GEOLOGY OF THE ZUNI SALT LAKE 7½ MINUTE QUADRANGLE

Open-File Report 405

Orin J. Anderson

The Upper Cretaceous rocks of the Zuni Salt Lake area (Fig. 1) have been generalized in past works and compilations as part of the Mesaverde Group (Dane and Bachman, 1957; Gadway, 1959; Dane and Bachman, 1965, Bradbury, 1967). There are two reasons for not applying the name Mesaverde Group to these rocks, one of substance and involving the recognition of a fault in the area, the second relating only to semantics and nomenclature, but nonetheless pertinent.

Addressing the latter first, the post-lower Mancos Turonian rocks (here read as post Rio Salado Tongue) of west-central New Mexico were designated as the Atarque Sandstone and the Moreno Hill Formation by McLelland, et al., (1983). This regressive sequence is pre-Gallup Sandstone, which categorically excludes it from the Mesaverde Group - as defined and used by the NMBMMR. The NMBMMR usage recognizes the base of the Gallup Sandstone as the base of the Mesaverde Group, consistent with Beaumont, et al., (1956); however, the U.S. Geological Survey would further restrict the Mesaverde and recognize the base of the much-younger Point Lookout Sandstone as the basal Mesaverde Group contact (U.S. Geological Survey Geological Names Committee, Oral Communications, 1991). This more restrictive definition obviously results in the Atarque-Moreno Hill sequence being even more out of place in the Mesaverde Group.

The justification for recognition of the base of the Mesaverde as the base of the Gallup

