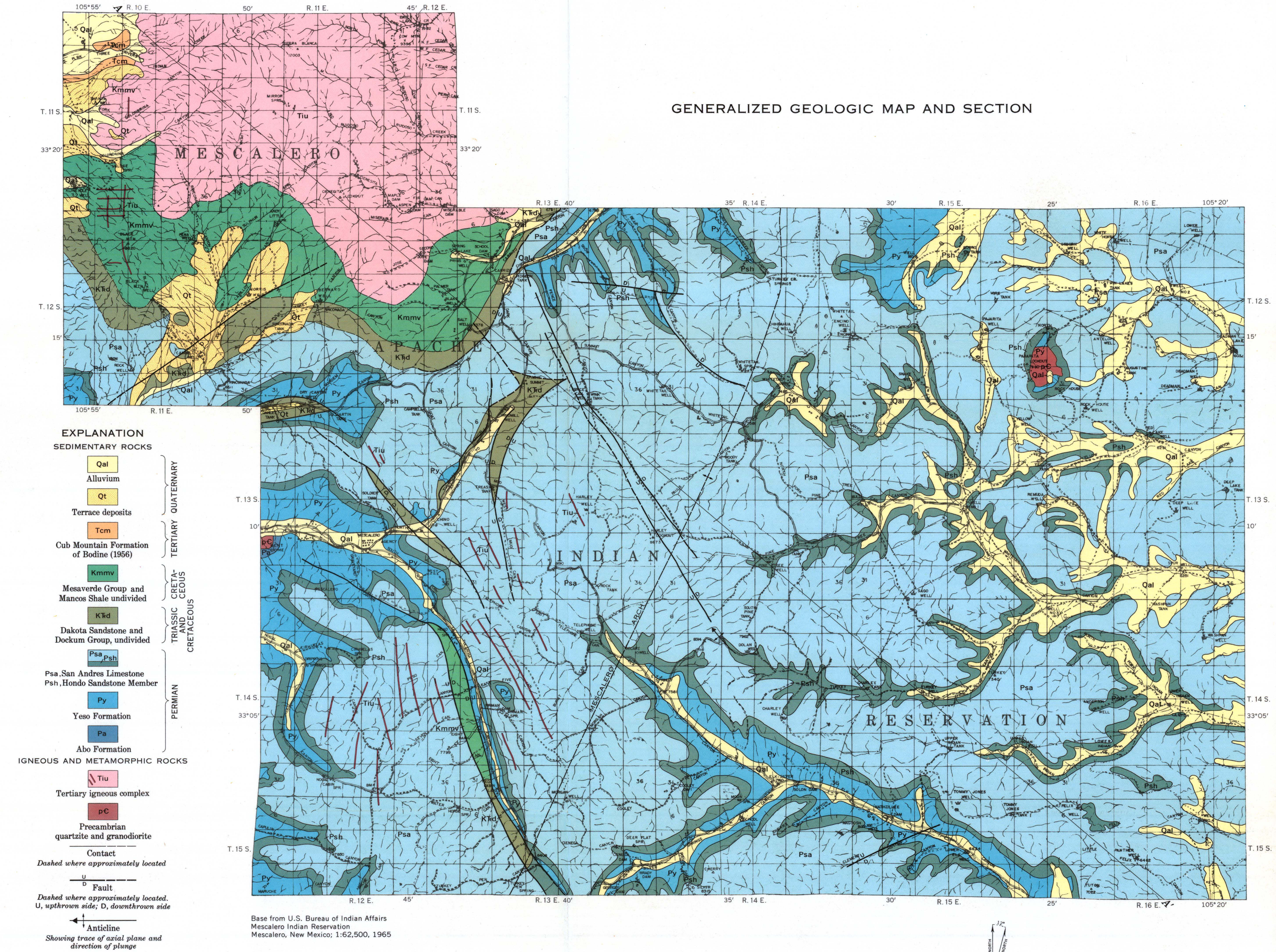
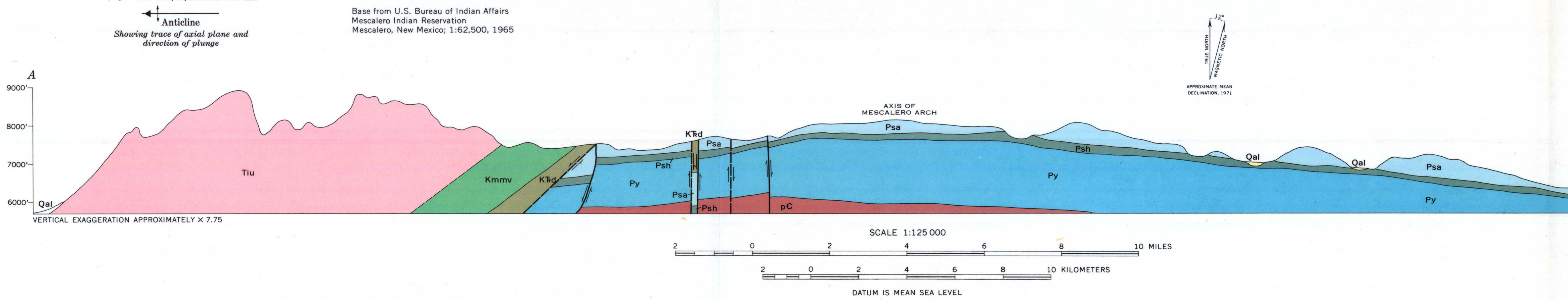
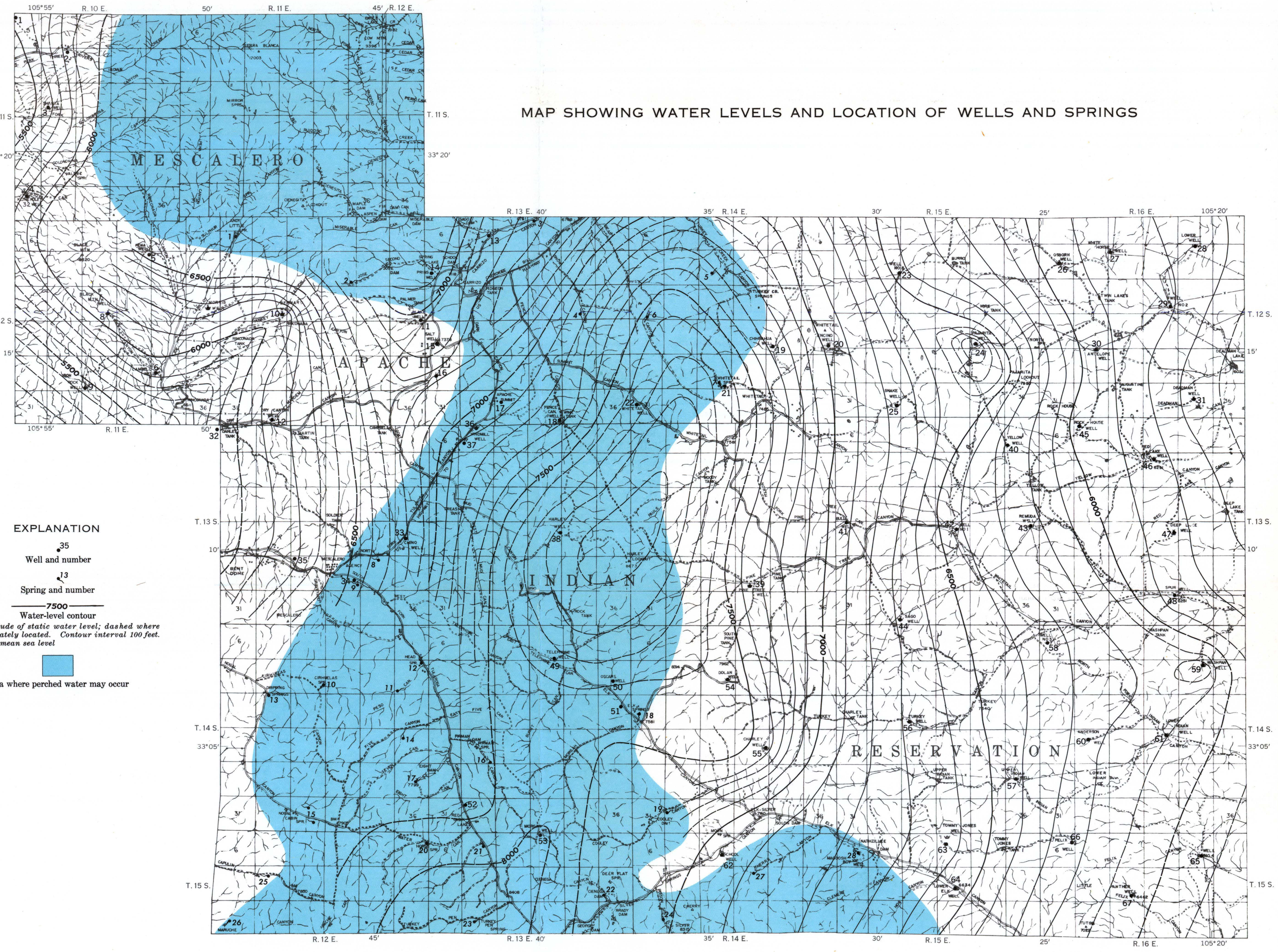
GENERALIZED GEOLOGIC MAP AND SECTION





