Open-File Report 81-31 **Open-File Report** 81-31

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GEOLOGY OF NASH DRAW, EDDY COUNTY, NEW MEXICO

By

George O. Bachman

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ABSTRACT

Nash Draw is a partially closed depression about 29 km (17 mi) east of Carlsbad, Eddy County, New Mexico. It has been mapped geologically in conjunction with detailed studies to evaluate the proposed nuclear Waste Isolation Pilot Plant (WIPP). Maps at scales of 1:24,000 accompany this report.

The stratigraphic section exposed in Nash Draw includes the Rustler Formation and Dewey Lake Red Beds of Late Permian (Ochoan) age, the Dockum Group of Late Triassic age, and the Pleistocene Gatuna Formation. Other deposits of Middle to late Quaternary age include the Mescalero caliche, spring deposits, and windblown sand.

Dissolution of evaporites has been a major process in the formation of Nash Draw. Nash Draw formed before, and during, Gatuna time about 600,000 years ago. Near-surface dissolution of gypsum in the Rustler Formation is presently active and is responsible for numerous collapse sinks and related karst features.

INTRODUCTION

Nash Draw is a topographic depression about 29 km (17 mi) east of Carlsbad, Eddy Co., N. Mex. (fig. 1). It trends northeasterly from a broad alkaline playa, Salt Lake, for about 27 km (16 mi). As compared with normal erosional valleys it appears to be unusually wide, ranging from 4.8 km (3 mi) to about 14.5 km (9 mi), in proportion to its length.

The Nash Draw 15-minute quadrangle has been mapped previously (Vine, 1963) at a scale of 1:63,360 (1 in.=1 mi). The present mapping utilized more recent aerial photographs (U.S. Geological Survey, 1977 edition) and has been compiled at a scale of 1:24,000 (1 in.=ca. 0.38 mi) (pls. 1, 2, 3, 4).

The present work was oriented toward the distinctive problems encountered at the proposed nuclear Waste Isolation Pilot Plant (WIPP) which is about 6-9.7 km (4-6 mi) east of Nash Draw (fig. 1). The WIPP is a proposed repository site for nuclear waste in beds of salt about 665 m (2,000 ft) beneath the surface. A major problem that is being addressed at the WIPP site is whether or not the salt beds are geologically stable; the solubility of salt is a particular consideration in assessing the future integrity of the site. The current study is pertinent to that problem because dissolution is partly responsible for the formation of Nash Draw and because Nash Draw contains the most complete rock exposures for the interpretation of geologic history near the site.

This study was done in cooperation with Sandia National Laboratories, Waste Management Technology Department on behalf of the U.S. Department of Energy. R. E. Kelley of the U.S. Geological Survey assisted in much of the mapping.

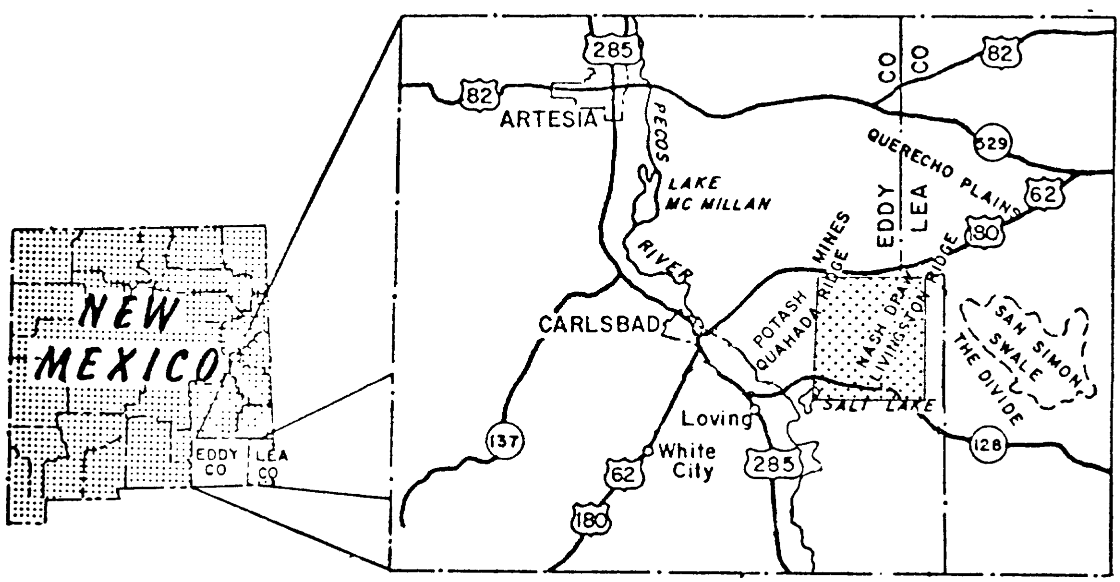

Figure 1.--Index map of southeastern New Mexico showing location of Nash Draw quadrangle (stippled).

