Geology of C-3977 (Pre-shaft Corehole) for Waste Isolation Pilot Plant (WIPP)

February 2018





Drillpad for pre-shaft corehole (C-3977) and monitoring well locations at proposed location of unfiltered exhaust shaft (UES). Image from Google Earth, dated 2/1/2017.

Front cover: Larger area showing facilities at Waste Isolation Pilot Plant and the relationship of the drilling pad for C-3977 to the site. Image from Google Earth, dated 2/1/2017.

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Geology of C-3977 (Pre-shaft Corehole) for Waste Isolation Pilot Plant (WIPP)*

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EXECUTIVE SUMMARY

C-3977 is located in section 20, T22S, R31E, in Eddy County, NM. The location is west of the current main facilities at the Waste Isolation Pilot Plant (WIPP). The drillhole was permitted by the Office of the State Engineer (New Mexico) as an exploratory hole without testing and with the provision that it be plugged and abandoned at the conclusion of work.

C-3977 was cored from 12 ft depth to 2308 ft (by drill pipe tally) to obtain reference samples and provide direct data regarding the geological conditions at the location of the proposed unfiltered exhaust shaft (UES). The core was photographed and described in the field, boxed, and put into climate-controlled, secure storage. Core recovery was very good except for shallow intervals. Rock Quality Designation (RQD) data were recorded. The cores were examined in more detail in the lab, and these data are included.

C-3977 was logged in open-hole and cased conditions with a suite of geophysical tools. At total depth (TD), a continuous (0.25 ft interval) spectral gamma log was obtained. Because of an obstruction in the hole, logging did not reach TD. Interim deviation surveys were conducted during drilling. A final deviation survey after reaching TD showed total deviation to the southwest of 20.87 ft at 2240 ft.

Near-surface geology includes dune sand, Mescalero caliche, Mio-pleistocene Gatuña Formation, and Triassic Santa Rosa Formation. The Permo-triassic(?) Dewey Lake Formation was encountered at 32.1 ft, top of Permian Rustler Formation at 503.7 ft, and top of Permian Salado Formation at 821.9 ft.

The stratigraphy and lithologies encountered compare well to the air intake shaft (AIS), with some adjustment in depth because of regional dip and variability that is natural to these lithofacies. The mapping report of the air intake shaft provides a good reference point for details of the lithology; here we include detailed descriptions of the core as well as other information.

There was no observed water inflow at C-3977 while coring with air to 250 ft depth, within the Dewey Lake. The Culebra Dolomite Member (Rustler Formation) is the most important water-bearing unit at the location; the Culebra was cored with air-mist in the upper part and with circulating brine in the lower part. There are no observations regarding Culebra water inflow or potentiometric level from C-3977.

Core samples from nearby monitor wells were tested for various geotechnical parameters. The results are summarized. Selected samples from C-3977 were provided to Cementation, Inc., for confirmation of some geotechnical parameters. The data are included in an appendix.

*This report is based on a geological team effort by Rick Salness (RES), Brett Seal (RES), Allen Hall (RES), John Thurston (RES), Robert Holt (University of Mississippi), and Dennis Powers (Consulting Geologist).

INTRODUCTION

Purpose of Waste Isolation Pilot Plant (WIPP)

WIPP is a deep geologic repository for permanent disposal of transuranic and mixed waste that are byproducts of the US nuclear defense program. The facility is located ~25 miles (40 km) east of Carlsbad, NM (Figure 1) in Eddy County.

Purpose and Location of C-3977

C-3977 (also referred to as the pre-shaft corehole [PSC]) was proposed and executed to obtain representative cores of the geology from ground level to a total depth up to 2,350 ft (~716.5 m) below ground level (bgl). The site is proposed as the location for a new shaft designated the unfiltered exhaust shaft (UES). In addition, geophysical logs would be obtained from the corehole, to include directional logging at various depths. As planned, no hydrologic testing was conducted in the PSC, and it was plugged and abandoned at the end of the drilling.

C-3977 is located in the southwest 1/4 of the southeast 1/4 of section 20, T22S, R31E. The lat/long (Figure 2) is 32° 22' 21.8757" (32.37274325°) (N), -103° 47' 56.9829" (-103.799167°) (W). The surveyed elevation is 3400.38 ft amsl.

C-3977 was permitted by the Office of the State Engineer (NM) on August 22, 2016 (Appendix A). The location as permitted was lat 32° 22' 21.88", long -103° 47' 56.99", which is nearly identical to the surveyed location.

Purpose of Report and Remarks

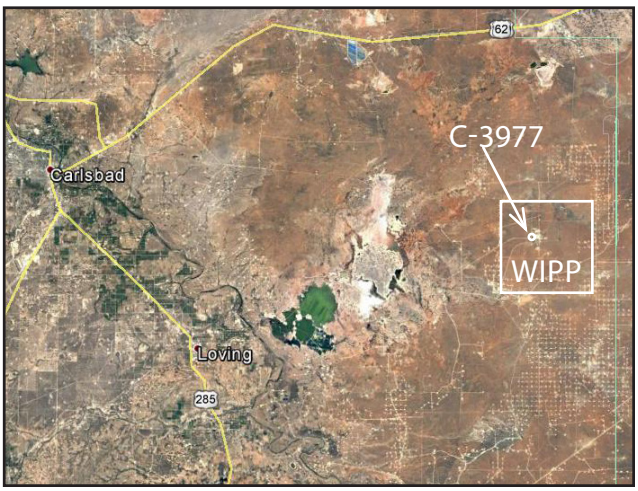
This report provides basic to general information and background for corehole C-3977. It expands on the information provided in a preliminary report (Powers, 2017). Major additions are detailed descriptions based on the core obtained from C-3977 and depth-indexed photos that are mostly spaced at 0.25 ft intervals. The descriptions and discussion in this report expand on the preliminary report; descriptions are included (Appendices B & C) and photos are provided by flash drive/memory stick as the files are very large.

Core run and recovery data are presented in Appendix D in tabular form with notes.

For most of this report, English units are used; metric equivalents are provided for main units. We have mixed units in some of the detailed descriptions, as metric units in the mm-cm range are much more convenient than either fractions of an inch or decimal ft.

Some of the descriptions are not as detailed as might be expected. The principal reason is that there is merit in retaining the core in complete and good condition rather than breaking, slabbing, or otherwise conducting extensive testing; the core is a tangible record of the rocks to inform those responsible for mining a shaft at the location. Surficial damage to some rocks, especially sulfates, by coring obscures subtle bedding or sedimentary structures. A few samples were scraped or sanded slightly to enhance observations, but this was not practical for most core. Some samples (Appendix E) were taken and provided to contractors to Cementation, Inc., for testing to confirm geotechnical parameters. Data from this testing are available in Appendix F. Unabbreviated text of the Salado core descriptions shown in graphic logs (Appendix C) are included in Appendix G. A larger version of the geophysical log below 200 ft is annotated for marker beds (MBs) and other stratigraphic units (Appendix H).

Figure 1. Google Earth image showing location of WIPP and C-3977.



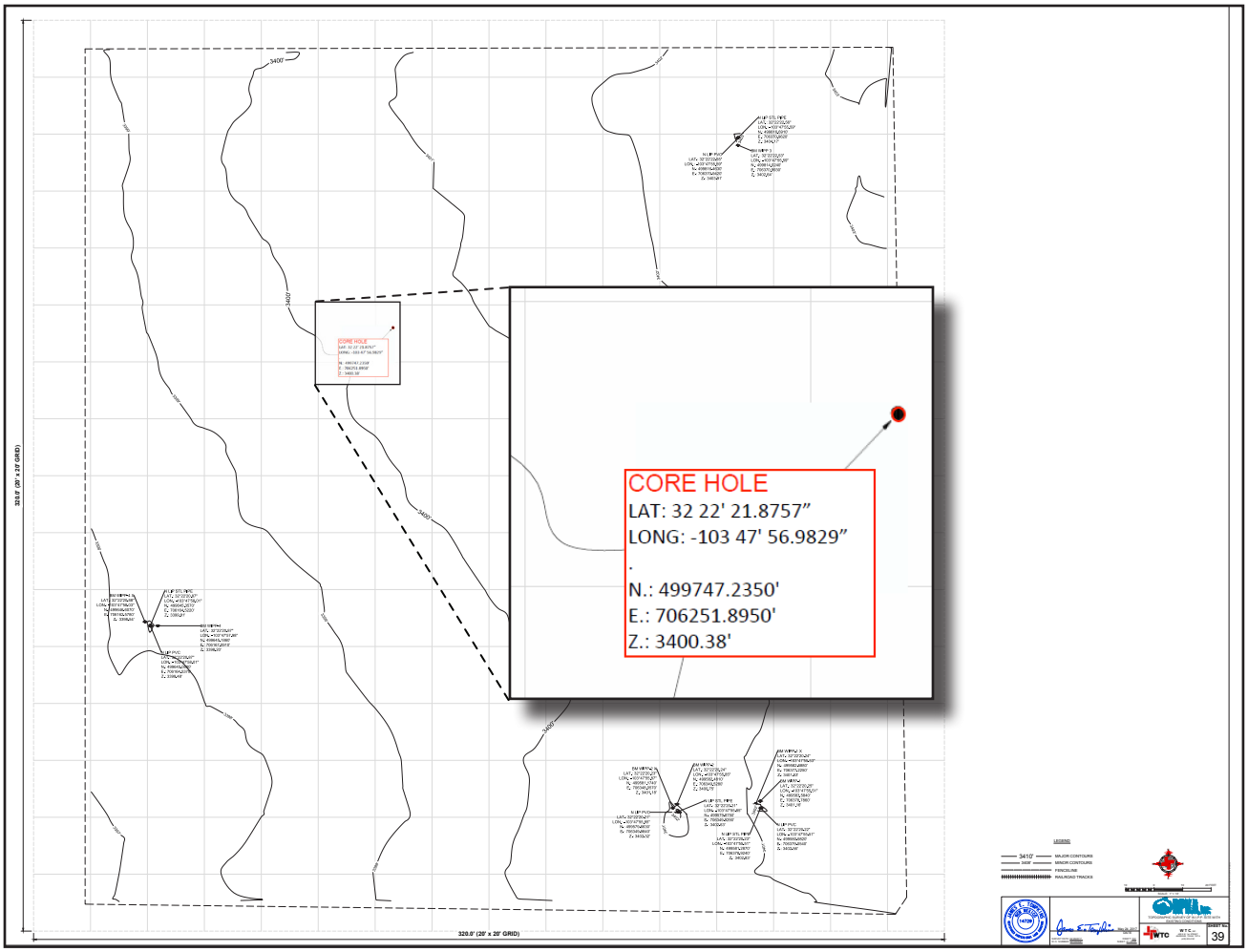


Figure 2. Survey of the location of C-3977. James E. Tompkins, surveyor, May 24, 2017.