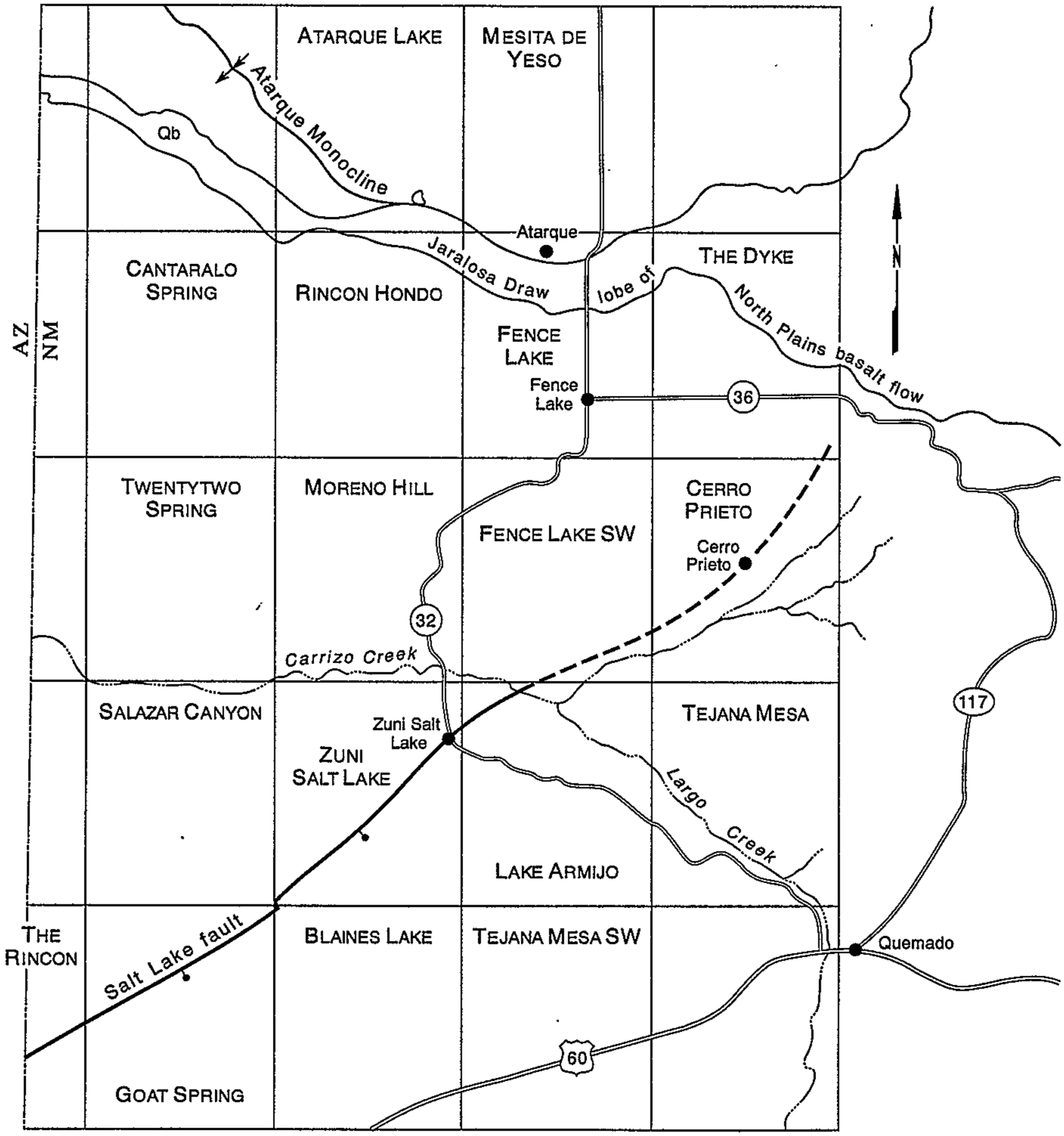


Fig. 1. Index map to Zuni Salt Lake area, showing surrounding quadrangles, highways, major drainages, the quaternary basalt flow (Qb) near Fence Lake, and major structures.

Sandstone consists of the following: (1) This arrangement restricts the usage of Mesaverde Group to the San Juan and its related basins, a concept which is consistent with past usage in New Mexico; (2) Mesaverde Group strata represent deposition in an area that experienced numerous transgressive-regressive episodes (the T1 through T-4 transgressions of Molenaar, 1983) and is indeed overlain by marine rocks. By contrast the area in which the Atarque-Moreno Hill Formations were deposited lies outside (south of) the San Juan basin and witnessed only one marine transgression, the Greenhorn cycle, represented in the rock record by the upper part of the Dakota, the Rio Salado Tongue of the Mancos, and the Atarque Sandstone (Fig. 2); (3) Atarque-Moreno Hill strata (essentially all middle and Late Turonian) are significantly older than the type Mesaverde Group (mostly Coniacian, Santonian and Campanian); and (4) outcrops of Upper Cretaceous rocks are not continuous from the San Juan and its associated Gallup-Zuni basin into the area where Atarque and Moreno Hill Formations are recognized; a Quaternary basalt flow (the Jaralosa Draw lobe) conceals outcrops in the Fence Lake area (Fig. 1) and a major northwest-trending structure, the Atarque monocline (Fig. 1) brings Triassic rocks to the surface immediately north of the basalt flow.

These are four convincing reasons to restrict usage of the term Mesaverde Group to Gallup Sandstone and younger strata in the San Juan basin. This, however, is only part of the Upper Cretaceous stratigraphy problem in the area. The remaining problems relate to the presence of the Salt Lake fault shown on both the map and cross section A-A'. The presense of this normal fault makes it clear that no matter what definition one accepts for the Mesaverde Group, it is not present on the northwest side (upthrown block). The rocks on the

