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# The Los Medaños Member of the Permian (Ochoan) Rustler Formation

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### Abstract

We propose Los Medaños Member as the formal name for the lower part of the Upper Permian (Ochoan) Rustler Formation, below the Culebra Dolomite Member, in the northern Delaware Basin. The stratotype is at the exhaust shaft of the Waste Isolation Pilot Plant (WIPP) site in sec 20 T22S R31E, Eddy County, New Mexico. The name is derived from the nearby sand dune field (Los Medaños) and the quadrangle map of the same name. Cores of the Los Medaños from WIPP studies correspond to the exhaust-shaft geology, though larger features revealed in the shaft must be inferred. Geophysical log signatures permit regional correlations and interpretation of lithology. Outcrops of this unit are poorly exposed and have been little studied. Recent radiometric ages from correlative units in the Texas panhandle suggest that the top of the Rustler is near the Permian–Triassic boundary.

The stratotype consists of 34.4 m of siliciclastics, halitic mudstones, muddy halite, and sulfates (mainly anhydrite). Bedding, invertebrate fossil remains, and bioturbation indicate a saline lagoon with connections to open marine water, in contrast to the shallow-water, desiccating evaporite cycles of the underlying Salado Formation. The lagoon was generally drying up, with some periods of subaerial exposure, as the Los Medaños was deposited. The uppermost claystone marks the transgression that deposited the overlying Culebra Dolomite.

### Introduction

"…it is nearly impossible to piece together suitable stratigraphic sections from surface exposures alone." So wrote J. D. Vine (1963) about the Permian (Ochoan) Rustler Formation in the Nash Draw area of central Eddy County in southeast New Mexico (Fig. 1). Because soluble evaporites constitute much of the formation, it crops out poorly. While the general stratigraphy of the Rustler (Fig. 2) is well known from geophysical logs, very little detail of the geology of the formation was described before the 1980s.

Large diameter (~6 m) shafts at the Waste Isolation Pilot Plant (WIPP) site in the northern Delaware Basin, however, have provided unrivaled exposures of the Rustler to correspond with cores, geophysical logs, and the limited outcrops in our study area (Fig. 1; Holt and Powers, 1984, 1986, 1988, 1990). Along with details about the four formal members of the Rustler, WIPP shafts expose the lower part