General Activities Summary for C-3977

Drilling began December 12, 2016 and ended March 2, 2017. The borehole was plugged and abandoned on March 4, 2017 (see Driller's Report at end of Appendix A). Final depth estimated from the pipe tally was 2308.8 ft (703.9 m).

About 12 ft (~4 m) were initially drilled to emplace a temporary near-surface large casing and diverter. From ~12 ft (~4 m) to 202 ft (61.6 m), C-3977 was cored, using compressed air, with a core diameter of 4 inches (~10 cm) and a hole diameter of 6.25 inches (20.5 cm). Recovery was poor initially but improved with depth.

After the drillhole was logged to 200+ ft (Figure 3), it was reamed to 17.5 inches diameter to 205 ft. Surface casing (J55; 13.375 inches outside diameter, 12.75 inches inside diameter) was set and cemented to the surface.

Coring with air resumed from 205 ft (62.5 m) to 250 ft (76.2 m). From 250 ft to 694.5 ft (211.7 m), coring was done with air and mist (fresh water). From the lower Culebra at 694.5 ft to total depth (TD), C-3977 was cored with circulating brine that was chemically supplemented to preserve potash salts. Recovery below 250 ft was close to 100%. Geophysical logs were also acquired after the corehole reached TD (Figure 4, Appendix H).

From 12 ft to 2308.8 ft (pipe tally), the sum of recovered core lengths for individual runs was 2277.2 ft or 99.1% recovery. The sum of core segments >4 inches over the entire cored interval is 2060.5 ft or RQD of 90.5 (Appendix D).

Figure 3
Open-Hole Geophysical Logs Run By JetWest Prior to Emplacing Large-Diameter Surface Casing. Reference point is ground level.

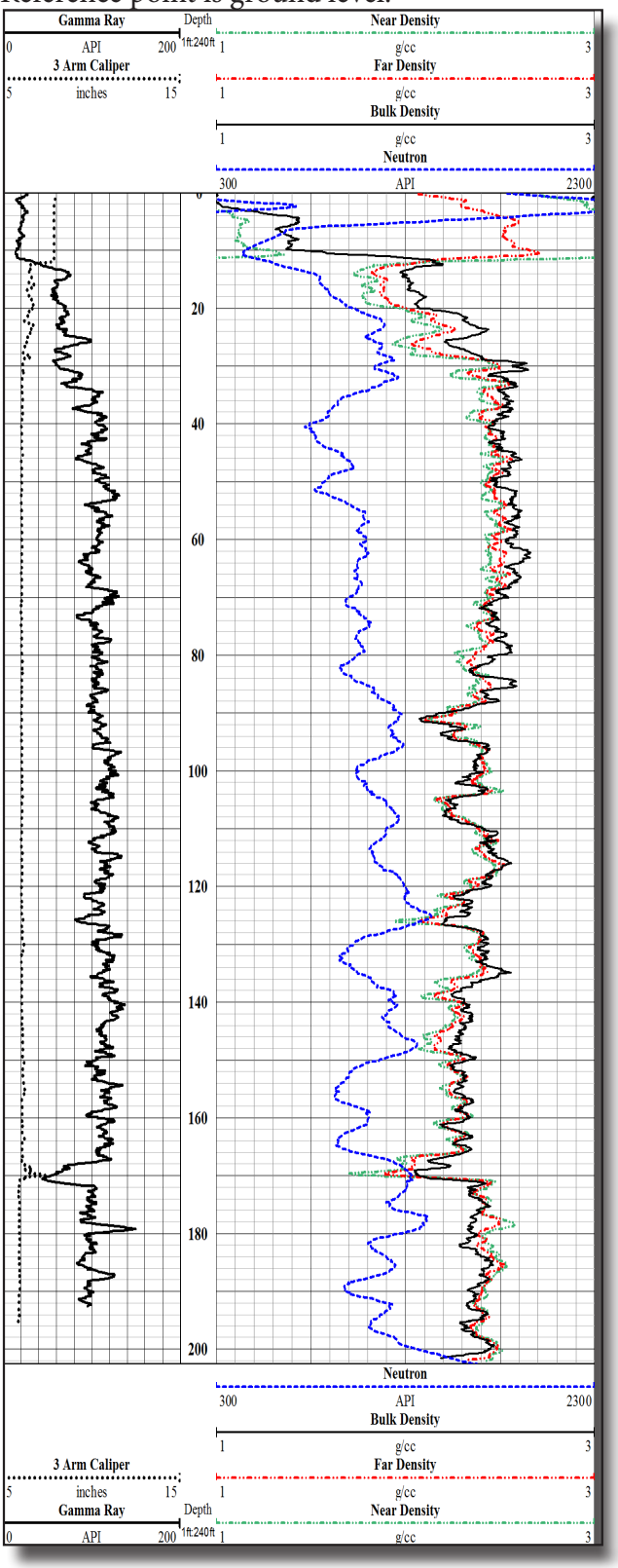
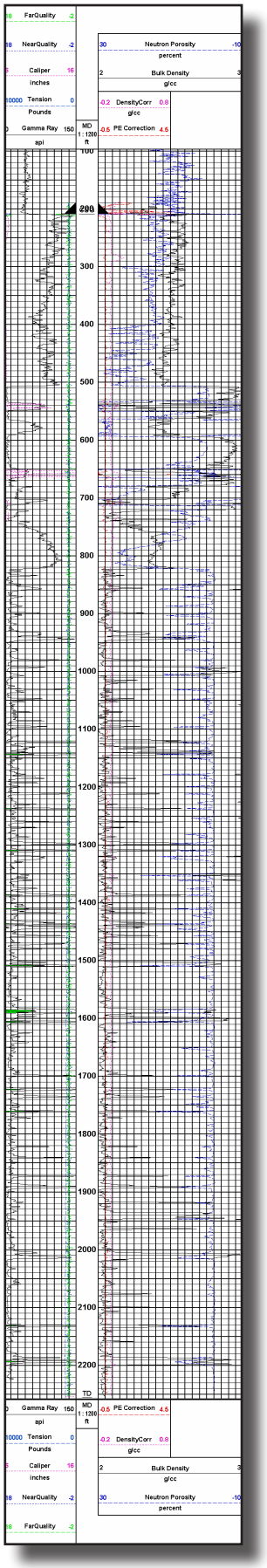


Figure 4 Geophysical Logs Run By Halliburton Below Casing to Refusal* (See larger version in Appendix G)



* Depths are uncorrected for true vertical depth; log reference point is 3 ft above ground level. See Figure 3 for log of interval above 200 ft.

From 836 ft (~15 ft below top of Salado) to TD, the sum of the measured lengths of recovered core is 1479.0 ft, which is 6.2 ft greater than the drilling interval, and the sum of core segments greater than 4 inches over this interval is 1472.8 ft. The RQD (measured vs core recovered) is 97.7 or 98.1 compared to the cored depth.

Core was extruded into wooden troughs, fitted to the extent practical, marked, measured, photographed, described, and boxed. With a few exceptions at shallow depths, these tasks were completed prior to retrieving another core.

Core boxes were inventoried, put under chain of custody, and transferred to climate-controlled, secure storage in the custody of Sandia National Laboratories in Carlsbad. Core will be available for inspection with notice to NWP.

Photographs were taken in the field at ~0.5 ft (~15 cm) intervals with a frame width of ~1.2 ft (~36.5 cm) to provide good overlap. These photographs are an initial field record and have been supplemented with higher quality photographs, at ~0.25 ft intervals, under more carefully controlled conditions. Contact NWP for electronic files of these higher resolution photographs on transportable media. Directional surveys were conducted several times in the borehole using industry logging tools. In addition, spot checks of hole inclination were performed as needed or desired using a Totco™ single-point tool. After reaching TD, deviation and other geophysical records were acquired, although an obstacle in the hole at ~2256 ft (687.8 m) preventing reaching TD.

Beginning at a depth of 205 ft, operations proceeded on a 24-hour, 7-days/week basis until completion. Work was halted twice for mechanical issues beyond standard maintenance.

GEOLOGICAL OBSERVATIONS C-3977

The core from C-3977 was initially described in the field. The cores were re-examined in the lab in detail. Field observations were revised as needed. Detailed geological observations are included in Appendices B & C.

In this section, important stratigraphic units and their lithologies and features are more generally described or summarized with illustrations of some of the salient features. Core data are presented in detail in the graphic logs. The Salado depth data can be related (see Comparison of Marker Beds . . . in Appendix H) to the mapping results of the AIS (Holt and Powers, 1990), and we point out some observations that may further affect shaft design.

Many background references for the geology of C-3977 and the WIPP area are omitted to focus more clearly on the geology relevant to shaft design and construction.

Stratigraphy and Depths of Significant Units

The upper 12 ft (3.7 m) of C-3977 were drilled, not cored. Core recovery was limited above the Permo-triassic(?) Dewey Lake Formation, the first significant stratigraphic unit. Above the Dewey Lake, the drillhole penetrated drill pad construction material (caliche), dune sand, the informal Mescalero caliche, Mio-Pleistocene Gatuña, and possible Triassic Santa Rosa Formation (Table 1).

The *dune sand* that is present at the WIPP site is loose.

The *Mescalero caliche* ranges from poorly lithified to hard in the area. The samples obtained from drilling C-3977 establish its presence but not its quality as a rock. The Mescalero caliche is a pedogenic calcrete (e.g., Bachman and Machette, 1977) and is generally 2-3 ft thick. The unit is interrupted locally, mainly due to plant growth.

The *Gatuña* is mainly sandstone with some siltstone in the vicinity of WIPP. Where the Gatuña underlies the Mescalero caliche, the upper part is variably lithified by infiltrated carbonate during the formation of the pedogenic calcrete. It is probable that the upper Gatuña did not survive the coring process. The recovered core was moderately indurated. In the vicinity of WIPP, the Gatuña is thin. It thickens to the west toward Nash Draw, where it displays a wider variety of lithofacies (Powers and Holt, 1993).