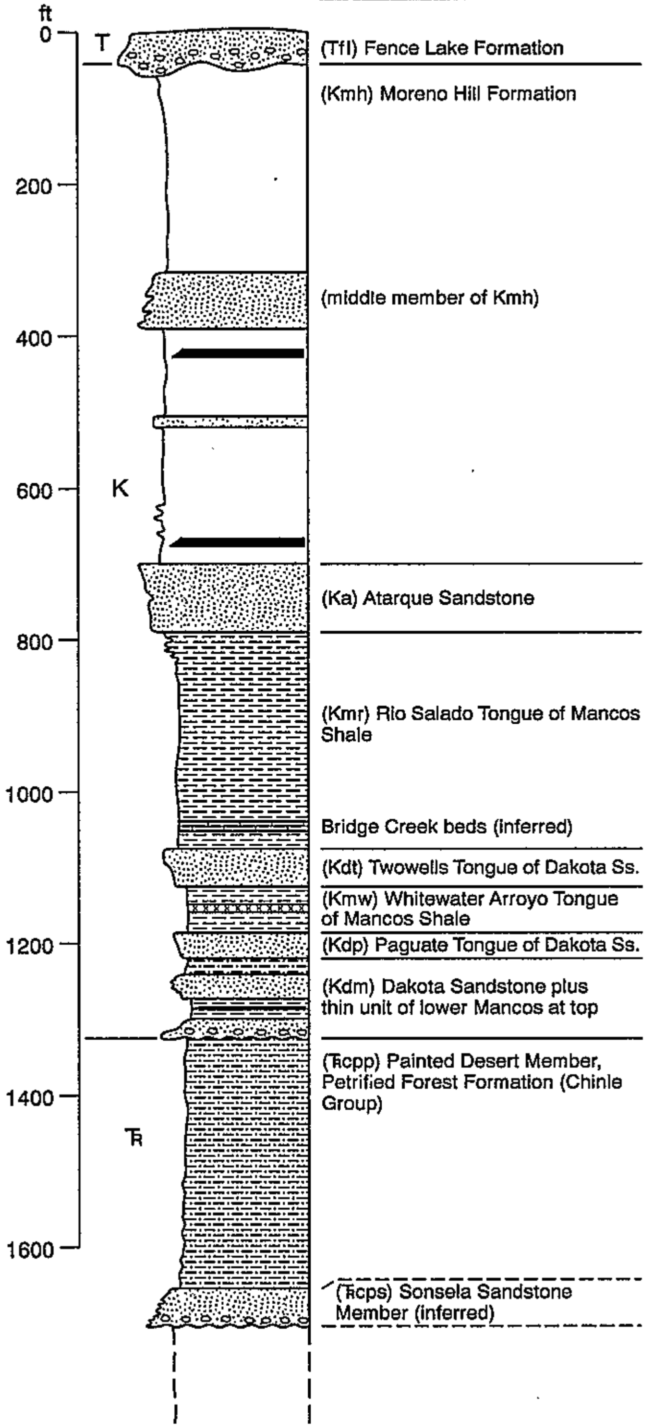


Fig. 2. Composite stratigraphic column for Zuni Salt Lake Quadrangle. The Greenhorn Cycle of Deposition is represented by the Dakota Sandstone and Intertongued overlying Mancos Shale units, the Rio Salado Tongue, and the Atarque Sandstone.

northwest side are clearly those of the intertongued Dakota-Mancos sequence (in contrast to what has been advanced by earlier workers) and as such are all Cenomanian in age. Recognition of this fact, plus the discovery of the significant northeast-trending fault associated with Zuni Salt Lake maar, constitute the primary reasons for the preparation of this report.

Salt Lake Fault

The Salt Lake fault was first recognized during the summer of 1991 while doing reconnaissance work on The Rincon Quadrangle (Fig. 1). This reconnaissance was part of the effort to complete the Quemado 30'x 60' quadrangle as NMBMMR open-file 406; The Zuni Salt Lake report is really intended as a companion to the larger Quemado report.

On The Rincon Quadrangle it was noted that stacked channel sandstones of the Moreno Hill Formation were faulted against the Twowells Tongue of the Dakota, and that the fault had a northeast strike. Continued tracing of the fault led to Zuni Salt Lake maar. Stratigraphic expression of the fault is questionable northeastward from Zuni Salt Lake, however, it would appear to be continuous and trend toward Cerro Prieto, a late Tertiary basaltic neck (Fig. 1).

From Zuni Salt Lake southwestward to the Arizona state line the fault strikes approximately N 50° E (Fig. 1). It is down-to-the-southeast with the throw, based upon juxtaposition of stratigraphic units, ranging between 300 to 600 ft., although locally may be much less. The interpretation that it is normal is based on the following: (1) essentially all the northeast and east-northeast trending faults in this area (Catron County) are normal faults, (2) any high angle reverse faults in the vicinity occur to the north and trend northwest; (3) the vent for Zuni Sale Lake maar would be difficult to relate to a fault plane that dipped to the NW (see cross section) as would be required in a reverse fault, and (4) no subsidiary faults of the type that would normally be associated with a reverse, oblique, or wrench fault are obvious in the area.

The age of the faulting is loosely constrained. The fault does appear to influence the areal distribution, specifically the northern limit, of the Baca Formation (Upper Eocene) in the area to the south of the Zuni Salt Lake quadrangle although Baca outcrops are poor and sporadic in that area. This indicates the fault may be syn-Baca and thus as old as Middle to Late Eocene. On the other hand the Fence Lake Formation (Miocene) buries the fault (to the southwest) with no evidence of post-Fence Lake motion on the fault. Thus faulting is pre-middle Miocene. Most normal faults in the Quemado region are of late Oligocene to Pleistocene age.

It is possible that the onset of faulting took place during the Middle to Late Eocene and may have been related to Late Laramide deformation. With northeast-directed Laramide compressional forces active throughout much of the Eocene it follows that the direction of <u>least</u> principal horizontal stress would be perpendicular to this vector and hence NW-SE. The Zuni Salt Lake Fault could have developed as a normal fault in this stress field, during the Late Eocene. However, this explanation implies some compartmental deformation and the existence of discrete structural blocks (after Brown, 1984), for which there is little or no evidence.

With respect to the Tertiary sedimentary units in the area it should be noted that even though the distribution is very limited on this quadrangle the lithologies can be very confusing. The only Tertiary unit present is the Fence Lake Formation, generally rich in Middle Tertiary volcanic clasts. On this quadrangle and on the Goat Spring Quadrangle (Fig. 1) the Fence Lake Formation, however, consists almost entirely of well-rounded siliceous pebbles and cobbles recycled out of the Baca Formation. It is the presence of sparse subangular basaltic clasts which distinguish the Fence Lake from the Baca Formation.

Economic Geology

Salt harvested from Zuni Salt Lake is perhaps the most significant mineral production on the quadrangle. However, it is not currently sold on the open market, being used instead by the Zuni people within their society, and thus a production value is difficult to determine.