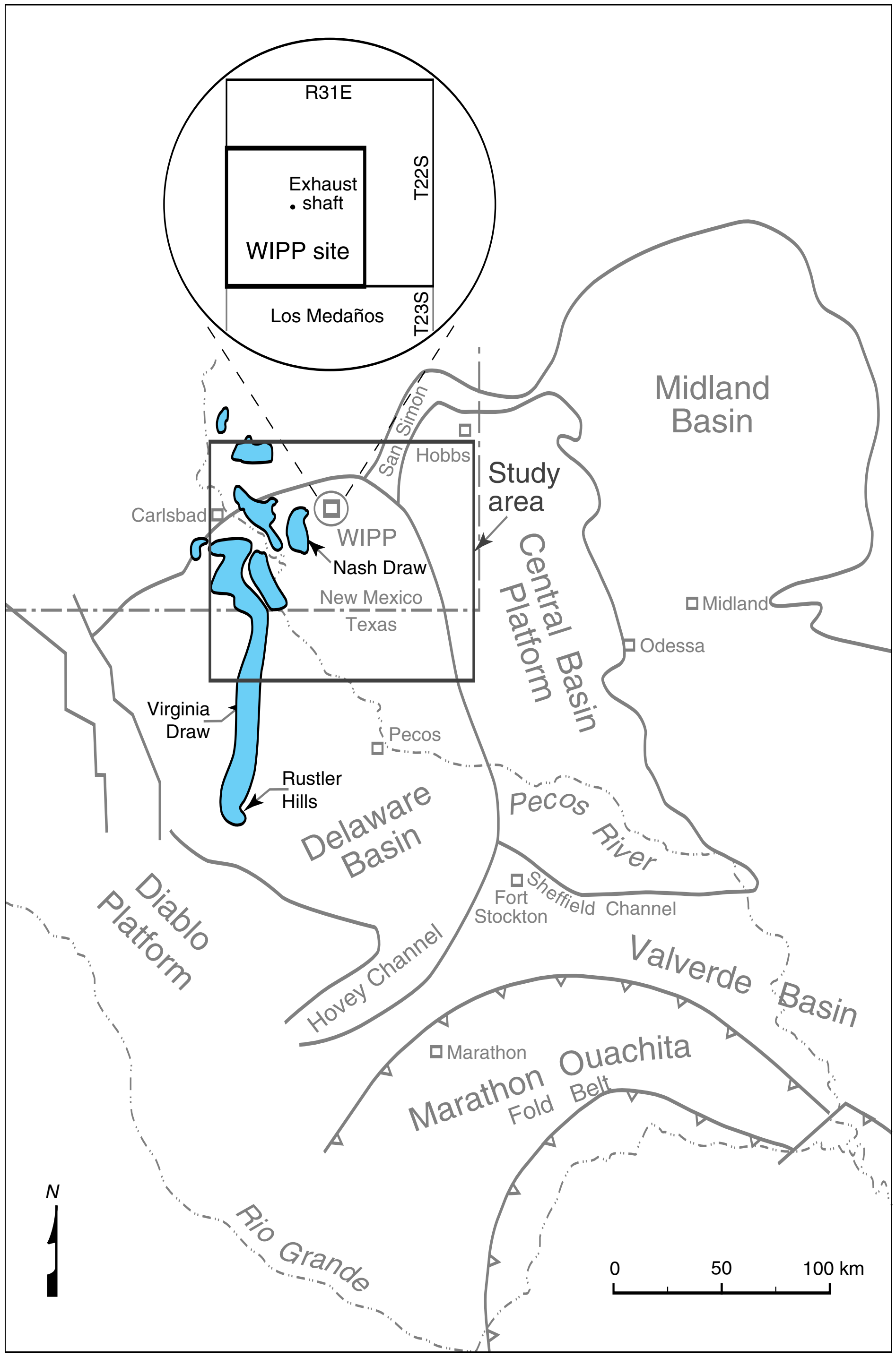


FIGURE 1—General location map of area studied; Rustler Formation outcrops are shown in blue. The exhaust shaft at the WIPP site is the stratotype location for the Los Medaños Member, and the stratotype is named after the sand dune area south of WIPP and the quadrangle map including the area. The nearest Rustler outcrops to the stratotype are in Nash Draw, west of WIPP. The Rustler was named for outcrops in the Rustler Hills. (modified from Hills, 1984)

| SYSTEM / Series | | Formation | Members |
|---|---|---|---|
| TRIASSIC | | Santa Rosa | |
| | | Dewey Lake | |
| PERMIAN | Ochoan | Rustler | Forty-niner |
| | | | Magenta Dolomite |
| | | | Tamarisk |
| | | | Culebra Dolomite |
| | | | **Los Medaños** (proposed formal name for "unnamed lower member") |
| | | Salado | |
| | | Castile | |

FIGURE 2—The Los Medaños Member is the lower part of the Rustler Formation, between the Salado Formation and the Culebra Dolomite Member. Note that we have included the Dewey Lake Formation in the Triassic System, based on the work of Renne et al. (1996) in the Texas panhandle.

of the formation, which has remained unnamed because of poor outcrops and was little studied before the WIPP project.

Here we describe the lithology of the lower Rustler, propose Los Medaños Member as the formal name for this unnamed member, and relate geophysical log signatures to lithology. This will provide a basis for further, efficient communication about the Rustler and its geological significance for understanding the final stages of deposition within the Delaware Basin.

## Rustler stratigraphy

### History of Delaware Basin studies

Richardson (1904) described approximately 45 m of sandstone and pitted, magnesian limestone outcrops in the Rustler Hills near Rustler Springs, Culberson County, Texas, and he named this unit the Rustler Formation. The Rustler Hills outcrops are equivalent to the lower part of the Rustler in our study area. Some early work on the Rustler in the southern Delaware Basin was conducted as part of exploration for sulfur deposits (Porch, 1917).

As part of his work on delineating the Upper Permian in the Delaware Basin, Lang (1935) described Rustler core from eastern Loving County, Texas, as providing "type material for the formations of the Delaware Basin." The lower Rustler was described as less than 3 m of red beds. Lang (1938) attributed outcrops that total approximately 150 m in thickness along the Pecos River in Eddy County, New Mexico, to the Rustler, but we believe the lower 40 m is a residue from solution of the upper Salado Formation (Fig. 2).

Because it crops out poorly, the Rustler is not well known from surface exposures anywhere. Adams (1944) used subsurface geology to demonstrate continuity of the Rustler across the Delaware Basin and the relationship of the Rustler to the underlying Salado and overlying red beds. Vine (1963) included a general lithologic log of the Rustler from drill hole AEC 1 (located in sec 34 T23S R30E) and described beds 109 m thick. Gard (1968) described some important details of the Rustler from shaft mapping for Project Gnome, a test detonation of a nuclear device in the underlying Salado Formation. The Rustler was later addressed as part of U.S. Geological Survey (USGS) studies to assess southeast New Mexico as a potential site for a radioactive-waste repository in bedded salt before WIPP was initiated (Brokaw et al., 1972; Jones et al., 1973; Bachman, 1974).