Table 1
Geology at Drillhole C-3977

System/ Period/Epoch		Formation or unit	Member or Marker Bed (MB)	Depth below surface (ft) by core markings	Depth below surface (ft) by gamma/density log**
Cenozoic	Holocene	surface dune sand and Berino soil		drilled to ~12 ft	
	Pleistocene	Mescalero caliche		10-12 ft from cuttings	
	Miocene-Pleistocene	Gatuña		? - 27.5 ft?	~12 ft - 26 ft?
Mesozoic	**Triassic**	Santa Rosa		27.5 ft? - 32.1 ft?	26 ft? - 34 ft
		Dewey Lake		32.1-503.7 ft	34.0 ft - 503.5 ft
Paleozoic	**Permian**	Rustler 503.7 - 821.9 ft	Forty-niner *A-5* *M-4/H-4* *A-4*	503.7 ft - 563.9 ft *503.7 ft - 533.5 ft* *533.5 ft - 545.7 ft* *545.7 ft - 563.9 ft*	503.5 ft - 562 ft *503.5 ft - 530.5 ft* *530.5 ft - 546 ft* *546 ft - 560.5 ft*
			Magenta Dolomite	563.9 ft - 588.8 ft	560.5 ft - 587.5 ft
			Tamarisk *A-3* *M-3/H-3* *A-2*	588.8 ft - 679.7 ft *588.8 ft - 647.2 ft* *647.2 ft - 665.0 ft* *665.0 ft - 679.7 ft*	587.5 ft - 678.5 ft *587.5 ft - 646 ft* *646 ft - 663.5 ft* *663.5 ft - 678.5 ft*
			Culebra Dolomite	679.7 ft - 701.3 ft	678.5 ft -699.5 ft
			Los Medaños *M-2/H-2* *A-1* *M-1/H-1*	701.3 ft - 821.9 ft *701.3 ft - 710.2 ft* *710.2 ft - 719.7 ft* *719.7 ft - 821.9 f*t	699.5 ft - 819 ft *699.5 ft - 709.5 ft* *709.5 ft - 718.5 ft* *718.5 ft - 819 ft*
		Salado 821.9 - TD	*MB103* *MB109* *Vaca Triste* *Union Anhydrite* *MB123-124* *MB134* *MB136* *MB139* *MB140* *MB142*	*990.3 ft - 1005.2 ft* *1116.3 ft - 1143.1 ft* *1316.8 ft - 1324.0 ft* *1503.8 ft - 1510.9 ft* *1584.5 ft - 1605.9 ft* *1936.1 ft - 1947.3 ft* *2006.8 ft - 2016.4 ft* *2130.4 ft - 2134.5 ft* *2186.9 ft - 2199.6 ft* *2305.7 ft - TD** **TD marked on core 2311.1 ft*	*989 ft - 1004 ft* *1115 ft - 1141 ft* *1315 ft - 1324 ft* *1501 ft - 1507 ft* *1581 ft - 1603 ft* *1933 ft - 1944 ft* *2003 ft - 2013 ft* *2127 ft - 2131 ft* *2183 ft - 2196 ft* *not logged - tool to 2256 ft* ***Subtracted 3 ft for surf. elev.*

The interval from 27.5 ft - 32.1 ft is tentatively assigned to the *Santa Rosa* based on lithology and color. C-3977 is near the erosional edge of the Santa Rosa/Dockum Group (Jones, 1973; plate 2). P-3, a WIPP potash exploration hole drilled south of C-3977, showed similar depth to top of Dewey Lake (Jones, 1978). The AIS also showed similar depths and thickness.

Dewey Lake Formation

The Permo-triassic(?) Dewey Lake Formation was encountered from 32.1 ft - 503.7 ft (core depth; 9.8 m - 153.6 m). There are no formal stratigraphic units within the Dewey Lake. Holt and Powers (1990, p. 3-5 and 3-6) differentiated a lower interbedded interval ("basal bedded zone") that was about 94 ft (28.7 m) thick in the AIS. That interval was not distinguished during preliminary field observations of cores from C-3977. The geophysical log break at 389 ft (Figure 4; 386 ft bgl) corresponds approximately to the lower interbedded interval in the AIS. The detailed geologic log (Appendix B) shows several breaks in lithology from 386-383.5 ft bgl that correspond to the top of the basal bedded zone. The Dewey Lake above ~386 ft at C-3977 corresponds to the fining upward cycles noted in Holt and Powers (1990) and Powers (2003).

The Dewey Lake is characterized by fine-grained clastics, especially very fine sandstones and siltstones; clay sized particles are common, but true claystones are rare. The reddish-brown color is relatively uniform; small spots and zones of greenish-gray ("gg") color ("reduction spots") are present throughout the formation. Very thin laminae to thin beds are most common, along with small ripples. Bedding is parallel, horizontal to wavy, with some zones low-angle cross-cutting relationships. Sediments were deformed or sheared while soft below some contacts with overlying coarser sediments, although soft sediment deformation is not restricted to these contacts. Desiccation cracks (Figure 5) are present as well at some lithologic boundaries, and they indicate exposure and possible erosion. Other desiccation cracks are not apparently associated

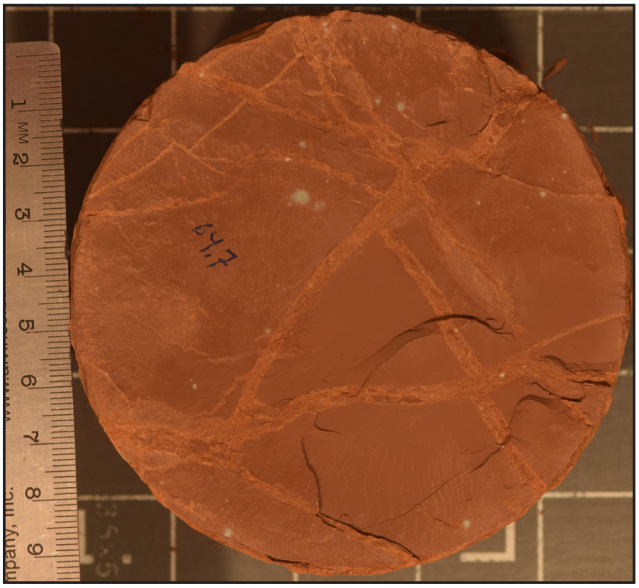


Figure 5. Example of desiccation cracks on core separation at 64.7 ft. Scale in cm.

with lithologic contacts. Bioturbation is very limited, although a few small borings or burrows have been noted.

There is a change in the natural cements of the Dewey Lake at ~167.5 ft (~51.1 m) at C-3977. Above that point, carbonate cement is variable. Below ~167.5 ft, carbonate cements are not observed, but gypsum cement is common.

Although the Dewey Lake is generally well indurated and gypsum cements below 167.5 ft make sandstone or sandy zones hard, the cores tend to separate along bedding planes.

Another prominent feature of the Dewey Lake is the separations that are filled with gypsum that is usually fibrous (Figure 6). These gypsum-filled separations generally fall into two classes: those following the bedding planes and a subvertical set (generally between ~45°- 90° dip). The core will frequently separate at the junction of rock and gypsum.

Low natural gamma from 168 ft - 172 ft (51.2 m - 52.3 m log depth) (Figure 3) is a common feature of logs of the upper Dewey Lake throughout southeastern NM. Powers (2003) informally called this sandstone 1 (ss 1) and noted the sandstone in at least two other WIPP drillholes (e.g., Powers, 2009). Similar sandstones are present in the AIS

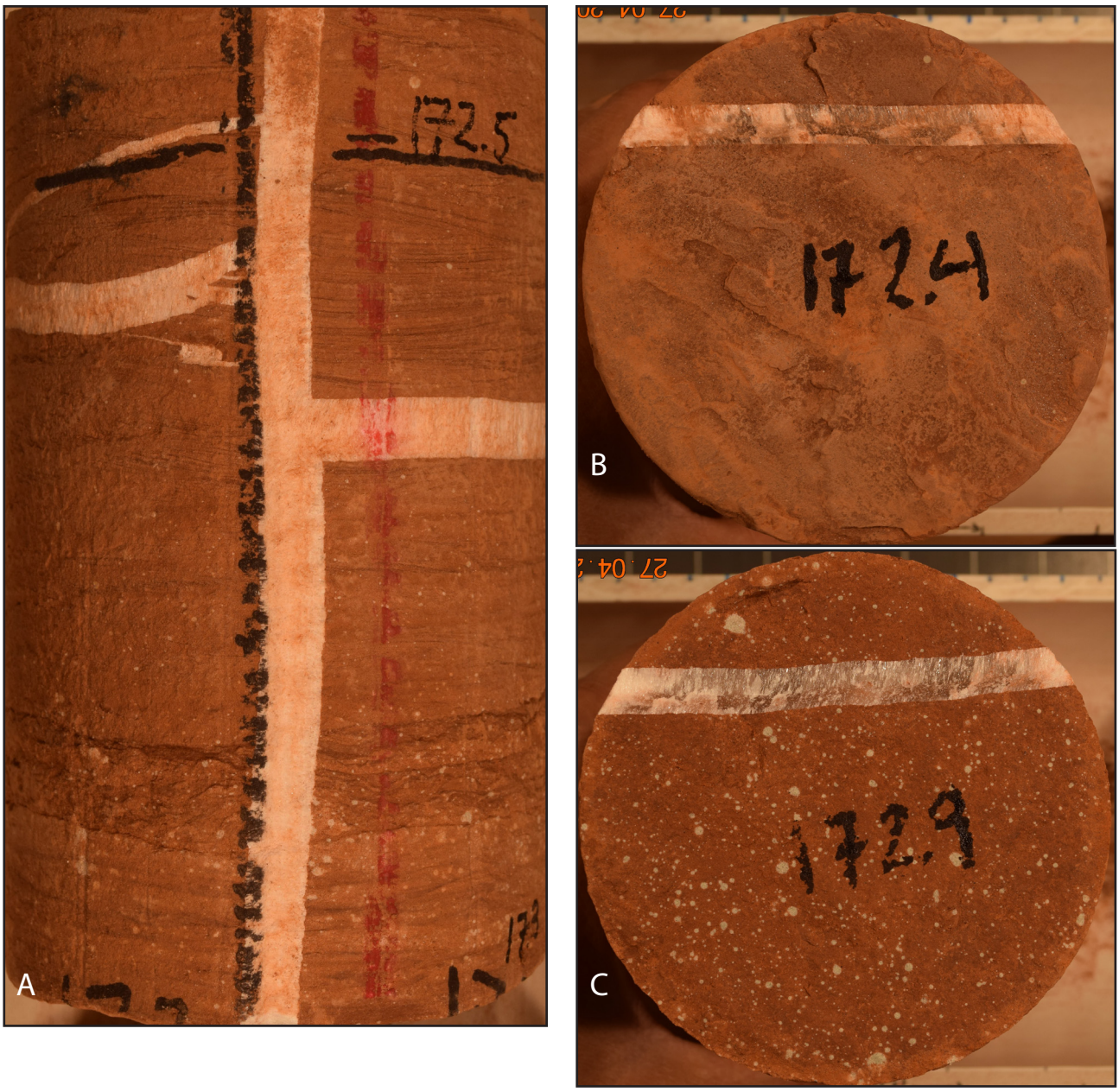


Figure 6. Vertical and horizontal gypsum-filled separations in upper Dewey Lake at C-3977. **A** - core interval from 172.4-172.9 ft. Gypsum fibers are approximately perpendicular to separation plane in each type. **B** - View downward on core cross-section at 172.4 ft. (In layers, click on "Figure 6 enhancements" to view fiber features). **C** - View upward on core cross-section at 172.9 ft. *Note* fine bedding and ripples near top of core. Darker wavy band at ~172.8 ft is similar to others where desiccation features are present. Small greenish-gray reduction spots that are common in the Dewey Lake are easily visible here.

at a similar depth. H-16, next to the AIS, showed two sandstones in geophysical logs (Mercer and Snyder, 2009).