No petroleum production exists on the quadrangle, however, nearby tests have been conducted. The Transocean No.1 was drilled in Sec. 12, T2N, R18W to a T.D. of 4275 ft into the Precambrian. The Skelly Oil No. 1 Teel was drilled in Sec. 7, T2N, R19N, near the west edge of the quadrangle boundary; T.D. = 2365 in the upper Paleozoic. Neither well reported an oil show; records of each well are on file at the NMBMMR Petroleum Section, in Socorro.

Cinders represent a potentially marketable product, but distances to market (for landscaping or decorative material) are large, putting these limited resources at a severe disadvantage. The only local use for this product would be as a road-surfacing material.

A good quality bentonite bed, 12-14 inches thick is described as part of the Kmw in the explanation of units. It is, however, a subeconomic occurrence because of the limited dimensions and remoteness.

Coal resources on the quadrangle potentially occur in two stratigraphic units; the Dakota Sandstone (medial part), and the Moreno Hill Formation. Resources are, however, nil. One caveat to drillers and coal explorationists is that whatever coal resource may exist within the Moreno Hill formation locally will be restricted to the down-thrown side (SE side) of the Salt Lake fault. Explorationists would be advised to use this map in conjunction with the Quemado 30'x 60' map, NMBMMR open-file 406, while evaluating the area.

Explanation of Map Units

Quaternary units

Qa - Alluvium; mostly poorly sorted sand and gravel deposits, unconsolidated; lesser amounts of silt and clay as matrix

Qpl - Fine grained, unconsolidated material in ephemeral lakes or playas; probably not more than 30 ft thick.

Qe - Evaporite and fine grained lacustrine beds (salt and fine clastics of Zuni Salt Lake maar).

Qcl - Colluvium and landslide debris.

Qc - Volcanic cinder cone; basaltic cinder and bombs; weathers brown, brownish red, blackish red, or shades or orange. At depth grades into intrusive rocks shown as Qi on accompanying cross section.

Qta - Volcanic tuff and ash; (Qt unit of Cummings, 1968).

Qag - Coarse, older alluvium of upland surfaces; siliceous cobbles were derived from

Baca Formation (Eocene) or from recycled Baca cobbles that weathered out of Fence Lake Formation (Miocene); present only as a thin (/25 ft) veneer.

Tertiary units

Tnb - Basalt and/or basaltic andesite; nearby flows at similar elevation have been dated at 6.08 Ma (McIntosh and Cather, 1994).

Tfl - Fence Lake Formation (Miocene); conglomerate and conglomeratic sandstone, consisting largely of volcaniclastic material derived from Mangas Mountain and other volcanic rock sources to the south and southeast; also contains large clasts of siliceous material derived from the Baca Formation. Approximately 40 ft thick.

Upper Cretaceous units

Kmh - Moreno Hill Formation; shale or mudstone, crossbedded sandstone, carbonaceous shale and coal; nonmarine depositional sequence associated with a mid-Turonian regression which resulted in deposition of the coeval Tres Hermanos Formation. Thickness unknown on this quadrangle. Sandstone capping high mesas in southeast and southern parts of quadrangle may correlate with the "middle member" of Campbell (1989), which is locally as much as 450 ft above the base of the Moreno Hill Formation. However, members of the Moreno Hill were not mapped as separate units on this quadrangle (Kmha on south rim of Zuni Salt Lake is combined Kmh and Ka).

Ka - Atarque Sandstone; very fine to fine grained very pale orange to grayish orange quartzose sandstone; coarsens upward in a general way; flat bedded in lower part, crossbedding, both low and high angle, in thin to moderate sets, present in upper part. A molluscan faunal assemblage collected from a structurally disturbed block on the northwest rim of maar in Sec. 30 T3N, R18W includes *ostrea* sp., *Trigonarca* sp., *Phelopteria* sp., *Inoceramus* sp., *Plicatula ferryi* coquand, *Crassatella excavata* Stanton, *Pleurocardia pauperculum* (Meek), Gyrodes depressa Meek, and *Rostellinda* sp.; thickness approximately 45 ft.

Kmr - Rio Salado Tongue of Mancos Shale; Shale and silty shale, medium gray; calcareous concretions in upper part; lower part, not well exposed on quadrangle, normally has nodular to platy limestone beds in a zone immediately above (within 25 ft) the top of the Twowells Tongue of Dakota sandstone. These limestone beds which represent the local expression of the Bridge Creek Member of Greenhorn Formation, are likely to be present, veneered with alluvium, in Secs. 33 and 34 T3N, R19W, and in Secs. 4 and 5 T2N, R19W; commonly associated with the limestone beds are abundant specimens of *Pycnodonte newberryi*; worn and weathered fragments of P. *newberryi* are found as float at scattered localities in the northern half of quadrangle; entire Rio Salado Tongue as much as 300 ft thick locally.