Since the middle 1970s, the Rustler has been studied intensively in southeast New Mexico as part of the WIPP project. Geological and hydrological studies (e.g., Beauheim, 1987; Beauheim and Holt, 1990; Beauheim and Ruskauff, 1998; Holt, 1997) of the unit are generally complete under this U.S. Department of Energy (DOE) program. Bachman (1981) remapped Nash Draw, where the Rustler crops out nearest the WIPP site (Fig. 1). A variety of sources provide background for geological and hydrological studies of the Rustler and the WIPP project, in general (e.g., Powers et al., 1978; Weart, 1983; Lappin, 1988; Powers and Martin, 1992; or the WIPP web page at www.wipp.carlsbad.nm.us/library/cca/cca.htm).

In the southern part of the Delaware Basin, the Rustler is of some interest hydrologically and as a sulfur prospect (e.g., Eager, 1983; Wallace and Crawford, 1992; Miller, 1992). Weber and Kottlowski (1959) noted the Rustler in evaluating gypsum resources in New Mexico.

### Nomenclature of the Rustler

A type section, per se, of the Rustler does not exist. The Rustler Hills area in Texas serves as a general type area, though a full section is not well displayed.

Adams (1944) used the names Culebra Dolomite and Magenta Dolomite (Fig. 2) for the two carbonate members of the Rustler in this area of southeast New Mexico. In reviewing the stratigraphic section prepared by Lang (1938), Adams stated that "Lang favors" these names based on outcrops at Culebra Bluff (along the Pecos River) and Magenta Point (in Nash Draw), though Lang (1938) did not actually use the names in print. Vine (1963) introduced two new names to formalize the more sulfatic members. Vine named the Forty-niner Member after a small ridge (Forty-niner Ridge) on the east side of Nash Draw. A mainly sulfatic unit between the Magenta and Culebra was named the Tamarisk Member after outcrops near Tamarisk Flat in Nash Draw. The lower part of the Rustler remained unnamed because it crops out poorly over the entire region. The most common designation is "unnamed member" or "unnamed lower member." Powers and Holt (1990) reported the intent to formally name this member the Los Medaños Member, but that paper was never submitted for publication. Lucas and Anderson (1994) named this interval the Virginia Draw Member, from Virginia Draw in the Rustler Hills of Texas (Fig. 1). They reported that "[a]t its type section, the Virginia Draw Member is 20 m thick and consists of interbedded sandstone, limestone and dolomite…. These beds weather buff, orangish-brown and gray. The sandstones are fine-grained and quartzose, display flaser beds and indistinct crossbeds, and locally are bioturbated. Kaolinite and gypsum inclusions are present locally. The base of the Virginia Draw Member is a sandstone bed disconformably overlying gypsum of the Castile Formation …." Hill (1996, p. 138) lists the members of the Rustler as "… the Virginia Draw (Unnamed), Culebra, Tamarisk, Magenta, and Forty-niner…, a five-fold division first proposed by Vine (1963)." Though Vine did show five members, he left the lower part unnamed.

In the vicinity of the WIPP site, the unnamed lower member is dominated by fine-grained clastics (siltstones, claystones, and mudstones) and evaporite beds. The evaporites include anhydrite or polyhalite as well as halite with various admixtures of fine-grained clastics. Dolomites are not present, and sandstone is uncommon. Sedimentary structures, bedding, bioturbation, and some fossils occur in the northern Delaware Basin. We believe that the fully expressed lower Rustler facies in the northern Delaware Basin differ sufficiently from the southern part of the basin, as described by Eager (1983) or Lucas and Anderson (1994), to justify a different name.

Vine (1963) did not attempt to describe lithologic sections based on outcrops; he used drillhole AEC 1 as a reference section for his report. We also rely on our lithologic descriptions of cores and shafts as a basis for interpreting the Rustler, and we use our description of the exhaust shaft as the basis for the type section.

### Extent and stratigraphic equivalents

The Rustler is best known within the Delaware Basin, though it also exists within the Midland Basin (e.g., Page and Adams, 1940; Mear, 1968) and on the intervening Central Basin platform. The Rustler also extends north of the Delaware Basin, with equivalents (the Alibates Formation) in the panhandle of Texas and Oklahoma (Johnson, 1978).