The basal contact between Dewey Lake and Rustler is sharp and exhibits relief (Figure 7) similar to that in the AIS (Figure 8). The lower 1-2 ft of the Dewey Lake in the AIS (Figure 8) displayed soft sediment deformation, and the mapped sulfate-filled separations in the basal Dewey Lake change orientation at the top of the mapped deformed zone.



Figure 7. Dewey Lake - Rustler contact at 503.7 ft, as marked on core from C-3977. The upper surface is irregular, and a greenish-gray layer underlies the reddish-brown clastics of the Dewey Lake. In this core, the upper sulfate (A-5) of the Rustler has been disrupted and some infiltration of clastics occurred, likely as a result of some period of exposure immediately prior to Dewey Lake deposition. Regular horizontal lines are core cutting marks.

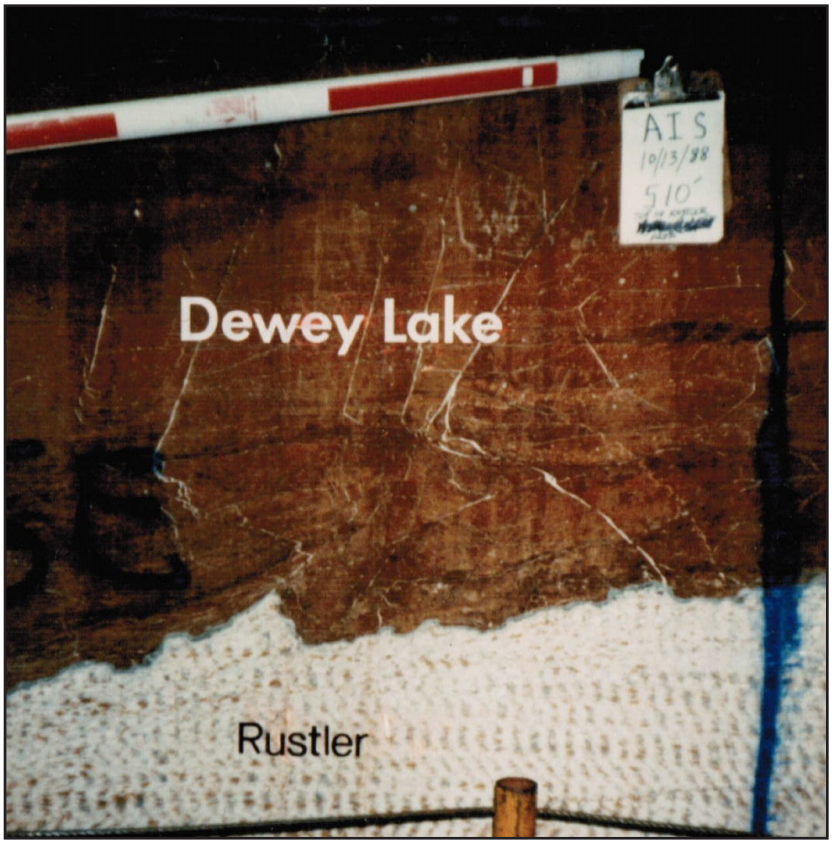


Figure 8. Dewey Lake - Rustler contact at ~515 ft in the AIS (Holt and Powers, 1990). The width here is several ft, contrasting with the 4-inch diameter of core in Figure 7. The greenish-gray lamina overlying the Rustler is apparent here as well as in C-3977. Detailed mapping in the AIS showed some separations/fractures in the Rustler sulfate. (White sulfate shows surface markings from the cutter heads.) The lower 1-2 ft of Dewey Lake shows some soft sediment deformation or disruption, and sulfate-filled separations change orientation at the top of this zone.

Permian Rustler Formation

The Rustler Formation was encountered from 503.7 ft - 821.9 ft (153.6 m - 250.6 m) as marked on core (Table 1). All five members of the Rustler were cored with generally high recovery rates.

The *Forty-niner Member* occurs from 503.7 ft - 563.9 ft (153.6 m - 171.9 m), a thickness very close to that in the AIS. At the location of C-3977, the Forty-niner consists of sulfate beds at top (A-5) and bottom (A-4), separated by a mudstone (M-4). A-5 and A-4 are regionally extensive, and M-4 transitions east of WIPP to halite (H-4) (Holt and Powers, 1988).

Both A-5 and A-4 are hard and had high RQD (Appendix D). They both displayed subhorizontal laminae; A-5 included sulfate swallowtails and some pseudomorphed gypsum crystals. A faint laminar nodular texture is observable in some zones. There are likely additional features in these two sulfate units, but a thin altered drilling rind on the core surface obscures more details.

The Forty-niner mudstone (M-4) (Figures 9, 10) is slightly thinner at C-3977 than in the AIS. The mudstone shows wavy bedding to soft sediment deformation, some gypsum-filled separations, and is variably indurated (Figure 10).

The *Magenta Dolomite Member* occurs from 563.9 ft - 588.8 ft (171.9 m - 179.5 m) at C-3977, and the thickness of ~25 ft (~7.6 m) is similar to that in the AIS. The depth to the top of the Magenta is ~10 ft (~3 m) less at C-3977 than in the AIS descriptions. Upper and lower contacts (Figure 11) are generally somewhat gradational as carbonate laminae can be identified in the bounding sulfate beds. At C-3977, the contacts are more distinct.

The Magenta displays a variety of sedimentary structures. Near the base of the Magenta (Figure 11B), stromatolites are widespread and range in form from somewhat wavy bedding to domes and biscuits. Most of the sedimentary structures through the Magenta here and around the WIPP area are relatively small wavy and lenticular cross-bedding (Holt and Powers, 1988). Cross-bedding amplitude decreases upward.

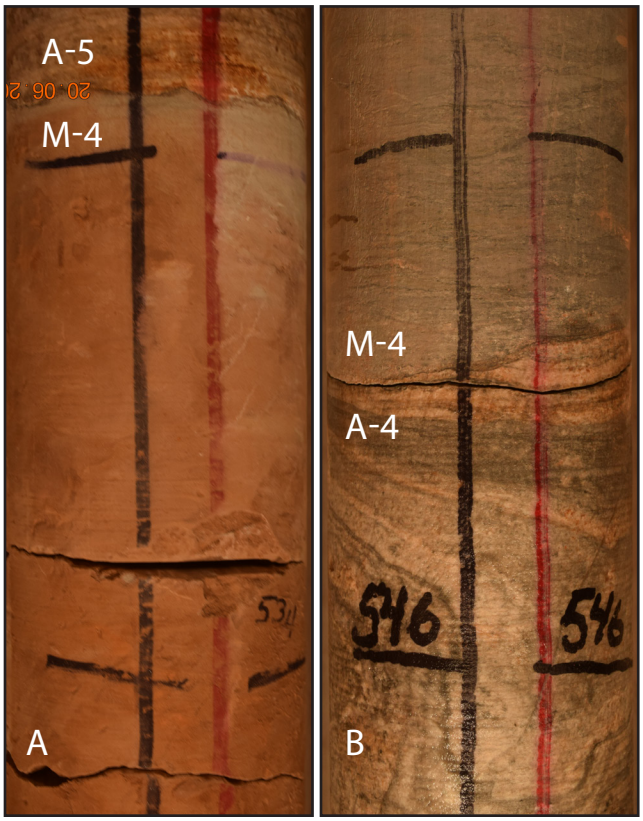


Figure 9. Forty-niner mudstone (M-3) contacts. Upper (A) and lower (B) contacts of Forty-niner mudstone (M-4) (533.4 ft - 545.7 ft). Both contacts are sharp and slightly irregular at the scale of this core. At the AIS, both contacts showed some broad relief around the shaft circumference.



Figure 10. M-4 from about 539 ft at C-3977 shows poor induration relative to the top and base of the mudstone.

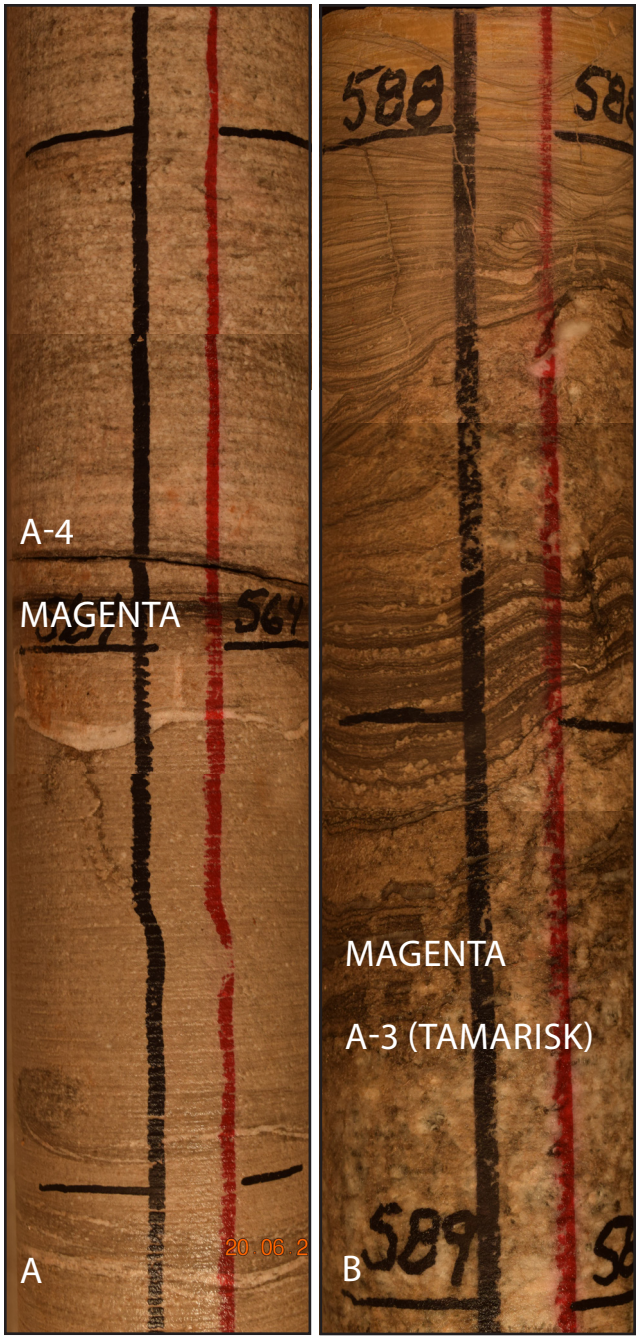


Figure 11. Composite photos of upper (A) (563.9 ft) and lower (B) (588.8 ft) contacts of the Magenta Dolomite. Stromatolites are visible at the base of the Magenta here. Biscuit and dome forms have been observed in WIPP shafts and other cores.