MAP SHOWING WATER LEVELS AND LOCATION OF WELLS AND SPRINGS



SYSTEM	STRATIGRAPHIC UNIT	THICKNESS, IN FEET	DESCRIPTION
QUATERNARY	Alluvium	0–200	Sand, silt, and gravel, fine to coarse grained; generally drained. Not a good aquifer near Mescalero, but is very good in Three Rivers and Ruidoso areas.
	Terrace deposit	0–30	Coarse sand to large boulders. Not known to yield water.
TERTIARY	Cub Mountain Formation of Bodine (1956)	2,000±	Interbedded sandstone and shale; purple, red, and yellow. Lower sands may yield fair quantity of water.
CRETACEOUS	Mesaverde Group	500±	Sandstone, yellowish brown, interbedded; with dark gray shale, lignite, and coal. Upper sands and coal beds may yield fair quantities of water.
	Mancos Shale	400±	Shale, black, soft, with thin bentonite seams at base and thin limestone beds in lower part. Poor aquifer.
	Dakota Sandstone	125–175	Basal conglomerate and sandstone with shale, siltstone and upper sandstone, silica cementation, iron stained. Fairly good aquifer.
TRIASSIC	Dockum Group	300±	Redbeds, shale, siltstone and sandstone (Santa Rosa Sandstone and Chinle Formation). Poor aquifer.
PERMIAN	Bernal Formation	0–165	Siltstone and gypsum, reddish orange. Poor aquifer.
	San Andres Limestone	300–1,000	Limestone, thin to thick bedded, gray, fossiliferous dolomite in the lower part; generally drained but is the best aquifer in areas where saturated. A few wells on the reservation yield water from lower part of San Andres.
	Hondo Sandstone Member	125–175	Limestone, massive to thick bedded; with well-sorted, upper zone of fine- to medium-grained sandstone. Good aquifer if saturated.
	Yeso Formation	1,000–1,500	Siltstone, interbedded limestone, dolomite, shale, and fine-grained sandstone; yellow and pink. Limestone units are good aquifers. Most wells on reservation are in Yeso.
	Abo Formation	0–800	Arkosic conglomerate, sandstone, and shale; red. Does not yield water to wells on reservation.
PRECAMBRIAN		?	Quartzite and granodiorite.