Kdt - Twowells Tongue of Dakota Sandstone; very fine to fine grained, yellowish gray to pale olive, quartzose sandstone, coarsens upward and upper most portion is locally lower-medium grained; lower part commonly bioturbated, upper part crossbedded with numerous, moderate to large diameter burrows (up to 1 inch diam) and horizontal feeding trails, tracks, and burrows (an excellent ichnofauna); in upper part of bivalues *Exogyra levis* and *Pycnodonte kellumi* locally abundant; unit ranges from 22 to 28 ft thick. Good outcrops are indicated on map.

Kmw - Whitewater Arroyo Tongue of Mancos Shale; shale and silty shale, medium gray to medium dark gray; approximately 30 ft below the top of unit is a white to orange- weathering bentonite bed, 12-14 inches thick. Shell fragments of *Exogyra trigeri* common in unit, particularly in upper part above the bentonite bed; present in the slope wash as float from the overlying unit are fragments of *Pycnodonte kellumi*; unit approximately 50 to 60 ft thick, but base not exposed.

Kdp - Paguate Tongue of Dakota Sandstone; very fine to fine grained (coarsening upward) yellowish gray to pale olive quartzose sandstone; large, oblate calcareous concretions common throughout except in uppermost portion; best exposure of concretionary facies in SE¼ Sec 32 T3N R19W. Concretions commonly contain fragments of bivalues, including *Exogyra levis* and *Pycnodonte kellumi*, poorly preserved and difficult to identify. Specimens of these two genera all also present in the upper part in low-angle crossbedded facies; fossils not as common as in Twowells Tongue; thickness less than 20 ft. Unit not well exposed on quadrangle, with best outcrops in SE¼ sec 20, T3N R19W. Proximity of this unit (SW¼ sec 24 T3N R19W) to the Salt Lake fault (projected through adjacent sec. 25) allows for a more arcuate estimate of throw on this down-to-the-southeast fault; estimate of throw is 500 ft.

Kdm Main body of Dakota Sandstone and an overlying, thin and unmappable (less than 25 ft thick) sandy unit of the lower Mancos Shale. Main body of Dakota consists of a lower, very poorly exposed sandstone and shale unit; a middle, carbonaceous shale with very minor coal unit, which varies widely in thickness (10 to 50 ft), and an upper fine to medium grained, flat to crossbedded sandstone, commonly up to 40 ft thick. Base is a profound unconformity very commonly marked by siliceous pebble conglomerate. Large wastage blocks of Dakota Sandstone mark contact with underlying Triassic rocks. Unit as much as 120 ft thick locally. (For more information on Dakota and intertongued Dakota - Mancos sequence see McLellan, et al., 1983; Anderson, 1987; Campbell, 1989; Hook, et al., 1980; Landis, et al., 1973).

Triassic units

Trcpp - Painted Desert Member of Petrified Forest Formation (Chinle Group, Upper Triassic, Norian); sandstone, very fine grained to fine grained, silty mudstone and siltstone, pale red, pale purple, yellowish gray and grayish pink, mainly lithic arenites. Exposures poor, and for this reason a measured section of this unit from Lucas and Hayden (1989), described from an outcrop one mile north of the quadrangle boundary is here presented.

On the cross section the Sousela Sandstone Member (Trcps) is inferred in the subsurface.

Section LC-1 (of Lucas and Hayden, 1989)

SW¼ SE¼ NE¼ sec. 3, T3N, R19W; Catron County, New Mexico; measured 8 July 1988, by S. G. Lucas and S. N. Hayden.

lithology	thickness (ft)
Dakota Formation:	
Sandstone (Quartzarenite), pale yellowish orange (10 YR 8/6) and grayish orange (10 YR 7/4); trough crossbedded; medium grained (to 400 µm); calcareous cement; forms ledge.	not measured
Sandstone/conglomerate; grayish yellow-green (5 Gy 7/2), dusky yellow-green (5 GY 5/2), yellowish gray (5 Y 7/2) and dusky yellow (5 Y 6/4); sand is quartz up to 200 µm, chert, siltstone, micas and some mafic lithics of varying grain sizes up to coarse sand; conglomerate is matrix supported, with clasts of quartzite and chert; contains oxidized plant debris.	2.0

Disconformity

Chinle Group

Painted Desert Member of Petrified Forest Formation

Silty mudstone; pale greenish yellow (10 Y 8/2), pale olive (10 Y 8/2) and grayish yellow-green (5 GY 7/2); "bleach-out" below disconformity	20.0
Silty mudstone; grayish red (10 R 4/2), with pale greenish yellow (10 Y 8/2) mottling. "popcorn" weathering, calcareous.	22.5
Sandstone; same lithology and colors as unit 6, but contains greater amount of mud.	24.0
Sandstone; same lithology and colors as unit 7.	4.6
Sandstone; same lithology and colors as unit 6.	10.0
Sandstone (lithic arenite), pale red (5 R 6/2 and 10 R 6/2), with grayish red (5 R 4/2) bases of laminate in parallel laminations interbedded with grayish red (10 R 4/2) siltstone; contains light greenish gray (5 GY 8/1), lenticular sandstone bodies; ripple to parallel laminated: sand is fine grained to 150 μm and consists of quartz, chert, siltstone and mafic lithics.	19.2