During the core inspection, two zones of apparent greater porosity were noted in the upper half of the member. These zones total ~10 ft (3 m) thickness. Two lower zones of lowest resistivity (Figure 12) in the upper Magenta, separated by a "spike" of higher resistivity, likely represent these zones observed during initial core inspection and description. Air with mist was being used to core the Magenta; there were no field observations that indicated water inflow to the borehole from the Magenta.

The *Tamarisk Member* at C-3977 is similar to the Forty-niner in consisting of two sulfate beds separated by a mudstone. The Tamarisk was encountered from 588.8 ft - 679.7 ft (179.5 m - 207.2 m), as marked on recovered core. The upper contact of the Tamarisk with Magenta is relatively sharp (Figure 11B and Figure 12).

The upper sulfate (A-3) of the Tamarisk is well indurated and hard. Some generally prismatic textures (crushed prisms) (Figure 13A) in A-3 are interpreted as evidence of former bottom-grown (or "swallowtail") gypsum crystals that were partially dissolved (possibly after being pseudomorphed by halite) and compacted. A common texture (Figure 13B) is called here "bedded nodular" (Holt and Powers, 1988, p. 6-18). An erosional surface in A-3 at 631.9 ft is overlain by sulfate intraclasts (Figure 13C). As with other sulfate beds cored at C-3977, bedding and textures are variably obscured by a thin surface film created by coring.

The Tamarisk mudstone (M-3) is generally soft to stiff. The contacts show local disturbance noted elsewhere (Holt and Powers, 1988). The upper contact displays a zone of small sulfate clasts immediately below a relatively sharp contact (Figure 14A). Other cores may show larger clasts or intercepts that may represent other layers. M-3 is the facies-equivalent to thick halite (H-3) with at least three thinner sulfates (e.g., Holt and Powers, 1988). Powers and Holt (2000) interpreted the sulfates as amalgamating with the basal A-3 where halite was not deposited. Some of the clasts at the upper boundary of the mudstone may be remnants of these thinner sulfates. The margin

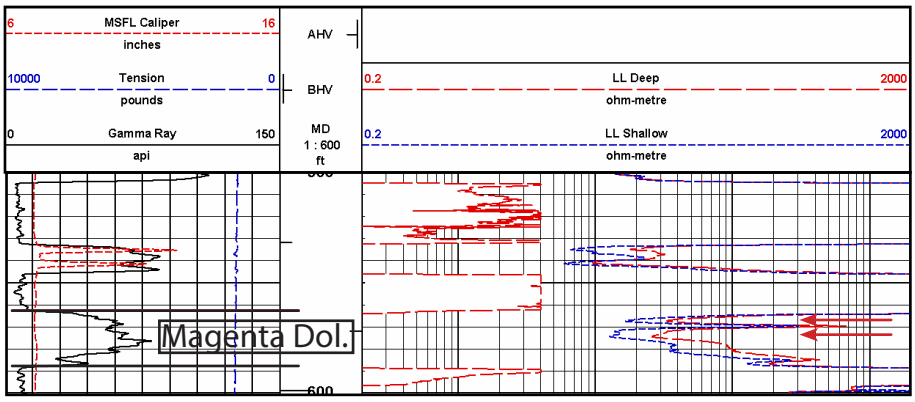


Figure 12. Portion of natural gamma and resistivity log for upper Rustler Formation illustrating resistivity for the Forty-niner and Magenta Dolomite Members. Red arrows identify low resistivity zones equivalent to porosity zones identified in cores.

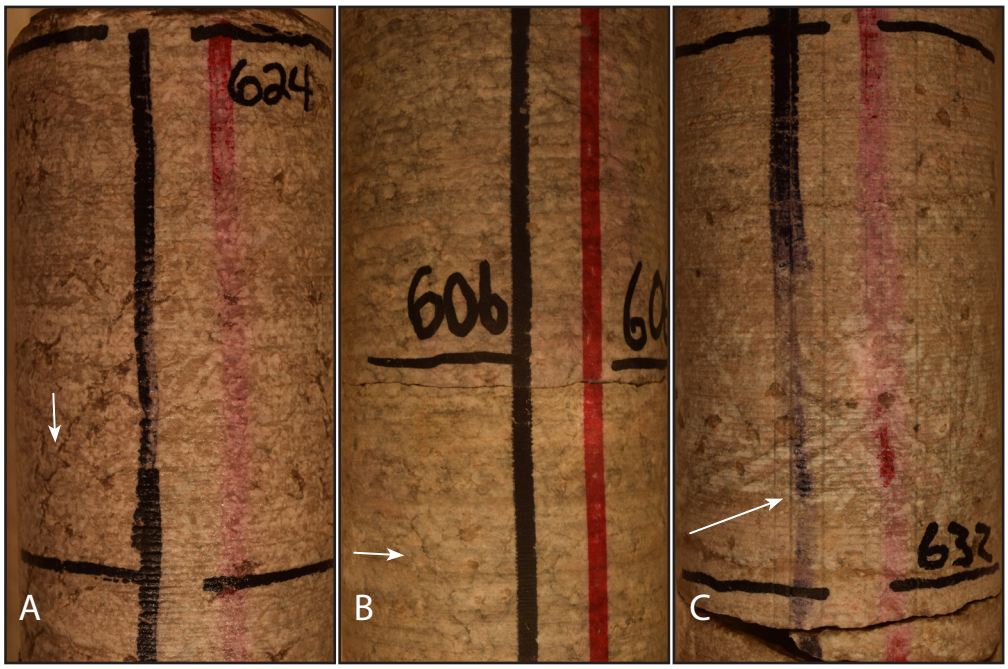


Figure 13. Photos of A-3 textures on core surface. **A** - Prismatic textures (v-shaped) interpreted as ghosts of bottom-grown or swallow-tail gypsum crystals. **B** - Bedded nodular textures. C - Erosion surface and overlying intraclasts. Core width is 4 inches (10 cm). Height of each photo interval is ~7 inches (~18 cm).

of H-3 (e.g., Powers, et al. 2003) is a zone where some limited dissolution of halite has occurred. Drillhole SNL-8 shows some fracturing in the lower A-3 that may be associated with dissolution (Powers, 2009).

The M-3/A-2 contact (Figure 14B) at C-3977 exhibits minor local relief. Holt and Powers (1988) interpreted this contact as erosional. The underlying Tamarisk sulfate bed A-2 has been removed by erosion at drillhole WIPP 19 and eroded ~3 ft (~1 m) at the waste handling shaft (Holt and Powers, 1986; 1988). The contact is eroded as well in the AIS (Holt and Powers, 1990).

The lower sulfate (A-2) of the Tamarisk is generally well indurated and hard. A thin claystone/mudstone interbed at 668.9-669.8 ft in the core (670 ft in geophysical log) is regionally extensive, and the core separates at this clastic unit. At C-3977, the clastic bed includes a subhorizontal separation that is filled with fibrous gypsum.

A-2 is laminated, and the bedding becomes more visible, common, and wavy to deformed upward below the clastic interbed. A zone from 670.7-671.5 is the most deformed. Some of the deformed laminae may be enterolithic, although other wavy beds could be stromatolitic. The lower part of A-2 also displays bedded nodular textures.

The *Culebra Dolomite Member* was cored from 679.7 ft - 701.3 ft (207.2 - 213.8 m) in C-3977. The upper and lower contacts are sharp (Figure 15).



Figure 14. Photos of upper (A) (647.2 ft) and lower (B) (665 ft) contacts of Tamarisk mudstone with sulfate beds. These contact relationships are described extensively in three shaft mapping documents (Holt and Powers, 1984, 1986, 1990), in the lengthy report of Rustler facies (Holt and Powers, 1988) and in a journal article (Powers and Holt, 2000).

The Culebra is the principal water-bearing interval above the Salado at the WIPP site. At C-3977, the Culebra was cored with air/mist to 694.5 ft (211.7 m). From that depth to TD, the hole was cored while circulating halite-saturated brine with added components to stabilize potassium-bearing chloride minerals. Because of this, there are no observations at C-3977 regarding Culebra hydrology.

Holt (1997) recognized four informal hydrostratigraphic units within the Culebra (designated CU-1 to CU-4 downward). Depths for these units in core from C-3977 are approximately: CU-1 679.7-688.3 ft, CU-2 688.3-694.5 ft, CU-3 694.5-696.8 ft, and CU-4 696.8-701.6 ft. CU-2 and CU-3 are generally the most porous and transmissive interval of the Culebra.

CU-1 is laminar and organic-rich near the top (Figure 15A). Below the laminar interval, CU-1 has a zone with little visible porosity. The lower part of CU-1 has increased porosity in zones parallel to bedding (Figure 16A). CU-2 has much greater porosity than CU-1; the change in porosity is gradational from lower CU-1. The lower part of CU-2 has larger pores and can have significant silt-filled pores (Figure 16B). Fractures can connect pores or between zones of porosity. At C-3977, CU-3 is very porous and parts of the zones collapsed to rubble when cored. CU-4 in the lower part can be brecciated and deformed over a distorted boundary overlying soft mudstone of the Los Medaños (Figure 15B).

The lower 2/3 of the Culebra shows lower resistivity than the upper part.

There are many reports and publications regarding Culebra geology and hydrology for WIPP. Among those with more geological aspects are Beauheim et al. (2007), Holt (1997), Holt and Powers (1988), Holt et al. (2005), Powers and Holt (1999, 2000), and Powers et al. (2003, 2006).

Water levels for monitor wells in the Culebra are reported annually (US Department of Energy, 2016). A nearby well on the H-2 pad is ~2150 ft (~655 m) southwest of C-3977. The water level elevation there on 8/1/16 was 3026.20 ft amsl (not adjusted for specific gravity).



Figure 15. Field photos Culebra contacts. **A** - Tamarisk-Culebra contact (679.7 ft). **B** - Culebra-Los Medaños contact (701.6 ft). The lower contact is inclined; red arrows point to the exact contacts.