EXPLANATION

Limestone Dolomite Sandstone Conglomerate Lignite Shale Siltstone Bentonite Quartzite Granodiorite

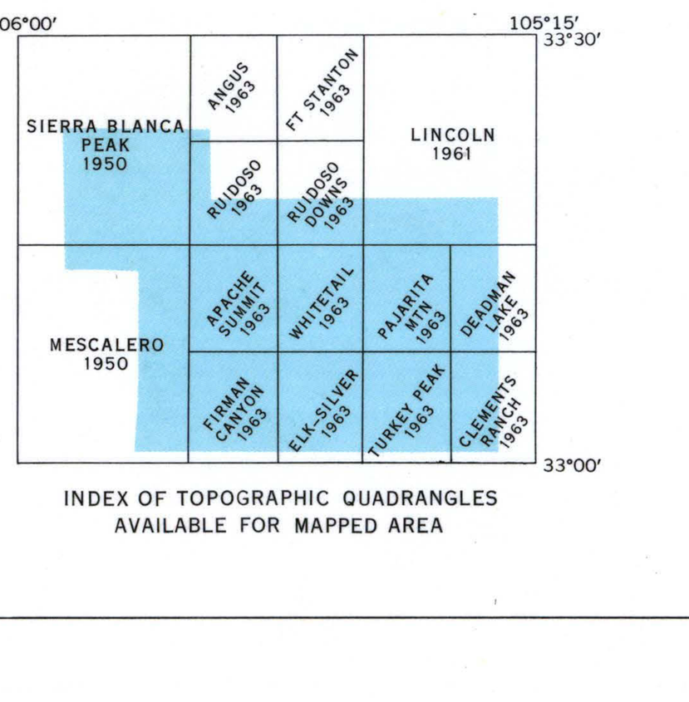
GENERALIZED STRATIGRAPHIC COLUMN

TABLE OF SELECTED SPRINGS

Index No.	Location: Section	T	R	Name of spring	Altitude of land surface (feet)	Estimated yield (gpm)	Stratigraphic unit. (See map explanation)	Conductance (micromhos at 25°C)	Total dissolved solids (mg/l)	Sulfate (mg/l)	Hardness (as CaCo₃) (mg/l)	Water temp. (°C)	Date of collection
1	NE¼SE¼ 6	12S	12E	Andy Little	7,000	10	Tiu	----	---	---	---	---	--------
2	SE¼SE¼ 10	12S	12E	Jose 2nd	7,200	½-1	Tiu	----	---	---	---	---	--------
3	NE¼NW¼ 3	12S	13E	Carrizo	6,795	.3	Psa	1,330	954	453	694	11.7	12-19-47
4	NE¼SW¼ 14	12S	13E	Snow	7,095	0-1	Psa	----	---	---	---	---	--------
5	NE¼SW¼ 9	12S	14E	Turkey	7,200	3	Psa	880	570	165	375	---	4-29-66
6	SE¼SW¼ 18	12S	14E	Bear	7,591	0-1	Psa	----	---	---	---	---	--------
7	SW¼SE¼ 28	12S	14E	Whitetail	7,680	10	Psa	839	554	131	436	12.8	9-29-60
8	SW¼NE¼ 27	13S	12E	North	6,700	365	Py	1,060	734	298	568	12.8	9-18-60
9	SE¼ 27	13S	12E	South	6,625	-----	Py	----	---	---	---	---	--------
10	SE¼SW¼ 10	14S	12E	Cirhuelas	7,575	40	Psa	----	---	---	---	---	--------
11	SW¼SW¼ 12	14S	12E	Peso	7,630	-----	Psa	----	---	---	---	---	--------
12	NE¼NE¼ 12	14S	12E	Head	7,040	200	Psa	883	590	180	459	11.1	10-4-60
13	NW¼ 17	14S	12E	Dripping	7,100	15	Py	----	---	---	---	---	--------
14	NE¼NW¼ 24	14S	12E	Five Springs	7,900	1-2	Psa	----	---	---	---	---	--------
15	SE¼ 33	14S	12E	Nogal Cabin No. 1	7,825	5	Psa	----	---	---	---	---	--------
	SE¼ 33	14S	12E	Nogal Cabin No. 2	7,825	10	Psa	----	---	---	---	---	--------
16	NE¼NE¼ 36	14S	12E	Eight Canyons No. 1	8,032	5	Psa	----	---	---	---	---	--------
	NE¼NE¼ 36	14S	12E	Eight Canyons No. 2	8,032	8	Psa	----	---	---	---	---	--------
17	SW¼SE¼ 20	14S	13E	Firman	7,740	23	Psa	----	---	---	---	---	--------
18	NW¼SW¼ 18	14S	14E	Elk	7,600	5	Psa	711	445	85	369	10.0	10-4-60
19	NW¼SW¼ 32	14S	14E	Cooley	7,680	20	Psa	----	---	---	---	---	--------
20	SW¼NW¼ 6	15S	13E	Horse	8,028	5	Psa	----	---	---	---	---	--------
21	SE¼SE¼ 5	15S	13E	Upper Tularosa	7,900	8	Psa	----	---	---	---	---	--------
22	SW¼SW¼ 12	15S	13E	Cienega	7,760	18-50	Psa	----	---	---	---	---	--------
23	NE¼SW¼ 17	15S	13E	Turkey Pen	8,388	0-2	Psa	----	---	---	---	---	--------
24	NE¼SE¼ 18	15S	14E	Poison	7,760	8	Psa	----	---	---	---	---	--------
25	NE¼NW¼ 8	15S	12E	Capulin	7,650	0-1.5	Psa	----	---	---	---	---	--------
26	SE¼ 18	15S	12E	Maruche	6,950	-----	Psa	----	---	---	---	---	--------
27	NE¼NE¼ 10	15S	14E	Cherry	7,440	0-.5	Psa	----	---	---	---	---	--------
28	NW¼SE¼ 6	15S	15E	La Paz	7,140	3	Psa	----	---	---	---	---	--------