### Los Medaños Member of the Rustler Formation (new stratotype)

We propose Los Medaños Member as the formal name for the lowest member of the Rustler Formation between the underlying Salado Formation and the overlying Culebra Dolomite Member of the Rustler in the northern Delaware Basin. The Los Medaños Member is a lithostratigraphic unit of regional importance, and we intend the name to replace the informal "lower member" or "unnamed lower member" for this area. The Los Medaños Member is apparently equivalent to the "Virginia Draw Member" (Lucas and Anderson, 1994) in the southern Delaware Basin, though the type section of the Virginia Draw is quite different in lithology and is reported to lie disconformably on the Castile Formation at the type section. The Los Medaños Member is well displayed on geophysical logs throughout most of the eastern half of the Delaware Basin, and sedimentologic details for this member can now be based on shafts and cores from the WIPP site. Outcrops in the western part of the Delaware Basin are disrupted, primarily by dissolution of salt from the underlying Salado.

The geographic name (Los Medaños) is derived from the map name for the sand dune field, for which the map quadrangle is named, near the WIPP site. [The more common Spanish form is Los Médanos.] The type section was described from the exhaust shaft at the WIPP site (Holt and Powers, 1986), and the Los Medaños area

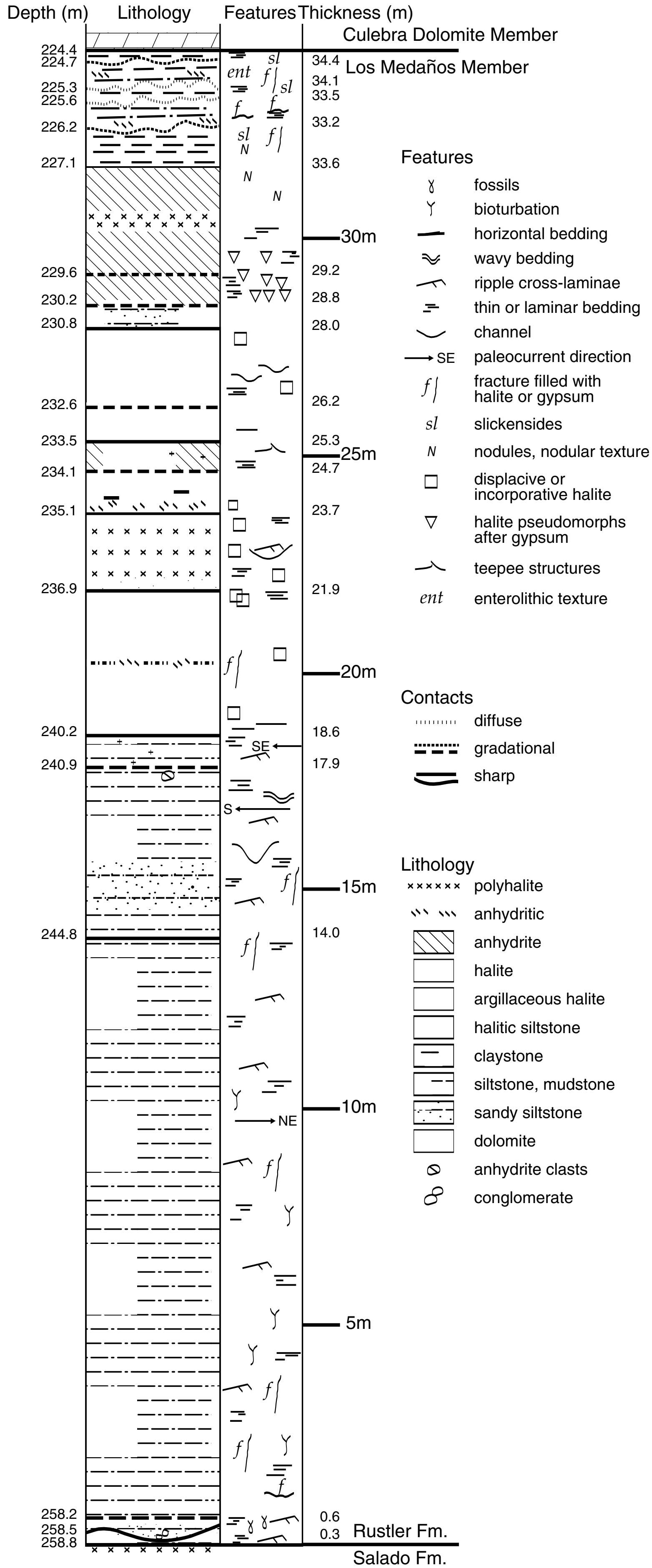


FIGURE 3—Los Medaños lithology and sedimentary features at the exhaust shaft stratotype.