Sandstone (lithic arenite); same colors as unit 4, finer grained, up to 300 μm; small trough crossbeds; poorly indurated, forms slope; sand is chert and mafic lithics; contains calcrete nodules with Fe staining: calcareous cement.	5.9
Sandstone; same lithology and colors as unit 3.	.33
Sandstone (lithic arenite), light gray (N7) and pale purple (5 PB 7/2), with medium dark gray (N4) markings on base of lamination in trough crossbeds; sand is quartz, pinkish siltstone, chert and mafic lithics; coarse grained to 500 μm; intrasparite calcite cement.	2.3
Sandstone (lithic arenite), yellowish gray (5 Y 7/2), weathers to light olive-gray (5 Y 6/1); fine grained to 250 μm; sand is quartz and mafic lithics; contains lateral accretion structures; parallel laminations showing parting lineations; claystone interbeds; contains abundant petrified wood.	10.6
Siltstone; grayish red (5 R 4/2) with grayish pink (5 R 8/2) and grayish orange-pink (5 YR 7/2) mottling; contains lunate ripples and concretions; slightly calcareous in lighter colored areas.	9.6

Sandstone (subarkosic, lithic wackestone), pale red (10 R 6/2), grayish pink (5 R 8/2), pale pink (5 RP 8/2) and yellowish gray (5 Y 8/1); siltier in red areas; poorly indurated; friable; slope former; noncalcareous; base not exposed.	not measured

References Cited

Anderson, Orin J., 1987, Geology and coal resources of the Atarque Lake 1:50,000 quadrangle: New Mexico Bureau of Mines and Mineral Resources, Geologic Map GM–61.

Beaumont, E. C., Dane, C. H., and Sears, J. D., 1956, Revised nomenclature of Mesaverde Group in San Juan Basin, New Mexico: American Association of Petroleum Geologists, Bulletin, vol. 40, pp. 2149-2162.

Bradbury, J. P., 1967, Origin, paleolimnology, and limnology of Zuni Salt Lake maar, west-central New Mexico: Ph.D. dissertation, University of New Mexico, Albuquerque, New Mexico 247 pp.

Brown, W. G., 1984, Basement Involved Tectonics Foreland Areas: American Associated of Petroleum Geologists, Continuing Education Course Note Series #26, 92 pp.

Campbell, Frank, 1989, Geology and coal resources of the Fence Lake 1:50,000 quadrangle: New Mexico Bureau of Mines and Mineral Resources, Geologic Map GM–62.

Chamberlin, R. M., Cather, S. M., Anderson, O. J., and Jones, G. E., 1994, Reconnaissance Geologic Map of the Quemado 30′x60′ sheet, Catron Co., New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 406.

Cummings, David, 1968, Geologic map of the Zuni Salt Lake volcanic crater, Catron County, New Mexico: U.S. Geological Survey Map I–544, 1:6,000.

Dane, C. H., and Bachman, G. O., 1957, Preliminary geologic map of the northwestern part of New mexico: U.S. Geological Survey Miscellaneous Investigations Map I-224, 1:380,160.

Dane, C. H., and Bachman, G. O., 1965, Geologic Map of New Mexico: U.S. Geological

Survey and New Mexico bureau of Mines and Mineral Resources, 1:500,000.

Gadway, K. L., 1959, Cretaceous sediments of the north plains and adjacent areas, McKinley, Valencia, and Catron Counties, New Mexico: *in* New Mexico Geological Society 10th Annual Field Conference Guidebook, pp. 81-84.

Hook, Stephen C., Cobban, W. A., and Landis, E. R., 1980, Extension of the intertongued Dakota Sandstone-Mancos Shale Terminology into southern Zuni Basin: New Mexico Geology, vol. 2, no. 3, pp. 42-46.

Landis, E. R., Dane, C. H., and Cobban, W. A., 1973, Stratigraphic terminology of the Dakota Sandstone and Mancos Shale, west-central New Mexico: U.S. Geological Survey, Bulletin 1372–J, pp. J1–544.

Lucas, S. G., 1993, The Chinle Group: Revised stratigraphy and biochronology of the Upper Triassic nonmarine strata in the western United States; *in* Morales, M., ed., Aspects of Mesozoic geology and paleontology of the Colorado Plateau: Museum of Northern Arizona Bulletin 59, pp. 27–50.

Lucas, S. G., and Hayden, S. N., 1989, Triassic stratigraphy of west-central New Mexico: *in* New Mexico Geological Society 40th Field Conference Guidebook, Southeastern Colorado Plateau, pp. 191-211.