TABLE OF WELLS

Index No.	Location: Section	T	R	Name of well	Altitude of land surface (feet)	Altitude of water surface (feet)	Depth of well (feet)	Estimated yield (gpm)	Aquifer (See map explanation)	Conductance (micromhos at 25°C)	Total dissolved solids (mg/l)	Sulfate (mg/l)	Hardness as CaCo₃ (mg/l)	Water temp. (°C)	Date of collection
1	NW¼NW¼ 5	11S	10E	BIA	5,600	5,569	67	65	Qal	----	----	----	----	----	-------
2	NE¼NE¼ 9	11S	10E	Three Rivers	5,950	5,890	127	----	Qal	----	----	----	----	17.8	-------
3	NW¼SW¼ 16	11S	10E	Shanta	5,655	5,548	522	2-3	Kmmv	3,820	3,909	1,230	1,700	16.7	10-18-60
4	SE¼NE¼ 32	11S	10E	Kline Kole	5,925	5,804	121	5.5	Kmmv	2,200	1,408	947	960	18.3	11-19-64
5	NE¼NE¼ 10	12S	11E	Penna	6,710	6,521	200	4	Kmmv	1,020	697	313	458	12.8	10-19-60
6	SW¼NW¼ 26	12S	11E	Campbell	5,950	5,941	53	----	Qal	1,090	760	304	480	14.4	5-4-66
7	NW¼SE¼ 13	12S	11E	Morris	6,500	6,297	268	75	KTrd	1,500	960	420	670	13.3	-------
8	SE¼ 16	12S	11E	Black Mountain	6,850	6,055	955	3	KTrd	3,430	2,195	1,107	2,075	20.6	-------
9	SW¼SW¼ 28	12S	11E	Iron Rock	6,095	5,445	671	----	Psa	3,350	3,230	1,613	203	18.9	5-4-66
10	SE¼SE¼ 17	12S	12E	Bernard	6,850	6,051	875	150	Py	2,150	1,938	992	1,280	17.2	-------
11	SE¼SE¼ 13	12S	12E	Blake	7,352	6,904	480	----	Kmmv	----	----	----	----	----	-------
12	SW½SE½ 32	12S	12E	Dry Canyon	6,745	6,155	604	9	Py	1,730	----	----	----	15.6	-------
13	NE¼SE¼ 5	12S	13E	Scott	6,926	6,876	132	----	Kmmv	----	----	----	----	----	-------
14	NW¼SW¼ 7	12S	13E	Prins	7,250	7,162	113	----	Kmmv	----	----	----	----	----	-------
15	NE¼SW¼ 19	12S	13E	Salt	7,354	6,922	500	8	Kmmv	----	----	----	----	----	-------
16	NE¼SW¼ 30	12S	13E	Peter Gaines	7,510	6,795	750	----	Psa	----	----	----	----	----	-------
17	SW¼NW¼ 33	12S	13E	Summit	7,610	7,060	710	12	Py	1,290	938	385	616	12.2	10-19-60
18	SE¼SE¼ 34	12S	13E	Fence Canyon	7,640	7,309	390	3	Py	955	663	230	472	11.1	9-29-60
19	SW¼SW¼ 23	12S	14E	Chihuahua	7,600	7,274	499	12	Py	970	978	230	458	----	8-10-66
20	NW¼SE¼ 24	12S	14E	Encino	7,670	6,981	725	4	Py	1,020	598	----	----	15.0	-------
21	SE¼SE¼ 28	12S	14E	Whitetail Springs	7,560	Dry hole	554	0	Py	----	----	----	----	----	-------
22	SE¼NW¼ 31	12S	14E	Whitetail	7,885	7,695	230	10	Psa	1,010	651	196	522	10.0	10-3-60
23	SE¼SE¼ 8	12S	15E	No. 5	6,917	6,402	616	7	Py	1,760	1,043	745	975	15.6	4-26-66
24	SW¼SW¼ 23	12S	15E	Pajarita	7,240	6,851	455	430	Py	760	470	132	378	13.3	-------
25	NE¼SE¼ 32	12S	15E	Snake	7,116	6,766	405	----	Py	860	550	168	395	12.8	4-25-66
26	NW¼SE¼ 7	12S	16E	Osborn	6,407	5,912	495+	----	Py	830	560	210	350	15.6	4-26-66
27	NW¼NW¼ 9	12S	16E	Whitehorse	6,374	5,864	560	----	Py	1,490	1,021	646	825	17.2	4-26-66
28	NW¼NE¼ 11	12S	16E	Lower	6,100	5,745	622	8	Py	2,340	2,210	1,380	1,560	16.7	10-13-60
29	SE¼SE¼ 15	12S	16E	No. 2	6,190	5,805	397	----	Py	----	----	----	----	15.0	-------
30	NW¼NE¼ 29	12S	16E	Antelope	6,380	5,918	540	12	Py	1,070	772	329	460	17.8	4-26-66
31	SE¼NW¼ 35	12S	16E	Deadman	6,255	5,651	640	275	Py	1,150	736	338	615	17.2	2-18-65