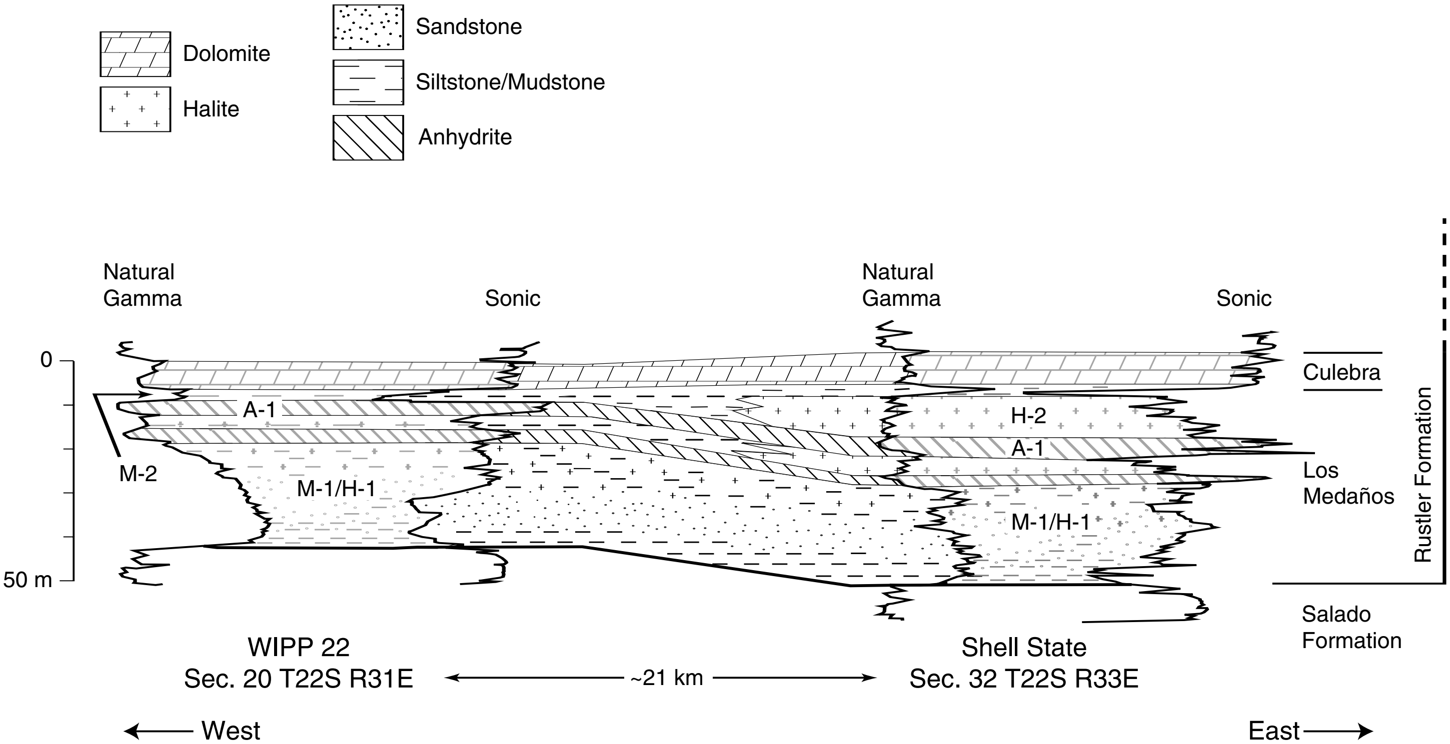


FIGURE 4—Two geophysical logs of the Los Medaños Member illustrate lithological changes from the WIPP area (WIPP 22) to the east (Shell State). Informal names (M-1/H-1, A-1, M-2, H-2, or intermediate M-2/H-2) have been used in much of our recent work to communicate more detail.

can be considered the type area. The member does not crop out in the type area, and nowhere is it well exposed in outcrops.

The type section consists of 34.4 m of mainly siltstone, mudstone, claystone, anhydrite, and halite (Fig. 3). A detailed lithologic description of this section from the exhaust shaft at the WIPP site (sec 20 T22S R31E, Eddy County, New Mexico; New Mexico grid coordinates Y 499287.23, X 667370.39) is included (Table 1).

The basal contact of the Los Medaños Member is placed at the top of a thin bed of Salado sulfate that is traceable in cores from the area. It is immediately overlain by siltstones that form the bulk of the member. The boundary is not as distinct in the central and western parts of the basin, where complex relationships between the Salado and Rustler are interpreted as the result of post-depositional dissolution of Salado halites. Any such residue should be treated stratigraphically as part of the Salado (Jones et al, 1960, 1973; Vine, 1963; Bachman, 1974). Holt and Powers (1988) report erosion near this contact, demonstrating that post-depositional dissolution does not complicate the boundary at the reference location, though upper Salado halite has been dissolved farther west.

The upper boundary of the Los Medaños Member is the contact between a gray claystone or siltstone and the base of the Culebra Dolomite Member. It may range from sharp to gradational over a few centimeters. The contact is conformable, though these soft mudstones and claystones are locally deformed (undulatory) in the type section over approximately 60 cm.