Figure 16. Field photos of Culebra porosity (A) (684.5-685.5 ft) and (B) (692-693 ft). **A** - Small pores in zones parallel to bedding with interzones of few pores. Fractures at variable angles can connect zones or pores (Holt, 1997). **B** - Large pores in this lower zone weaken the rock, and the clast boundaries are stained yellowish-brown.

The *Los Medaños Member* (Powers and Holt, 1999) was encountered in C-3977 from 701.3 ft - 821.9 ft (213.8 m - 250.6 m). Both contacts are distinct (Figures 15B, 17). In the AIS, the Los Medaños (then called "unnamed lower member") was mapped at depths from ~712.5 - 825 ft. In designating the type section, Powers and Holt (1999) simplified the informal divisions of the Los Medaños of Holt and Powers (1988) to: M-2/H-2, an upper mudstone with lateral halite facies; A-1, a substantial (~10 ft; 3 m), regionally-continuous sulfate bed; and M-1/H-1, a thick, lower clastic interval with halite, halite cements, some bioturbation, and some sulfate. Facies changes are less pronounced in M-1/H-1 in the WIPP area.

M-2 generally displays some soft sediment deformation near the contact with the Culebra, and the contact at C-3977 dips, at least locally (Figure 15B). M-2 at C-3977 generally appears to be deformed more than at the AIS. The mudstone is dark gray at the top and dusky red in the lower part with greenish gray mottling. Some probable sulfate clasts are preserved, and there are separations that have been filled with gypsum. Some of the separations also show slickensided

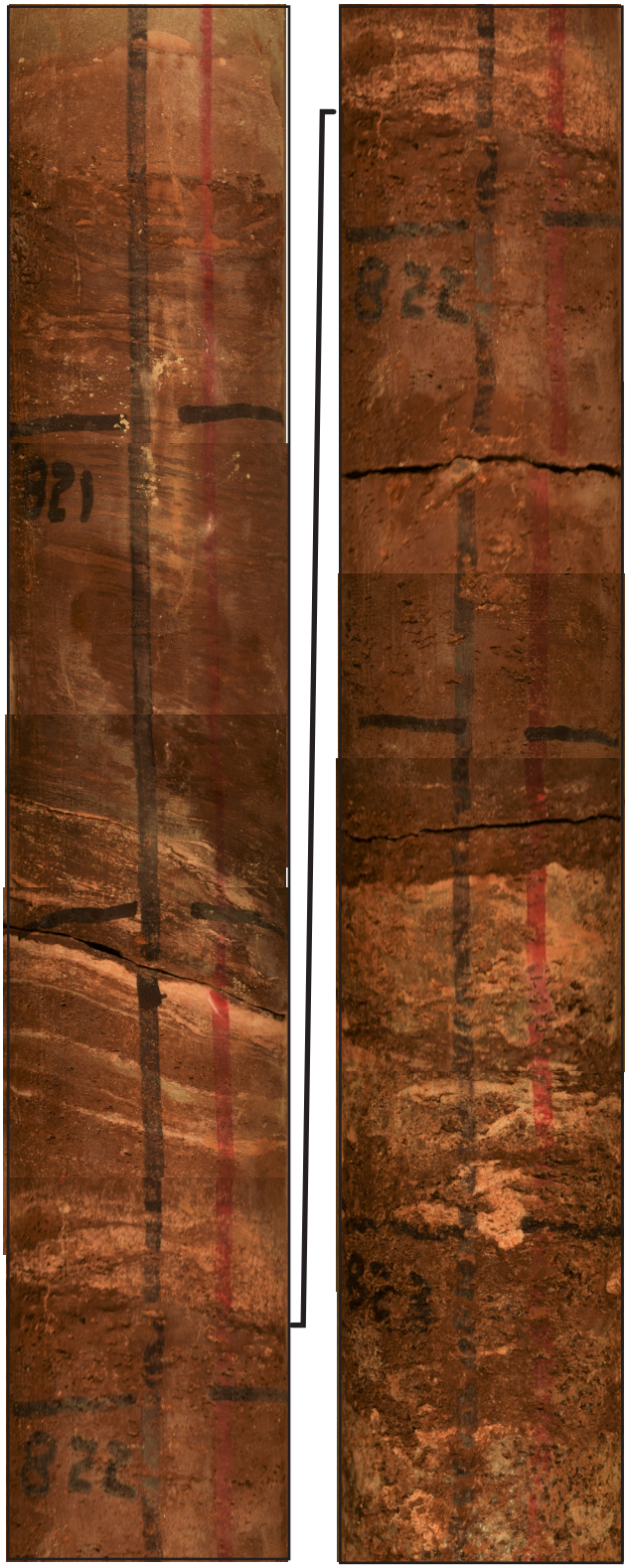


Figure 17. Photos of the Rustler-Salado contact (821.9 ft; 250.6 m). There is slight relief on the contact locally. A thin zone with sulfate overlies the contact.

surfaces. This interval is generally stiff but not hard or cemented.

A-1 was cored from 710.2 ft - 719.7 ft (216.6 m - 219.4 m) (Figure 18). At the AIS, A-1 is mapped at a depth of 716 - 725.5 ft. The outer core surface revealed some generally subhorizontal to horizontal laminae and possible pseudomorphs of gypsum crystals near the base. Small (mm-scale) surficial pores from 715.0 - 715.5 ft (Figure 18) are of undetermined origin. The drilling fluid was apparently saturated with respect to halite when cored; the pores are not expected to be from dissolving halite. The interval from 711 ft - 712 ft is reddish in color, which is often taken to indicate polyhalite (complex potassium sulfate) in the Delaware Basin evaporites. Here, however, the

Figure 18. Photos of A-1. **A** - Subhorizontal bedding in the upper part of A-1. The reddish color can indicate polyhalite, but the natural gamma log shows little activity. **B** - Small pores on the surface of the core from 715.0 - 715.5 ft are of uncertain origin.



natural gamma log does not indicate any natural gamma signature that would be expected from polyhalite. Recovery was good through A-1.

Within M-1/H-1, halite is common as cement or as displacive crystals in the clastics (Figure 19). The same classification for halite beds used in the AIS has been applied to the core descriptions (see Introduction, Appendix C). Thinner halite beds and additional sulfate beds occur in the interval from ~730 ft - 740 ft.

Subhorizontal laminae and thin beds are more abundant below ~760 ft (Figure 20). Ripples, minor crosscutting relationships, and bioturbation were more abundant downward.

An erosional surface at ~819 ft depth is overlain by intraclasts. WIPP shafts and some coreholes in the area show an erosional surface, some with clasts. The waste shaft included some invertebrate fossil fragments above the erosional surface (Holt and Powers, 1984; Powers and Holt, 2000).

The basal contact of the Los Medaños/Rustler with the Salado is distinctive and sharp in the core from C-3977 (Figure 17).



Figure 19. Halite-mud textures in Los Medaños Member. **A** - Displacive halite with mud boundaries in dominant halite interval (732.25 ft center; 223.2 m). **B** - Mud and halite in ~equal amounts (744.75 ft). Halite shows displacive to corroded boundaries as single crystals to clusters.



Figure 20. Halite-cemented sandstone in the lower Los Medaños Member. Fine laminae, ripples, cross-beds and bioturbation have been identified. **A** - Lab photos showing salt efflorescence from drilling fluid several months after collection. **B** - Same interval in field right after collection.

Core recovery and RQD were excellent through M-1/H-1. The rocks are medium to well indurated. Breaks occur along bedding planes or along separations that are mainly filled with halite (Figure 20).

Permian Salado Formation

The *Salado Formation* was cored from top at 821.9 ft (250.6 m) to TD.

The Salado consists mainly of bedded halite and muddy halite with interbeds of sulfate (anhydrite and/or polyhalite). The Salado has been divided into three informal unit: a lower unnamed member, the McNutt potash zone (Kronlein, 1939), and an upper unnamed member. Thicker, areally extensive sulfate interbeds have been called marker beds (MB) and given numbers (100 - 144, from top to near the base of Salado (Kronlein, 1939; Jones et al., 1960).

A regionally significant muddy halite has been named the Vaca Triste Sandstone (Adams, 1944). One marker bed has been informally called the Union anhydrite in this area. Much lower in the Salado, the Cowden Anhydrite Member (Giesey and Fulk, 1941) occurs but was not penetrated in C-3977.

C-3977 reached TD within MB142. MB139 is generally a few ft below the repository horizon.

Recovery and RQD were generally very good. There are natural breaks below many sulfate interbeds. Clay and silt concentrate on exposure surfaces (Holt and Powers, 1990, 2011) at the top of many depositional cycles, and these intervals display poor tensile strength in general. In addition, the core will separate along minor bedding planes or even within halite sequences.

In Table 1, several of the more important MBs encountered in C-3977 are referred to by depth by core markings as well as in geophysical logs. These more significant MBs are identified on Figure 3. All identified MBs encountered in C-3977 are related to the natural gamma and density log (Appendix H).

The Salado evaporites display a range of minerals and features that have been attributed to repeated or cyclic processes, generally of flooding by ocean water followed by evaporation to concentrate solutes to the point of crystallization. Schaller and Henderson (1932) first developed a concept of Salado mineral sequences based on the sequence of minerals evaporated from sea water. Lowenstein (1988) developed a two-fold classification of Salado depositional cycles, mainly based on whether a sulfate was at the base of a flooding event.

Holt and Powers (1990, 2011) evaluated the halite depositional sequence based on the detailed AIS mapping. Repeated major features were summarized into an idealized depositional sequence (op. cit.) that represents flooding (possibly multiple events) followed by general desiccation, significant subaerial exposure of the halite, halite crystallization in pores and pipes, and accumulation of insolubles. Synsedimentary dissolution pipes, fine halite interpreted as hygroscopically-altered salts (*aka* efflorescent salts), disrupted upper intervals ("podular" zones), and argillaceous halite to halitic mudstones are the main features. Holt and Powers (1990, 2011) separated four lithofacies (Figure 21) that summarize features related to the desiccating-upward halite depositional cycle. Holt (1997) catalogued halite and sulfate features identified during various shaft mapping activities, including the AIS. C-3977 cores display many of the features or sedimentary structures found in larger exposures in the AIS or underground at WIPP.

Based on field inspection and description of C-3977 cores, there is close correspondence to the AIS with respect to MB and the halite-dominated intervals (Table 1; end of Appendix H). ERDA-9, the initial exploratory drillhole at WIPP, also compares closely to C-3977 in interval thickness between marker beds, although depths are greater.