1/4 sec. 17, T. 22 S., R. 31 E.), indicate the thickness from the top of the Salado to its marker bed 101 is about 35.7 m (117 ft); in Nash Draw this interval has been reduced by dissolution and ranges from 6.3 to 20.5 m (24 to 78 ft).

SUMMARY

Geologic mapping of the Nash Draw area was undertaken to help evaluate the geologic stability of the proposed nuclear Waste Isolation Pilot Plant (WIPP). The mapping indicated the following:

1. Nash Draw is a topographic depression resulting in part from dissolution of soluble rocks in the Rustler Formation relatively near the surface.
2. Dissolution and erosion are presently active in Nash Draw, but the major part of this feature formed before and during Pleistocene Gatuna time about 600,000 years ago.

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STRATIGRAPHY

The stratigraphic sequence in Nash Draw and at the WIPP site has been discussed by various authors (Bachman, 1974; Jones, 1973; Vine, 1963). Therefore, the stratigraphy in Nash Draw is only summarized here (table 1).

GEOMORPHOLOGY

Nash Draw is a partially closed depression that is the result of both dissolution and erosion. Evaporite-bearing Permian rocks (Rustler Formation) underlying Nash Draw have been dissolved to form caves, sinks, and tunnels in a complex karst topography. At places in the southern part of Nash Draw, relatively undisturbed strata of the Pleistocene Gatuna Formation rest directly on extensively brecciated rocks of the Permian Rustler Formation. At other places, the Gatuna itself collapsed into sink holes during its deposition. This suggests that Nash Draw formed before and during Pleistocene Gatuna time (600,000 yrs ago) but is still undergoing modification by these processes.

Livingston Ridge is the eastern rim of Nash Draw and the western edge of an extensive geomorphic surface which extends across the WIPP site. The Maroon Cliffs, a northward extension of Livingston Ridge, are being eroded by headward cutting. The broad geomorphic surface is capped by the Mescalero caliche which is, in turn, overlain by the Berino paleosol and windblown sand. The sand occurs as various dune forms, but relatively stabilized coppice dunes are most common.

Playas, or dry lakes, are common in the southern part of Nash Draw. The largest of these, Salt Lake, which is usually covered by saturated brine. However, at various times in the past it has been dry and wind has deflated gypsiferous silt to form blanket deposits along the east and northeast edges of Salt Lake. These deposits no longer have dune forms, but steep eolian bedding is still preserved internally in the deposits.

Collapse sinks are common throughout Nash Draw and at places have coalesced to form prominent basins; the basin of Salt Lake may have been caused by one of these. Remuda Basin is very clearly a result of collapsed sinks and active sinks occur along its western margin.

There are no perennial streams in Nash Draw. However, a unique drainage system transects some of the higher elevations of Livingston Ridge. An arroyo drains westerly from Hill Tank (NW 1/4 sec. 24, T. 22 S., R. 30 E.) and empties into active collapse sinks in the central part of Nash Draw. Erosion is the active process at the head of this arroyo, whereas dissolution is the active process at its toe. In the vicinity of Hill Tank, the Mescalero caliche has been removed, or was never deposited, over an area of about one-quarter section.

DISSOLUTION IN NASH DRAW

Lee (1925) described the process of "erosion by solution and fill." He observed that sink holes and systems of underground passages are formed in soluble rocks and that surface drainage deposits sediment and collapse debris in these cavities. During the early stages of this process, water permeates fractures in soluble rocks to reach permeable subsurface horizons. At an intermediate stage, the fractures are widened by dissolution to form open cavities, or grikes, which connect with the subterranean passages. Incipient collapse sinks form at this stage as the walls of the grike fracture parallel to joints. At a later stage after most of the evaporites have been dissolved, the collapse sinks may be filled completely by sediments and are expressed on the surface as closed depressions or hummocky terrain.