The Rustler is covered by concrete or liner plate in all WIPP shafts. Several cores of the Rustler, however, are stored at the WIPP site and provide good reference material. WIPP 19, approximately 700 m north of the exhaust shaft, is a good core relatively close to the shafts. Holt and Powers (1988) provide additional data from these cores.

The Los Medaños Member is clearly manifested on geophysical logs over the Central Basin platform and over the Northwestern shelf, north of the Delaware Basin. Some regional facies changes are interpreted through the geophysical logs, though these are only partially reflected in the shafts and cores from a more limited area. For example, halite content definitely increases toward an interpreted depocenter. Two geophysical logs of the Los Medaños Member show the relationship between the WIPP site area and the northern end of the depocenter (Fig. 4).

Where it can still be reasonably identified in the study area, the Los Medaños Member ranges in thickness from the maximum of 63 m to a minimum of 7.6 m. It is most difficult to recognize clearly and extend the Los Medaños Member to areas thinned by erosion and where dissolution of the upper Salado produced a residue that is grossly similar to the Rustler siltstones.

The Los Medaños Member was deposited in near-marine to saline lagoon and desiccating continental salt pans and subaerially exposed mud flats (Holt and Powers, 1988; Powers and Holt, 1990). Laminae, ripple cross-laminae, and bioturbation in the lower part are consistent with a relatively low energy lagoon. Small channels, evaporite minerals, and evaporite textures high in the section indicate that the lagoon was desiccating in general, forming a series of saline pans. Some halitic mudstones show mineral truncations indicating the saline pan was subaerially exposed. The uppermost claystone was deposited as part of the transgression that formed the Culebra Dolomite Member.

The age of the entire Rustler is commonly accepted as Late Permian, mainly on the basis of a limited invertebrate fauna, and the formation is assigned to the Ochoan Series (Donegan and DeFord, 1950; Walter, 1953; Croft, 1978; Hills and Kottlowski, 1983; Wardlaw and Grant, 1992). Recent radiometric (Ar–Ar) ages on sanidines from volcanic ash beds near the base of the Quartermaster Formation in the panhandle of Texas place the Permian–Triassic boundary near the contact of the Quartermaster and Alibates (Renne et al., 1996). As have others (e.g., Johnson, 1978; Schiel, 1988, 1994; Lucas and Anderson, 1993), we accept the general lithologic and stratigraphic equivalence of Alibates to Rustler and Quartermaster to Dewey Lake Formation in southeast New Mexico. It seems very likely, as Schiel (1988) postulated, that the Rustler represents the end of the Permian in southeast New Mexico and that the Dewey Lake is Triassic (Fig.

TABLE 1—Description of type section of Los Medaños Member, Rustler Formation, from the exhaust shaft, Waste Isolation Pilot Plant. Total thickness is 34.4 m.