32	NE¼NE¼ 1	13S	11E	Joyce	6,400	----	650	.5	Py	2,530	2,030	1,120	1,450	16.7	10-19-60
33	SE¼NW¼ 24	13S	12E	Chino	6,960	6,797	175	32	Psa	----	----	----	----	----	-------
34	NE¼SW¼ 27	13S	12E	Irrigation Test	6,590	----	200	50	Qal	1,060	734	298	1,450	16.7	9-18-60
35	NW¼NW¼ 28	13S	12E	Old Folks Village	6,300	6,190	600	6	Py	----	----	----	----	----	-------
36	NW¼NE¼ 5	13S	13E	Windmill	7,410	7,077	385	15	Psa	----	----	----	----	11.7	-------
37	NW¼SW¼ 5	13S	13E	Sawmill	7,340	7,115	272	8	Psa	----	----	----	----	----	-------
38	SE¼NE¼ 22	13S	13E	Harley	8,220	7,833	471	210	Psa	670	429	273	330	11.1	11-6-64
39	SE¼SW¼ 27	13S	14E	Pine Tree	7,470	7,333	210	680	Py	780	499	91	400	11.7	-------
40	SW¼SW¼ 1	13S	15E	Yellow	6,820	6,260	631	10	Py	1,750	1,500	851	965	15.6	10-13-60
41	NE¼NW¼ 19	13S	15E	Bull	7,070	6,908	206	5+	Py	776	483	101	402	11.7	10-3-60
42	NW¼NE¼ 22	13S	15E	No. 1	6,780	6,405	454	----	Py	1,070	766	136	360	13.9	4-29-66
43	NW¼NE¼ 24	13S	15E	Remuda	6,630	6,232	420	4+	Py	890	572	183	469	13.3	10-3-60
44	SE¼SE¼ 32	13S	15E	Sago	7,470	6,692	846	130	Py	860	550	173	415	13.9	-------
45	NW¼NW¼ 5	13S	16E	Rock House	6,530	5,960	710	305	Py	560	358	230	270	14.4	12-3-64
46	NE¼NW¼ 10	13S	16E	Red Lake	6,291	5,859	525	15	Py	----	----	----	----	15.0	-------
47	SE¼NE¼ 22	13S	16E	Deep Lake	6,450	5,854	650	10	Py	900	576	234	445	15.6	3-9-65
48	NE¼NE¼ 34	13S	16E	Spur	6,251	5,849	427	6	Py	----	----	----	----	13.9	-------
49	SE¼SE¼ 3	14S	13E	Telephone	7,809	7,640	184	----	Py	----	----	----	----	9.44	-------
50	NE¼SW¼ 12	14S	13E	Oscars	7,720	7,634	118	----	Py	----	----	----	----	----	-------
51	SW¼NE¼ 13	14S	13E	Otero Mills	7,600	7,360	335	70	Py	743	463	117	368	----	11-20-66
52	NW¼NW¼ 32	14S	13E	8-Canyon—Job Corps	7,660	7,205	507	100	Py	470	600	218	250	12.8	-------
53	NE¼NW¼ 3	15S	13E	Morgan	8,550	8,077	562	8	Psa	690	448	122	318	11.1	8-8-66
54	NE¼SE¼ 9	14S	14E	Dolan	7,797	7,543	293	4	Py	713	441	139	352	11.1	10-4-60
55	NE¼SE¼ 22	14S	14E	Charley	7,740	7,489	336	10	Py	680	414	95	320	11.1	-------
56	NE¼SW¼ 16	14S	15E	Turkey	7,058	6,683	442	----	Py	748	465	121	396	12.8	10-11-60
57	SE¼NW¼ 25	14S	15E	Upper Indian	6,835	6,402	500+	15	Py	651	393	81	314	14.4	10-4-60
58	NW¼SW¼ 6	14S	16E	No. 3	6,635	6,354	468	9	Py	1,780	1,360	742	918	13.9	10-3-60
59	NW¼NE¼ 11	14S	16E	Wash Pan	6,580	6,205	410	120	Py	900	576	173	----	15.6	-------
60	SE¼NW¼ 20	14S	16E	Anderson	6,620	6,210	575	40	Py	880	563	183	425	15.0	1-7-65
61	NW¼NE¼ 22	14S	16E	Lower Indian	6,240	----	----	----	Py	----	----	----	----	15.6	-------
62	NW¼SE¼ 4	15S	14E	School	7,310	6,910	440	----	Py	----	----	----	----	----	-------
63	NE¼NW¼ 3	15S	15E	Tommy Jones	7,500	6,686	900	15	Py	660	450	----	----	13.3	-------
64	NW¼SE¼ 10	15S	15E	Lower Elk	6,634	6,533	146	3	Py	----	----	----	----	12.8	-------
65	NW¼SE¼ 2	15S	16E	No. 4	6,140	----	----	----	Py	720	454	132	355	----	4-29-66
66	SE¼NE¼ 6	15S	16E	Felix	6,880	6,258	850	5.5	Py	710	454	198	350	14.4	12-15-64
67	SW¼SE¼ 9	15S	16E	Panther	6,462	----	----	----	Py	1,020	701	304	535	16.7	4-29-66