McIntosh, William and Cather, Steven M., 1994, $^{40}Ar/^{39}Ar$ Geochronology of Basaltic Rocks and Constraints on Late Cenozoic stratigraphy and Landscape Development in the Red Hill-Quemado Area, New Mexico; *in* New Mexico Geological Society 45th Annual Field Conference Guidebook.

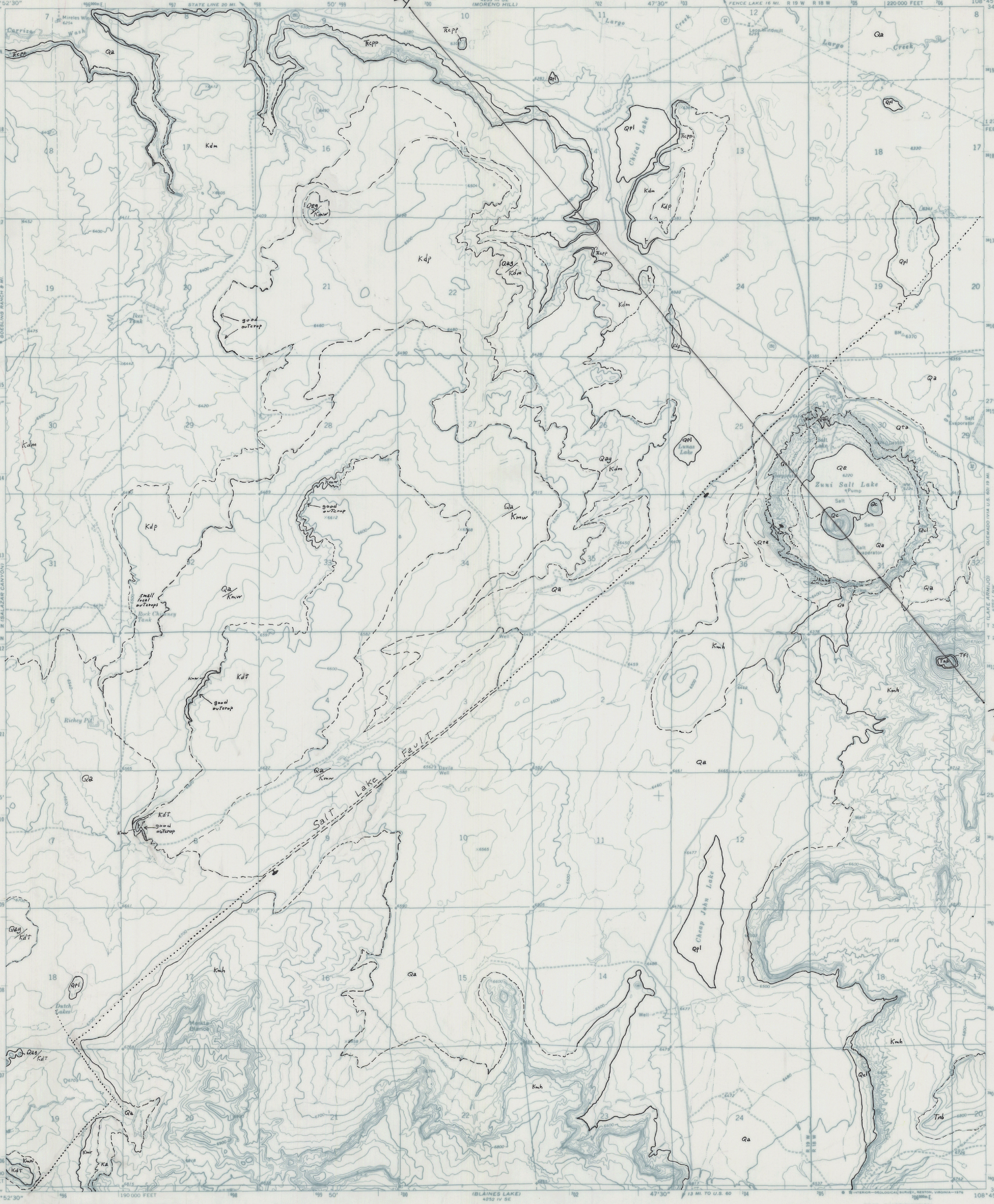
McLellan, Marguerite, Haschke, Laura, Robinson, Laura, and Landis, E. R., 1983, Geologic map of the Moreno Hill quadrangle, Cibola and Catron Counties, New Mexico: U.S. Geological Survey, Miscellaneous Field Studies MF–1509, 1:24,000.