| Depth (m) to unit base | Description | Thickness (m) |
|---|---|---|
| 224.4 | Base of Culebra Dolomite Member; top of Los Medaños Member; contact undulatory over approximately 0.6 m around circumference of shaft. | |
| 224.7 | Claystone; gray at top and bottom, grayish-maroon with thin (<3 mm) interbeds colored red and brownish-gray; thin laminae parallel to upper contact, nearly fissile; poorly indurated, soft; slickensides parallel to bedding; basal contact gradational. | (0.3) |
| 225.3 | Siltstone, argillaceous, to argillaceous claystone upward; reddish-brown to maroon with red and gray interbeds; broken interbeds of gray, finely to medium-crystalline anhydrite; 6-mm gypsiferous beds with poorly preserved enterolithic structure; rare gypsum-filled fractures; basal contact diffuse, very undulatory. | (0.6) |
| 225.6 | Claystone, slightly silty, greenish-gray, includes local reddish-brown areas; some thin laminae and some slickensided laminae; poorly indurated; thin (<6 mm) fibrous gypsum-filled fractures continuous through unit into underlying and overlying units; upper and lower contacts sharp to gradational, undulatory. | (0.3) |
| 226.2 | Siltstone, argillaceous, to silty claystone upward; reddish-brown; siltstone thinly laminated, claystone structureless to faint thin laminae; slickensides common in claystone. Only siltstone is present where unit thins. Lower siltstone includes 2.5–5-cm broken bed of argillaceous anhydrite. Abundant 1–2.5-cm thick gypsum-filled fractures are mainly horizontal to subhorizontal. Basal contact is gradational, undulatory. | (0.6) |
| 227.1 | Claystone, silty; reddish-brown with zones of greenish-gray; thin laminae, moderately poorly indurated in lower 0.6 m, very poorly indurated upper part; abundant gypsum nodules to 5-cm diameter in lower 0.6 m. Fibrous gypsum-filled fractures (1–6 mm thick) are abundant higher in unit. Basal contact is sharp, slightly undulatory. | (0.9) |
| 229.6 | Anhydrite, fine-crystalline; light-gray; laminar to nodular; upper 15–45 cm white, gypsiferous, with radial gypsum crystals; zone of mixed reddish-pink polyhalite and anhydrite 0.3 m thick in middle of unit, polyhalite more abundant in lower part of zone, with abrupt basal change; halite pseudomorphs (1–5 cm high) after gypsum swallowtails approximately 0.3 m above basal contact; basal contact gradational, marked by zone of horizontal vugs filled with anhydrite. | (2.5) |
| 230.2 | Anhydrite, fine-crystalline; light-brown to gray; thin laminae to laminae, bedding flat to slightly undulatory; abundant small (<1 cm high) halite pseudomorphs after gypsum swallowtail crystals in lower third; halite pseudomorphs after gypsum swallowtails up to 5 cm high between laminar zones in middle third, with some pseudomorphs slightly crushed; less bedding, fewer pseudomorphs in upper third; basal contact sharp, slightly undulatory. | (0.6) |
| 230.8 | Mudstone, sandy; dark reddish-brown, greenish-gray in upper 15–20 cm; thin laminae to thin beds; 1–2% halite; basal contact sharp, possibly erosional. | (0.6) |
| 232.6 | Mudstone, halitic, and halite, argillaceous; reddish-brown; thin laminae near base; clear displacive halite >2.5 cm near base to <1 cm upward. Small (<1 cm) greenish-gray spots are scattered through lower half of unit; small channels in southeast quadrant; basal contact gradational. | (1.8) |
| 233.5 | Halite, argillaceous; reddish-brown matrix, pink to white halite. Some halite crystals include primary fluid-inclusion zones. Clay content 10–15%, decreases upward, occurs both as interstitial material and as crude beds. Basal contact is gradational. | (0.9) |
| 234.1 | Anhydrite, fine-crystalline; gray. Laminae to thin beds in lower 10–15 cm, bedding not observed in middle 20–30 cm, upper 25–30 cm lighter in color and includes 5–10% clear halite in irregularly shaped horizontal vugs. Halite occurs in slightly distorted anhydrite, with bedding tilted in teepee-like structures. Basal contact is sharp to gradational. | (0.6) |
| 235.1 | Halite with interbedded anhydrite and claystone; basal contact sharp. | (1.0) |
| | *Basal 0.3 m:* gray anhydrite with small displacive halite in lower 2.5 cm. Argillaceous halite, with increasing clay content upward, overlies anhydrite. Halite is white to pink, mostly clear, with some primary fluid inclusions. Halite grades upward to reddish-brown mudstone in upper 2 cm. | |
| | *Upper 0.7 m:* 5 cm basal gray anhydrite interbedded with thin laminae of reddish-brown mudstone with small (<1 mm) displacive halite; coarsely crystalline, white to pink, clear halite with 10–20% primary fluid-inclusion zones interlaminated with anhydrite (1–2 mm thick); laminae erosionally terminated at top; dark reddish-brown mudstone overlies halite. | |
| 236.9 | Halite, argillaceous, some halitic sandy mudstone near base; reddish-brown; distinct thin laminae to very thin beds; lower half more halitic, displacive halite 1 mm–2.5 cm across; small (<6 mm) displacive halite in upper part; bedding deformed and disrupted around larger displacive halite; cross-laminae in slight trough in southeast quadrant; basal contact sharp, slightly undulatory, possibly disconformable. | (1.8) |
| 240.2 | Halite, argillaceous, and halitic mudstone; dark reddish-brown; crudely bedded near base, coarse to thin beds at top; halitic mudstone in lower 0.4 m and upper 0.3 m, argillaceous halite in middle with halite content increasing upward. Halite is displacive, has fluid inclusions, halite size increases upward from 1 mm to 2.5 cm. Gray anhydritic mudstone (6–12 mm) is 1.68 m above base. Basal contact is sharp, slightly undulatory. | (3.3) |
| 240.9 | Siltstone, sandy and halitic; alternating reddish-brown and gray; thin beds to thin laminae, bedding horizontal to wavy to cross-laminae, sets 6–12 mm thick with variable current directions; southeastward directions prevail; small (<1 mm) displacive halite; basal contact gradational, marked by gray color above contact. | (0.7) |
| 244.8 | Siltstone and sandy siltstone; light-brown to reddish-brown interbedded with thin layers of medium-gray claystone and mudstone; thin beds to microlaminae in units 20–50 cm thick, horizontal to subhorizontal bedding with some wavy bedding and cross-laminae; large cross-cutting relationships with some units partially to wholly removed, downcutting trend to east and southeast. Small-scale cross-laminae show variable current directions, but southward directions prevail approximately 2.75 m above base; symmetrical ripples, with clay drape; sets average 6–12 mm; few anhydrite clasts 1–2.5 cm diameter 0.7 m below top; minor soft-sediment deformation due to fluid shear. | (3.9) |
| 258.2 | Siltstone and argillaceous siltstone interbedded with claystone, gray and dark-gray; thin laminae (1–3 mm); horizontal laminae and low-angle cross-laminae in sets from 5 cm to 0.9 m high. Paleocurrent directions vary, with larger sets indicating mostly northeastward directions. Load structures and erosional scour and fill are rare. High-angle halite-filled fractures are rare but more common lower in unit, and rare horizontal to subvertical halite-filled fractures 3 mm–7.5 cm thick are spaced 0.9–2.5 m near base. Dark-gray spots and mottling from bioturbation are more abundant near base, decrease upward. Gray argillaceous siltstone in lower | |