INDEX OF TOPOGRAPHIC QUADRANGLES AVAILABLE FOR MAPPED AREA

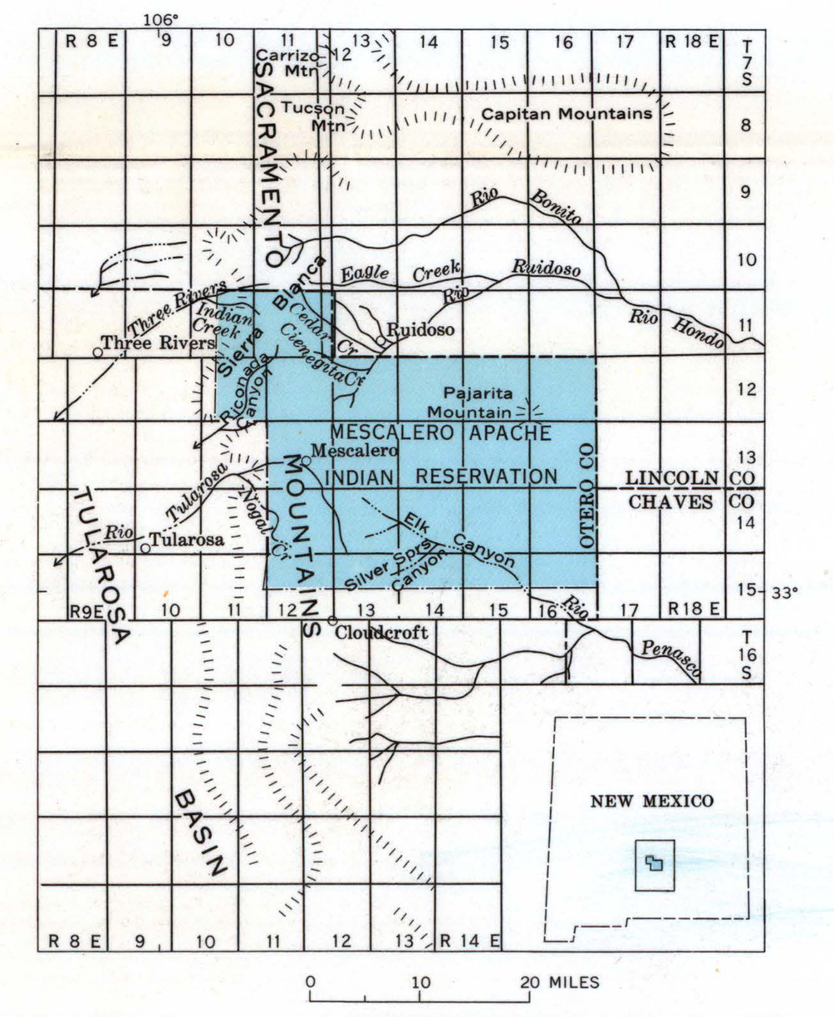
INTRODUCTION

Purpose and scope.—Grazing is a primary land use on the Mescalero Apache Indian Reservation, but forage utilization is hampered by a lack of watering facilities. In 1960, the U.S. Geological Survey began a ground-water reconnaissance as part of the Soil and Moisture Conservation Program to determine the availability of water for use by livestock on the reservation.

After the reconnaissance, the Survey evaluated well sites in areas selected by the Bureau of Indian Affairs. These evaluations were based on geologic and hydrologic information obtained during the reconnaissance. As a result of these evaluations, 18 wells were drilled during 1964 and 1965. This atlas summarizes the data gathered in the reconnaissance and from the wells subsequently drilled.

Acknowledgments.—Personnel in the Branch of Land Operations, Bureau of Indian Affairs, Mescalero Apache Indian Reservation, provided much valuable assistance and information. The authors gratefully acknowledge their cooperation.

Location and extent of area.—The Mescalero Apache Indian Reservation lies between 33°00' and 33°23' N. Latitude and between 105°18' and 105°56' W. Longitude (see location map) in the Sierra Blanca and Sacramento Mountains of south-central New Mexico.



LOCATION MAP

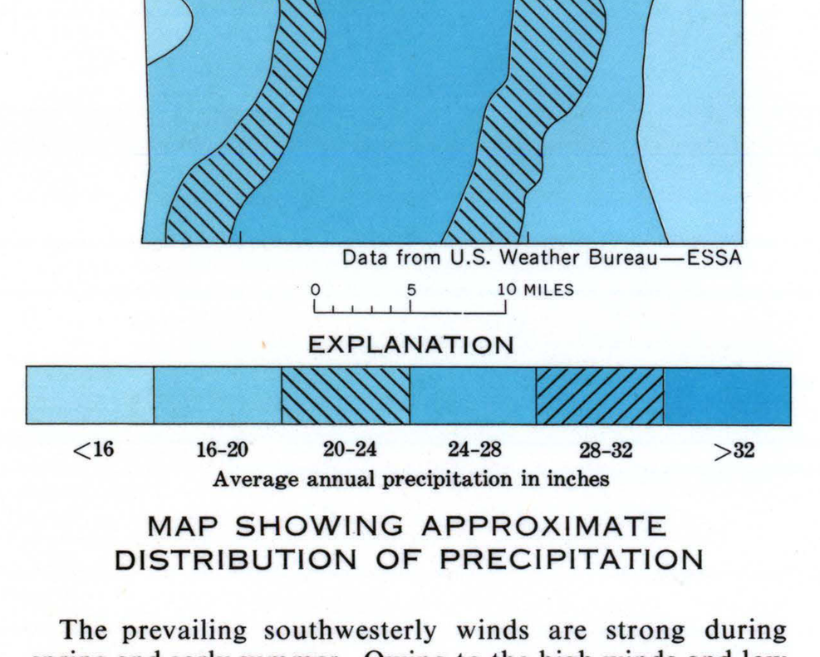
Physiography.—The reservation is in the Sacramento section of the Basin-and-Range physiographic province (Fenneman, 1931, p. 394). Altitudes range from 12,003 feet on Sierra Blanca Peak to about 5,500 feet where Indian Creek leaves the reservation near Three Rivers in the Tularosa Basin. This range, 6,500 feet in altitude, occurs within a distance of about 7 miles. The igneous complex of Sierra Blanca Peak in the northwestern part of the reservation overshadows the mountainous terrain which characterizes the reservation. This peak is the highest point in southern New Mexico and is the most southerly area of known Pleistocene glaciation in the continental United States (Smith, H. T. U., and Ray, L. L., 1941). South and southeast of Sierra Blanca, the Sacramento Mountains, uplifted along the Tularosa Basin to the west, slope gently eastward to the Pecos Valley, which lies about 25 miles east of the report area. The Sacramento Mountains and the Sierra Blanca form a continuous north-south barrier on the eastern side of the Tularosa Basin. Pajarita Mountain, in the eastern part of the reservation, is an igneous intrusive that rises above the gentle eastward slope of the Sacramento Mountains.