Molenaar, G. M., 1984, Major depositional cycles and regional correlations, upper Cretaceous rocks, southern Colorado Plateau and adjacent areas; *in* Rocky Mountain Section, Society of Economic Paleontologists and Mineralogists, Mesozoic Plaeogeography of west-central United States, M. W. Reynolds and E. D. Dolly, eds., pp. 201-224.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Map 1

ZUNI SALT LAKE QUADRANGLE
NEW MEXICO—CATRON CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1971. Field checked 1972

Projection and 10,000-foot grid ticks: New Mexico coordinate system, west zone (transverse Mercator) 1000-metre Universal Transverse Mercator grid ticks, zone 12, shown in blue. 1927 North American datum

Fine red dashed lines indicate selected fence lines

UTM GRID AND 1972 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface

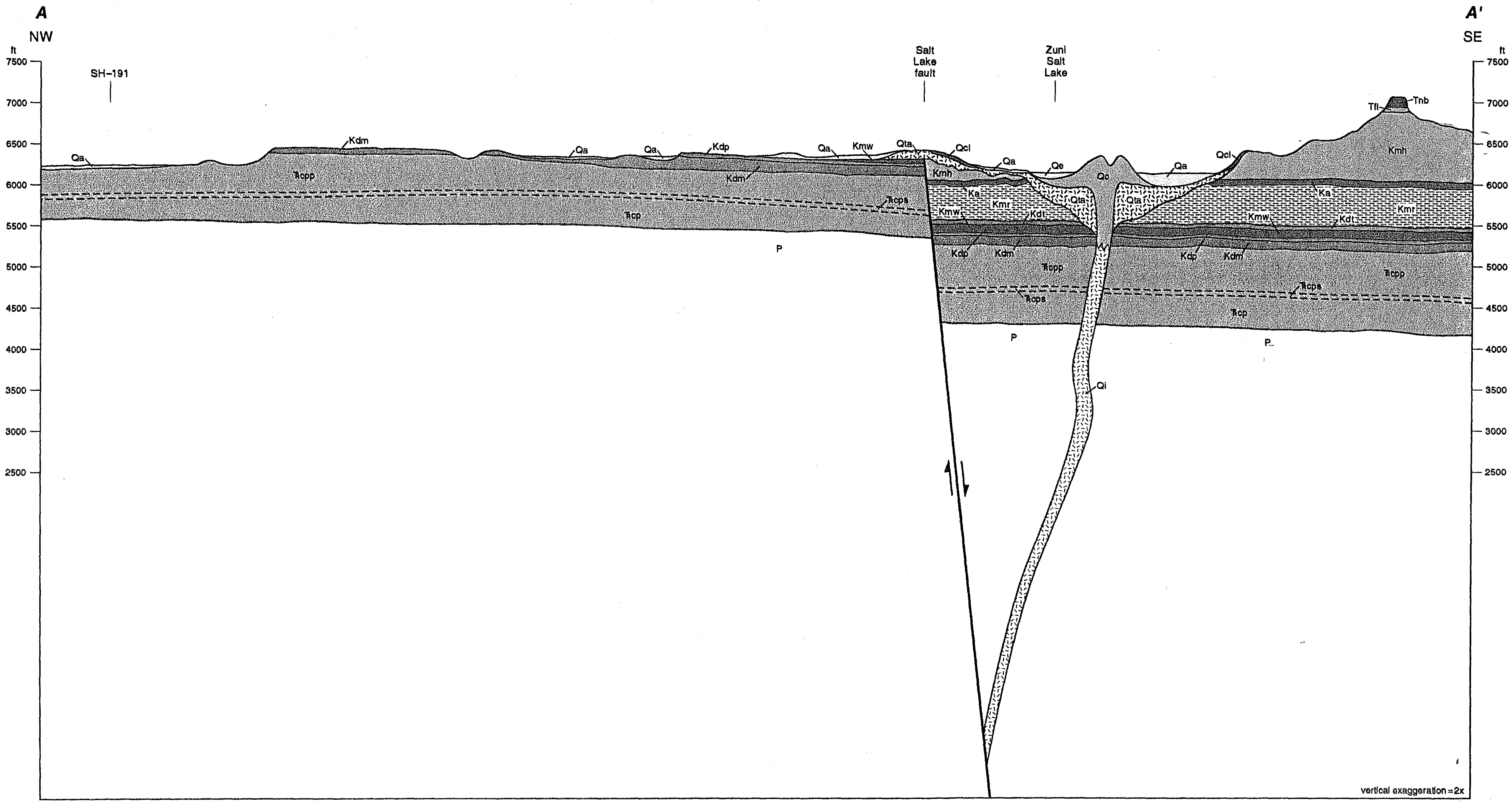
Secondary highway, hard surface — Unimproved road

Interstate Route — U. S. Route — State Route

NMBMMR OF-405
6/94
O.J.A.

ZUNI SALT LAKE, N. MEX.
N3422.5—W10845/7.5
1972
AMS 4252 IV NE—SERIES V881

Plate 1



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