Table 1.--Summary of stratigraphic units in vicinity of Nash Draw

Geologic age		Absolute age (yrs)	Formation	Thickness in meters (ft)	Lithology and conditions of deposition
QUATERNARY	HOLOCENE	~10,000	Mescalero sand	0-10 (0-30)	Well sorted, windblown sand. Yellowish brown. Forms dunes of various types. Indicates arid to semiarid environment.
QUATERNARY	PLEISTOCENE	~300,000	Berino soil	0-1 (0-3)	Reddish brown, slightly clayey paleosol. Absence of carbonates indicates moderate infiltration. Began forming under more humid conditions than present.
QUATERNARY	PLEISTOCENE		Unnamed spring deposits	0-5 (0-16)	Light gray, friable gypsite. Contains snails, ostracodes, root casts, camel and horse bones.
QUATERNARY	PLEISTOCENE	~500,000	Mescalero caliche	0-2 (0-7)	Calcium carbonate-cemented sand. May engulf underlying rock. Usually with distinctive morphology of loose nodular carbonate in lower half and massive carbonate in upper half. Top 2-5 cm may be laminated. Formed on very stable surface as soil carbonate.
QUATERNARY	PLEISTOCENE	600,000+	Gatuna Formation	0-45+ (0-150+)	Clay, sand, gravel. Most commonly reddish brown but at places yellowish brown windblown sand is present. Gravels fill ancient channels. Formation may be more than 250 m (820 ft) thick in subsurface south of Nash Draw. Contains deposit of Pearlette type O volcanic ash (age ca. 600,000 yrs) on east side of Nash Draw (NW 1/4 sec. 29, T. 21 S., R. 31 E.).
TRIASSIC	LATE TRIASSIC		Dockum Group	0-62+ (0-205+)	Reddish-brown to greenish-gray conglomeratic sandstone and shale. Deposited in stream channels and on mud flats. More than 450 m (1,475 ft) thick to the east of WIPP site.
PERMIAN	OCHOAN SERIES		Dewey Lake Red Beds	50-155+ (165-500+)	Light-reddish-brown thin-bedded shale, siltstone, and fine-grained sandstone.
PERMIAN	OCHOAN SERIES		Rustler Formation	90-130 (300-430)	Mostly anhydrite, gypsum, and some halite in subsurface. Includes two dolomite members, the Culebra and Magenta, which are separated by evaporites about 36 m (120 ft) thick. In Nash Draw interval is shortened by dissolution of the evaporites.
PERMIAN	OCHOAN SERIES		Salado Formation	533-600 (1,760-1,976+)	Not exposed in Nash Draw. In subsurface consists mostly of halite with complex mixture of potash minerals. Minor beds of anhydrite.
PERMIAN	OCHOAN SERIES		Castile Formation	412-433 (1,360-1,430)	Not exposed in Nash Draw. In subsurface consists of anhydrite with interbeds of halite, and minor amounts of limestone.

This process is presently active throughout Nash Draw. Grikes and collapse sinks are common in the central part of the draw (southwesterly from sec. 28, T. 21 S. R. 30 E.). Dissolution of the soluble rocks at these places has increased the stream gradiant and has resulted in active headward cutting by the drainage in the northern part of Nash Draw.

The process of erosion by solution and fill is responsible for the unusual proportion of width to length of Nash Draw. At present, fractures, open fissures, and incipient collapse sinks are more common along the flanks of Nash Draw. Thus, erosion appears to be responsible for the lengthening of this depression; whereas, dissolution is primarily responsible for its widening.

Dissolution is active in gypsum beds in the Rustler Formation in the central part of Nash Draw. These exposures may even explain the presence of Nash Draw. Caverns and collapse sinks are particularly common in the Forty-niner Member at places where the process of solution and fill is active. However, these near-surface caverns and sinks do not penetrate deeply into the subsurface. In the central part of Nash Draw dissolution has occurred preferentially along stratigraphic horizons within the Rustler Formation rather than vertically through the formation.

An exploratory hole was drilled in a closed depression about 2.4 km (1.5 mi) east of Livingston Ridge (WIPP-33, NE 1/4 SW 1/4 sec. 13, T. 22 S., R. 30 E.) to determine if the depression was the result of dissolution and collapse and to determine if dissolution has been active in beds underlying the Rustler Formation. In this drill hole the following sequence was encountered:

Dewey Lake Red Beds (108.8 m (357 ft) thick)
Rustler Formation (83.5 m (274 ft) thick)
Salado Formation (only 49 m (161 ft) penetrated)

There is no evidence of collapse in the Dewey Lake Red Beds, although the formation is about 9.8 m (32 ft) thinner than in drill holes located about 1.3 km (0.8 mi) to the northeast.