Drainage.—Dissection of the Sacramento Mountains has resulted in deep, steep-walled canyons that are drained eastward to the Pecos Valley and westward to the Tularosa Basin.

Perennial streamflow is restricted to a few streams that flow from the high western part of the reservation. The Rio Tularosa, which flows west to the Tularosa Basin, and the Rio Ruidoso, which flows east to the Pecos Valley, are the main streams that issue from the reservation. Eagle Creek, Cedar Creek, and Cienegita Creek flow from the northeast and southeast flanks of Sierra Blanca, respectively, and Indian Creek flows from the west side of Sierra Blanca. Nogal Creek flows into the Rio Tularosa from the southwestern part of the reservation. Perennial flow is maintained a short distance into the reservation in Silver Springs Canyon at the southern boundary.

The many ephemeral streams in the reservation flow in response to runoff from high intensity summer thunderstorms. Although the frequency of discharge from these ephemeral streams is low, the magnitude of discharge can be high.

Climate.—The climate of most of the reservation is semi-arid, although it is subhumid in the higher parts of the Sacramento Mountains and the Sierra Blanca. Precipitation occurs mainly as high-intensity summer thunderstorms and as winter snowfall. Spring and fall are usually dry. Greatest monthly precipitation occurs during July and August. Winter precipitation is not so great as summer precipitation, and snow accumulation is significant only in the higher parts of Sierra Blanca. Average annual precipitation at stations in and near the reservation ranges from 9.49 inches at Tularosa to 25.78 inches at Cloudcroft. The precipitation map shows the approximate distribution of precipitation within the reservation. Mean annual temperature decreases and mean annual precipitation increases with increasing altitude on the reservation. This climatic difference is clearly marked by vegetation zonation and is also reflected in the hydrology of the reservation.



MAP SHOWING APPROXIMATE DISTRIBUTION OF PRECIPITATION

The prevailing southwesterly winds are strong during spring and early summer. Owing to the high winds and low humidity, evaporation rates are high during this period. There are no evaporation stations on the reservation, but extrapolation from several stations at lower altitudes indicates an average evaporation rate of about 50 inches per year. Seasonal temperatures on the reservation range generally from 32°C to about −20°C. The lower mean annual temperature largely accounts for the lower evaporation rate than that indicated for adjacent stations where the annual evaporation is about 70 inches per year.

GEOLOGY AND HYDROLOGY

Occurrence of ground water.—Depth to ground water on the reservation ranges from a few feet to as much as 900 feet. Water-level altitudes range from about 5,400 to 8,000 feet, as shown on the contour map. The blue overprint on this map indicates areas where springs discharge and where ground water occurs at shallow depths owing to lack of drainage. The highest water-level altitudes occur in the central part of the reservation along a trend alined with the Mescalero Arch. Most of the ground water on the reservation occurs under water table conditions. Ground-water drainage is facilitated by a combination of high topographic relief and abundant faults and other fractures.

Geologic formations and their water-bearing properties.—The geologic map illustrates generalized distribution of rocks that crop out in the reservation. Lithologic and hydrologic properties of the rocks discussed here are summarized in the stratigraphic column.

Precambrian metamorphic and igneous rocks underlie Permian sedimentary rocks throughout the reservation and crop out on Bent Dome and Pajarita Mountain. The Abo Formation overlies the Precambrian rocks and crops out locally in the western part of the reservation. Because they are deeply buried throughout most of the area, the above units are not considered sources of ground-water supply; however, small quantities of water could probably be obtained from either unit.

The Yeso Formation of Permian age is the most extensive aquifer in the reservation. This formation is saturated, at least in part, wherever it occurs. Yields to wells in the Yeso vary from less than 1 gpm (gallon per minute) to more than 500 gpm, depending on the saturated thickness and permeability of beds penetrated. Solution openings that have been enlarged along joints or other fractures in limestone or dolomite furnish most of the ground water in the Yeso Formation. Sandstone yields minor amounts of water. Total dissolved solids in water samples from the formation range from 358 to 2,210 mg/l (milligrams per liter).

The San Andres Limestone of Permian age, overlying the Yeso Formation, crops out extensively over the eastern two-thirds of the reservation and locally elsewhere. Although relatively hard and resistant to erosion, the San Andres is readily soluble and contains numerous caverns and solution openings. Sinkholes formed by solution and collapse occur on the surface of the San Andres in many parts of the reservation.