Depths of rock units in C-3977 cores differ from AIS and ERDA-9 depths because of general eastward dip and some topographic differences. Depths to marker beds in the Salado at C-3977 are generally in the range of 20 ft (6.1 m) less than recorded in the AIS.

It is also evident from C-3977 that features in a 4-inch (10-cm) core only represent a small portion

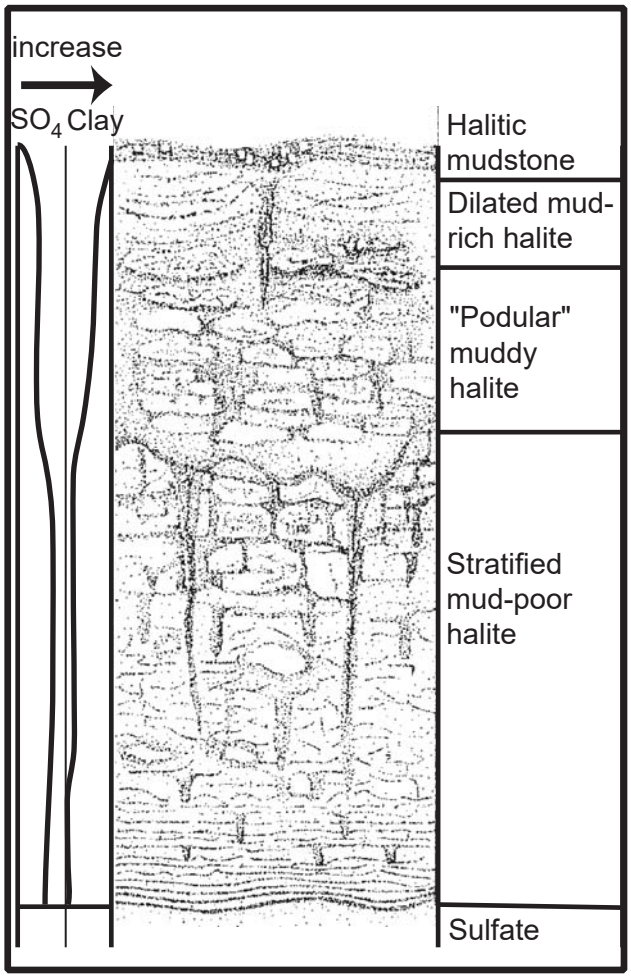


Figure 21. Idealized halite depositional cycle for the Salado (Holt and Powers, 1990, 2011) that represents flooding followed by desiccation, water (brine) table fluctuations, subaerial exposure, and halite crystallization to fill pipes and other porosity. General features, including dissolution pipes, "podular" features, and dilated mudstone from displacive halite growth, are displayed in the C-3977 core.

of the mapped AIS exposure and may sample (or miss) a feature such as a dissolution pipe. Thus a core may show large, clear halite crystals instead of the dominant argillaceous halite revealed in the AIS. These are differences that are expectable but not predictable for any particular interval.

The detailed core descriptions and graphics (Appendix C) are represented here by some examples of features. A photographic record of the core at ~0.25 ft spacing and indexed by depth is available on separate storage devices.

The lower halite of the desiccating-upward depositional cycle is typically mud-poor and stratified (Figure 22A). The basal mud-poor part of a depositional cycle above MB 112 begins at depth 1210 ft. The upper part of this desiccating-upward cycle is shown from 1197.8 ft downward (Figure 22B). In the upper 0.2 ft, reddish-brown argillaceous siltstone is concentrated; the zone below shows translocated clastic material and some stringers of the podular muddy halite (PMH; Holt and Powers, 1990, 2011) lithofacies. This lithofacies may present as infiltrated clastics here or as clastics surrounding cleaner zones ("pods") of halite. The mudstone zone at the top typically has little strength.

Dissolution pipes (e.g., Powers and Hassinger, 1985; Holt and Powers, 1990, 2011) interrupt lateral continuity of beds in the depositional sequence. They are syndepositional, developing downward from an exposure surface as the brine table drops below the surface. Some may interrupt more than one depositional cycle. Although they will not present difficulties mining, core intercepts can indicate a lithology that does not persist laterally. In Figure 23A, the right side of the core between depths of ~1468 ft and 1470 ft shows crystal size and clarity that contrasts with the left side. The core intersected the side of a dissolution pipe. The top of MB 121 is at 1471 ft.

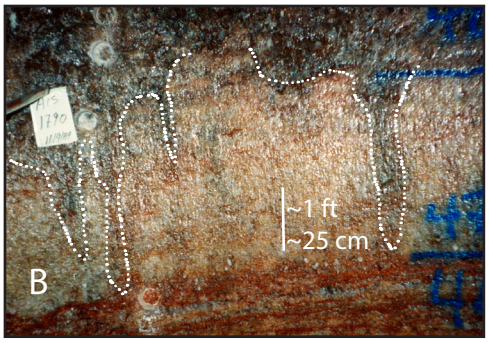
AIS photos (Figures 23B, C) provide context for the size and shape of dissolution pipes. The sides are near-vertical; they are seldom near-planar. A core that intersects the side of a vertical pipe will display textural features that differ horizontally over a very short distance. Sulfate or clay in the





Figure 22. Stitched overlapping photographs of core intervals from C-3977.
A - MB112 (below 1210.0 ft) overlain by mud-poor halite (with polyhalite).
B - Exposure zone (1197.7 - 1198.0 ft) at the top of this depositional cycle with accumulated clastics and underlying podular muddy halite facies.





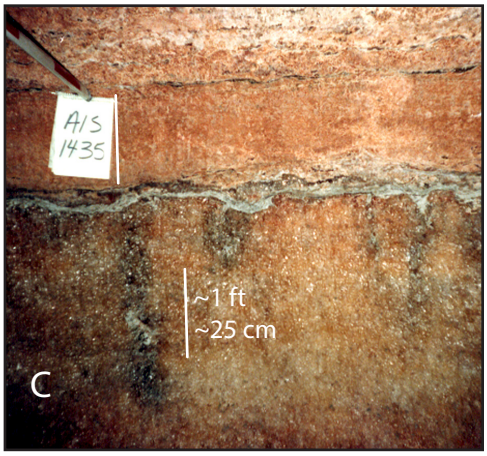


Figure 23. Dissolution pipes.
A - Overlapping photographs of core intervals from C-3977. White dots mark pipe boundary. Pipe and pipe fill of light orange halite cements to right of dotted line.
B - and **C** - Dissolution pipes displayed in broader context of the "host" halite beds. Both photographs from AIS (Holt and Powers, 1990, 2011).

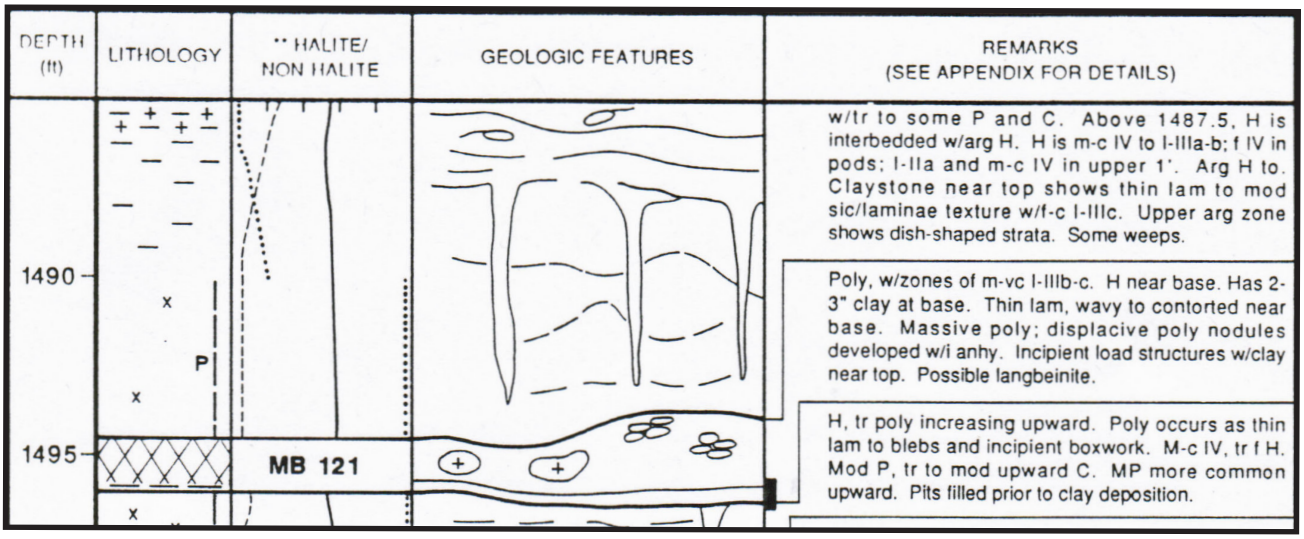


Figure 24. The map figure (Holt and Powers, 1990) of the interval above MB 121 in the AIS indicates relatively deep and narrow dissolution pipes. The core through this interval (Figure 23A) is consistent with the mapping, although intersecting the side of a dissolution pipe is less likely than missing the pipes.

"host" rock can be accumulated at the base of the pipe or perhaps have been largely removed. The cementing halite is commonly coarser, relatively clear, and contains larger fluid inclusions.

Dissolution pipes in the same interval above MB 121 in the AIS extended several ft deep (Figure 24).

Halite comprises a high percentage of the Salado, and it displays several textures (Figure 25) that are repeatedly reported for C-3977. Comprehensive guides to macroscopic features are Holt and Powers (1990) and Holt (1993). Lowenstein (1988) provides excellent examples of small to microscopic textures and features.

Through halite beds of the Salado, we have presented additional graphic information (Appendix C) to supplement descriptions. The estimated average size of the halite is graphed vertically, and this curve is biased somewhat toward the core along the vertical red and black marks. Descriptions normally provide a range estimate. A second curve is a visual estimate of the volume percentage of non-halite constituents by depth. A note here is that visual estimates of these constituents were greatly overestimated when underground mapping began at WIPP. Laboratory investigations showed that even rather "dirty" halite commonly has a low weight percentage of water insolubles. These estimates are more important for their vertical trends and breaks rather than for the estimated percentage at any point. The third curve is an estimate of the percentage of sulfate and "clay" of the non-halite constituents. No other constituents are considered, and "clay" covers all sizes and mineral types of siliciclastics.

The Vaca Triste Sandstone Member (Figure 26) of the Salado is regionally extensive, about 10 ft (3 m) thick, and poorly to moderately lithified. It is likely to spall when exposed.

At C-3977, the top of Vaca Triste is at 1316.8 ft (401.5 m); it extends to 1324.2 ft (403.7 m).