The Rustler Formation in WIPP-33 is cavernous throughout much of its interval where dissolution has been active. However, the upper 49 m of the underlying Salado Formation at this place is complete and has been no more dissolved than in adjacent drill holes.

In Nash Draw, about 3.3 km (2 mi) west of the drill hole, spring deposits composed of gypsite are interbedded with Quaternary colluvium. The effluent of these springs is preserved as a northeasterly trending alinement of gypsite mounds (E 1/2 sec. 15, T. 22 S., R. 30 E.). The spring deposits are believed to have resulted from evaporation of ground water which drained from the surface into fractures and circulated through and dissolved the Rustler Formation in the vicinity of drill hole WIPP-33. A fauna of camel, horse, and related Pleistocene forms is preserved in these spring deposits.

Uranium-trend ages of the spring deposits and some bones have been determined by J. N. Rosholt of the U.S. Geological Survey. The indicated ages range from 26±4,000 to 430±80,000 years. Age determinations on the tooth enamel are lowest and rnage from 26± 4,000 to 32±4,000 years. Determinations on bone range from 60±6,000 to 169±14,000 years but the spring deposits themselves appear to be 430±80,000 years. One interpretation of this discrepancy is that the various media "adsorbed" different quanities of uranium late in the history of the bone/gypsum environment (J. N. Rosholt, written commun., 1979). Further work is needed on these deposits.

Five other exploratory holes were drilled in Nash Draw to determine the extent of of dissolution and are summarized in table 2. The data indicate an irregular dissolution surface on the Salado Formation. Stratigraphic sections in the eastern part of the Nash Draw Quadrangle, where there is no evidence for dissolution of the Salado (WIPP-12, SE

Table 2.--Summary of exploratory drill holes in Nash Draw

[Intervals in feet are from geophysical logs in basic data reports: Drellack and Snyder, 1979a, b; Jones and McIntyre, 1979; Snyder and McIntyre, 1979; Gonzales and Jones, 1979. To convert to metric use the following: foot X 0.3048 = meter. MB=marker bed]

Location		Interval thickness				
		Rustler	Salado dissolution residue	Top Salado to 101 MB	101-105 MB	101-109 MB
WIPP 25	SW 1/4 sec. 15, T. 22 S., R. 30 E.	331 ft	35 ft	24 ft	51 ft	109 MB not recognized
WIPP 26	NE 1/4 sec. 29, T. 22 S., R. 30 E.	299 ft	11 ft	67 ft	94 ft	109 MB not recognized
WIPP 27	NW 1/4 sec. 21, T. 21 S., R. 30 E.	269 ft	88 ft	78 ft	105 MB not recognized	45 ft
WIPP 28	NE 1/4 sec. 18, T. 21 S., R. 31 E.	216 ft	58 ft	36 ft	31 ft	127 ft
WIPP 29	SE 1/4 sec. 34, T. 22 S., R. 29 E.	131 ft (Rustler Fm. at surface)	105 ft	32 ft	105 MB not recognized	53 ft

EXPLANATION for Plates 1-4 Open-File Report 81-31

QUATERNARY

Holocene

Qa — Alluvium and colluvium

Qs — Windblown sand

Qsd — Active and stable sand dunes

Qsg — Gypsum sand

Qt — Mine tailings

Qp — Playa deposits

Pleistocene

Qy — Gypsite spring deposits

Qc — Mescalero caliche

Qg — Gatuna Formation

Unconformity

TRIASSIC

Upper Triassic

TRu — Dockum Group, undivided. Continental deposits including reddish-brown shale, sandstone, and conglomerate

PERMIAN

Ochoan

Pdl — Dewey Lake Red Beds. Reddish-brown, fine-grained sandstone

Pr (Prf, Prm, Prt, Prc) — Rustler Formation. Gypsum, with interbeds of dolomite. Includes light-reddish-brown, clayey, insoluble residues. Prf, Forty-niner Member; Prm, Magenta Dolomite Member, Prt, Tamarisk Member, Prc, Culebra Dolomite Member. Note: Prmb and Prcb (pl. 3) indicate breccia

EXPLANATION for Plates 1-4 Open-File Report 81-31--Continued

Contact

Linear feature observed on air photos

Linear feature (fracture?) observed in field and on air photos

Fracture, barb showing direction of slump

Scarp (incipient collapse sink?)

Dome

General component of slope

SK Collapse sink

Large-scale collapse sink

Anticline showing direction of axial plunge

Caliche quarry

WIPP 12 Drill hole