TABLE 1—continued

| Depth (m) to unit base | Description | Thickness (m) |
|---|---|---|
| | part shows localized reddish-brown areas. Brownish clasts of anhydrite (3 mm–3.8 cm), rounded to somewhat flattened parallel to bedding, are scattered through unit. Basal contact, somewhat gradational over 1 cm, shows undulations of 0.6–0.9 m. Note: slabbed cores from nearby (< 0.5 km) drillholes better display mottling, bioturbation, and casts and molds of small (6-mm) invertebrates, probably pelecypods, in this unit. | (13.4) |
| 258.5 | Siltstone, sandy, with argillaceous siltstone at top; reddish-brown with gray areas; fine laminae and moderately abundant low-angle cross-laminae; brown clasts of anhydrite throughout, concentrated near top. Smaller clasts are partially aligned in zones parallel to bedding; basal conglomerate of rounded to subangular, poorly sorted pebbles of gray, fine sandstone in light-gray to black matrix of siltstone. Conglomerate also contains fragments of fossil bivalves. Thin, black laminae are throughout unit; smells petroliferous when broken. Basal contact is sharp, erosional, and undulatory; shows soft-sediment loading of conglomerate into underlying unit. | (0.3) |
| 258.8 | Siltstone, reddish-brown; thin laminae and cross-laminae; fines upward; basal contact gradational. | (0.3) |
| Top of Salado Formation | | |
| 259.1 | Anhydrite and polyhalite, reddish-brown to light-gray; poorly bedded to structureless, minor nodule to enterolithic features; sharp contact with argillaceous polyhalite and anhydrite with displacive halite crystals. In various WIPP reports, this unit is often taken, for mapping convenience, as the basal Rustler beds. | |

2).

## Significance of Los Medaños Member and Rustler Formation

The Rustler has some economic significance as a source of sulfur in the southern part of the Delaware Basin, and, in some areas, as a source of ground water. At and near the WIPP site, water in the Rustler is limited and of poor quality.

For the WIPP project, the Rustler figures prominently in scenarios about hypothetical releases of radionuclides. The Culebra Dolomite Member is the main water-bearing unit, and it is considered one pathway for transporting radioactive materials to the WIPP boundaries if they reach this unit. Early in the WIPP studies, the basal Los Medaños Member was considered to be a dissolution residue in areas near the WIPP and to be of hydrological significance. Early hydrological testing showed that it was not hydraulically significant at the site. Our studies at WIPP have demonstrated that the features of the basal Los Medaños are depositional and were not formed as a dissolution residue. The erosional contact and fossils just above the base of the Los Medaños in the exhaust shaft (Fig. 3, depth 258.5 m) are conspicuous evidence.

From a broader perspective, the Rustler records a major environmental transition in the evaporative end stages of a depositional basin (Holt and Powers, 1986, 1993) as well as the last tectonic events of the Delaware Basin (Holt and Powers, 1988; Powers and Holt, 1990, in press). The shafts at the WIPP have also provided unweathered exposures at a larger scale than cores, allowing us to reconstruct Rustler depositional events and reject predominant hypotheses of major post-depositional dissolution of Rustler halite in the area of the WIPP site (Holt and Powers, 1984, 1988; Powers and Holt, 1990, in press). In a more limited study of WIPP cores concurrent with some of our work, Lowenstein (1987) also reported sedimentary features of the Los Medaños Member. New sedimentary textures and features recognized, described, and interpreted from the Los Medaños Member, as well as the rest of the Rustler (Holt and Powers, 1988; Powers and Holt, 1990, in press), will help interpretation of other similar evaporite units elsewhere.

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