Owing to topographic relief, the San Andres generally is drained. The lower part of the formation, including the Hondo Sandstone Member, is locally saturated along the Mescalero Arch. The entire formation is saturated in those localities where it has been downfaulted below the local level of saturation. These local areas occur west of the Mescalero Arch and in the faulted basin surrounding Sierra Blanca.

Eight wells obtain water from the San Andres Limestone on the reservation. None of these wells penetrate the formation where it is entirely saturated. Yields of the wells range from less than 10 gpm to more than 200 gpm. Most of the springs on the reservation issue from the lower part of the San Andres along the margins of the Sacramento crest. Dissolved solids in water from the San Andres generally is less than 1,000 mg/l. At the Iron Rock well in the northwestern part of the reservation, however, the San Andres contains large amounts of gypsum and the dissolved solids in the water and the sulfate content exceed 3,000 mg/l and 1,600 mg/l, respectively. Water in the San Andres is generally hard.

The Bernal Formation of Permian age overlies the San Andres Limestone locally in the Rinconada area south of Sierra Blanca. For mapping purposes, it is included with the overlying Triassic redbeds of the Dockum Group. This group consists of the Santa Rosa Sandstone and Chinle Formation. These formations have not been explored for water on the reservation, but they probably would yield small quantities of poor quality water.

The Dakota Sandstone of Cretaceous age forms prominent ridges in many localities. Its outcrop area is limited to the western part of the reservation. Owing to structural and topographic relief, the Dakota is generally drained; but locally, where it is saturated, the Dakota is sufficiently fractured to yield moderate quantities of water to wells.

The Cretaceous Mancos Shale overlying the Dakota Sandstone yields no water to wells on the reservation.

The Cretaceous Mesaverde Formation, which consists largely of interbedded sandstone, shale, and coal, yields small quantities of potable water from all beds but the shale. The Mesaverde crops out in a rather broad zone surrounding Sierra Blanca. A profusion of igneous dikes and sills related to the adjacent Sierra Blanca intrusive have invaded the Mesaverde and other formations. Locally, they act as barriers to ground-water drainage and help to preserve shallow ground water in areas of relatively high topographic relief.

The Cub Mountain Formation of Bodine (1956) of Tertiary age, which crops out in the Three Rivers area in the northwestern part of the reservation, yields small to moderate quantities of water of good to fair quality in adjacent areas but has not been explored for water on the reservation.

Tertiary igneous rocks of intrusive and extrusive origin form Sierra Blanca. There are no wells in the igneous rocks, but the small springs in the Sierra Blanca region indicate that these rocks can yield small quantities of water of good quality.

Terrace and pediment gravels of Tertiary or Quaternary age veneer the surface in the Rinconada and the Three Rivers areas. Owing to their elevated positions, these gravels are generally drained and are not water-bearing. Quaternary alluvium occurs more or less continuously in the stream valleys throughout the reservation but is a useful aquifer in only a few places, owing to its lack of saturation or permeability, or both. The areas where water can be obtained from alluvium include the stream valleys near the Three Rivers area, Ruidoso and Mescalero.

Chemical quality of ground water.—Analyses of water from wells and springs on the Mescalero Reservation (see well and spring tables) show dissolved solids content ranging from 358 mg/l to 3,909 mg/l. The water is generally of the calcium-magnesium sulfate or bicarbonate type with hardness generally ranging from 300 to 2,000 mg/l.

High sulfate content (more than 250 mg/l) coincides with areas of deep ground-water circulation, abundant gypsum, and aridity. Spring water contains fewer dissolved solids and considerably less sulfate than well water from the same formation.

Surface storage of water.—Many of the springs on the reservation discharge perched ground water which is dissipated very rapidly downstream by seepage. Spring impoundments, such as those at Cienega Springs, Cooley Spring, and Maruche Spring, conserve this water for use in irrigation, as a source of livestock water, and as fishing ponds.

Large reservoirs have not been constructed on the reservation because of the absence of suitable sites. Runoff is generally low, whereas water losses from seepage outflow and evaporation are high. Local areas in the western part of the reservation appear feasible for the development of large-scale ground water supplies that could be used to fill and to maintain water levels in large reservoirs.

The collapse of underground solution caverns has formed many sinkhole depressions on the San Andres Limestone surface in the eastern part of the reservation. Water accumulates in these sinkholes from runoff, but only to shallow depth because they are generally filled with fine-grained sediment derived from the surrounding uplands. Charcos or pits with a large ratio of depth to surface area seem feasible as water-collecting and storage features in the sinkholes. A few charcos have been constructed on the reservation, but they have been generally unsuccessful because they were placed in sinkholes with extremely small drainage basins.

Use of the atlas.—This atlas can be used to plan the development of new ground water supplies. Altitude of a site can be determined from available topographic maps. The water-level contour map can be used to determine the altitude of the water surface at the site. The difference between the altitudes gives the approximate minimum drilling depth. The geologic map and section show formations that will be penetrated and the stratigraphic section shows their lithologic and hydrologic properties. Data for nearby wells indicates the yield and quality of ground water that can be expected.

The proposed use of the atlas can best be applied to the eastern two-thirds of the reservation where the geology is not complex and the water-level contours are reasonably accurate. Users should exercise considerable caution in application of the atlas to sites in the western and the northwestern parts of the reservation owing to the limitations of scale and the generalized structural relationships depicted on the geologic map. An experienced hydrologist should examine each well site in the western part of the reservation.

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