The upper 2 ft of the Vaca Triste and the interval below 1324.2 ft are muddy podular halite lithofacies. The Vaca Triste mainly is dilated mud-rich halite and halitic mudstone.

Geophysical logs (moderate gamma and low density or acoustic values) are diagnostic for the Vaca Triste regionally, and the unit is considered the top of the informal McNutt potash zone.

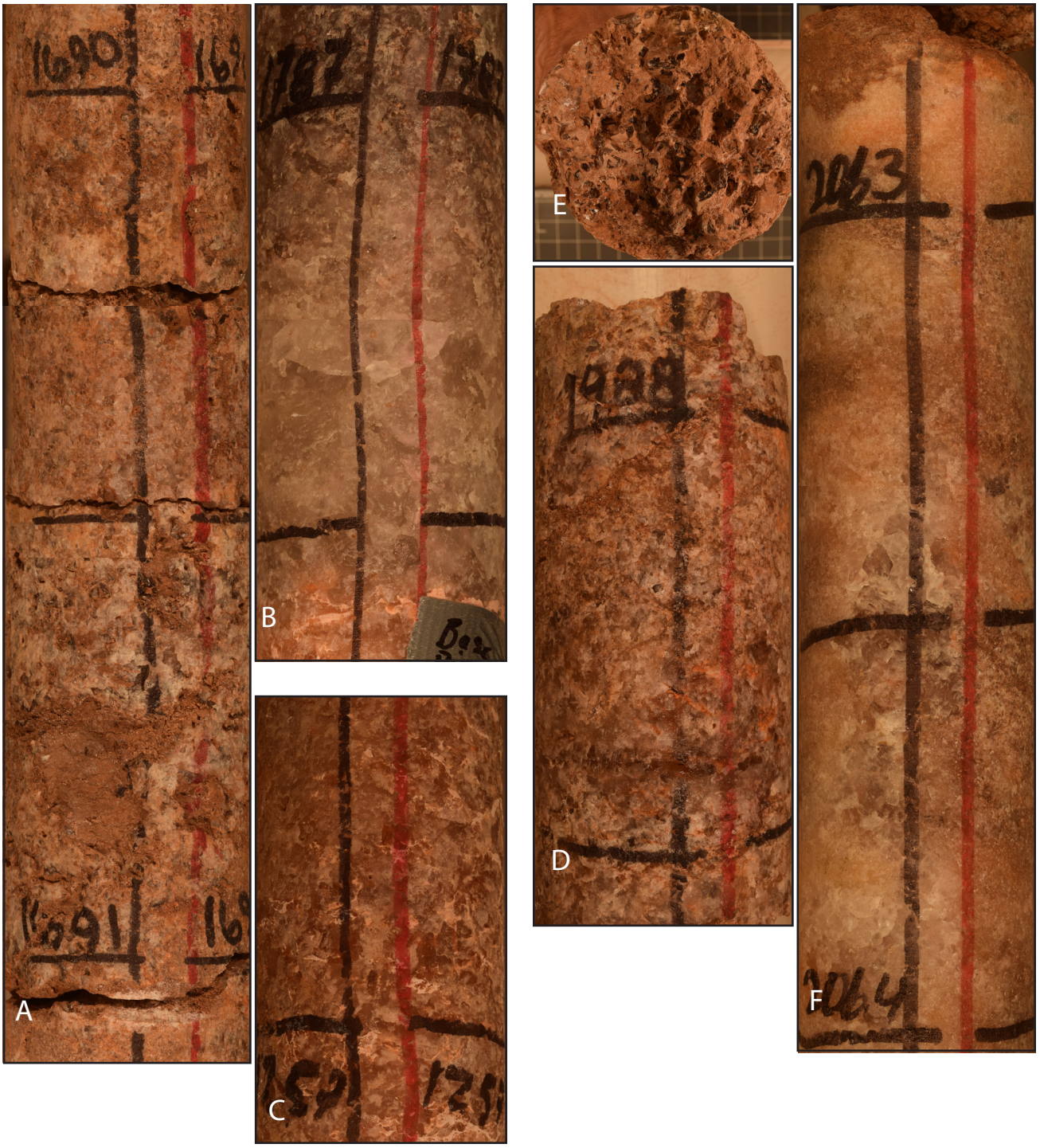
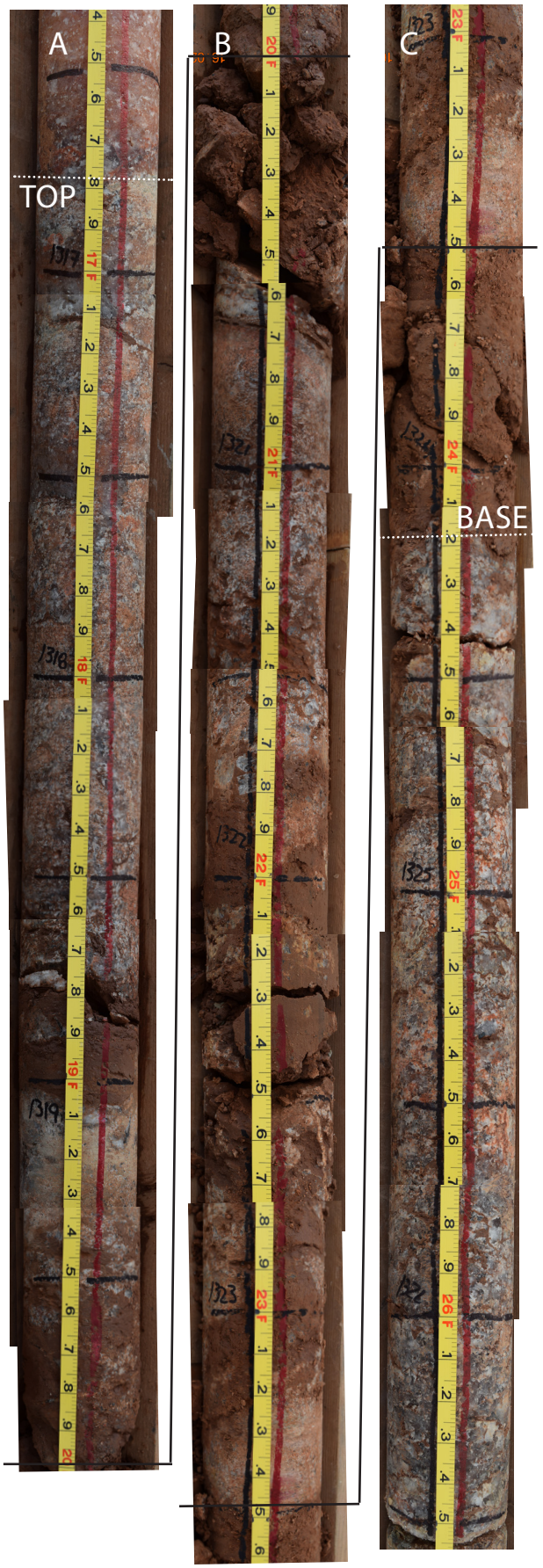


Figure 25. Halite from the Salado in C-3977. **A** - Muddy podular halite where translocated clastics outline some of the podular zones and also accumulate in irregular horizons at probable local paleo brine table. **B** - Coarse clear halite at 1787.5 ft in macropore; similar to halite filling dissolution pipes. **C** - Halite with polyhalite blebs to possible crystal rims. This is common in the lower zones of the desiccating upward cycle. **D&E** - Muddy halite where clastics have been translocated and some of the clastic unit is expanded or dilated by displacive halite (E). **F** - Fine halite (some medium to coarse) that forms in hygroscopically-altered zones and identified in this report as HAB (hygroscopically altered beds). HAB here replaces the oft-used term "efflorescent salt."



Sulfate beds of the Salado are anhydrite and/or polyhalite. Other sulfate minerals occur in the halite beds; the most important is langbeinite, a mineral used as fertilizer for chloride-sensitive plants.

As previously noted, coring produces a thin altered surface to sulfate beds that masks, or can mask, bedding and other sedimentary features. C-3977 has not been slabbed to preserve a reasonable concept of the rock integrity.

Holt (1993) grouped Salado sulfate beds into three categories: thin (<~60 cm or ~2.5 ft), multiple (closely-spaced thin beds), and thicker. C-3977, like the AIS, intercepted all of these types.

Upper and lower surfaces of sulfate beds range from flat and planar to having some relief. Contacts are very sharp to gradational. The base of some beds were deformed while soft. The relief at the upper contact has been interpreted several different ways, and more than one may be correct. Explanations include stromatolitic trapping of granular sulfate; clumps of vertical to subvertical gypsum crystals that trapped fine gypsum; and traction deposits of sulfate grains.

Bedding is thin or laminar, planar to wavy, and locally cross-cutting. Zones of thin "bedded nodular" textures are also observed.

Halite pseudomorphs after gypsum (HPAG) are spectacularly displayed in some sulfate beds (Figure 27). HPAG range in height up to several inches. They may be mainly vertical or may be tilted (but approximately normal to) above wavy bedding. Many of the HPAGs appear altered by dissolution. V-shaped prisms are interpreted as the remains of original vertical gypsum crystals.

Figure 26 A-C (left). Composite field photographs of core through the Vaca Triste Sandstone Member. Black lines tie together the photo composites. Scale is in 0.1 and 0.01 ft. **A** - top of Vaca Triste at 1316.8 ft. **B** - middle Vaca Triste with substantial mudstone component. **C** - Base of Vaca Triste at 1324.2 ft; underlain by podular muddy halite.



Figure 27 (left). Composite photographs of halite pseudomorphs after gypsum in upper MB 134.



Figure 28 (Right). Views of left and right side of an unusual mass of anhydrite overlying MB142. Some remnants of HPAGs and v-shaped fabric are indicated by arrows. Laminae at the base of the photographs separate the mass from the main MB body. Depth 2306.0-2306.7 ft.

The most striking example of an unusual sulfate feature encountered above or at the top of a marker bed occurred nearly at TD. A mass of irregular anhydrite (Figure 28) is separated from the main portion of MB142 by thin gray laminae. The mass itself has wispy or irregular boundaries with the adjacent halite. Some HPAGs and sideways prisms (V-shapes) are present. Possible nodular textures and deformed bedding were identified. The adjacent halite is bedded, and the halite adjacent to the base and in a thin bed at the top have vertical crystals. At this time, we are not sure if this anhydrite mass represents part of the MB.

Many of the sulfate beds in the Salado have some thickness of argillaceous siltstone or mudstone at their base (Figure 29A). These are intervals where there is little tensile strength perpendicular to bedding and where slip planes can develop after mining. There are fewer transitions where sulfate overlies halite without an intervening mudstone or claystone (Figure 29B).

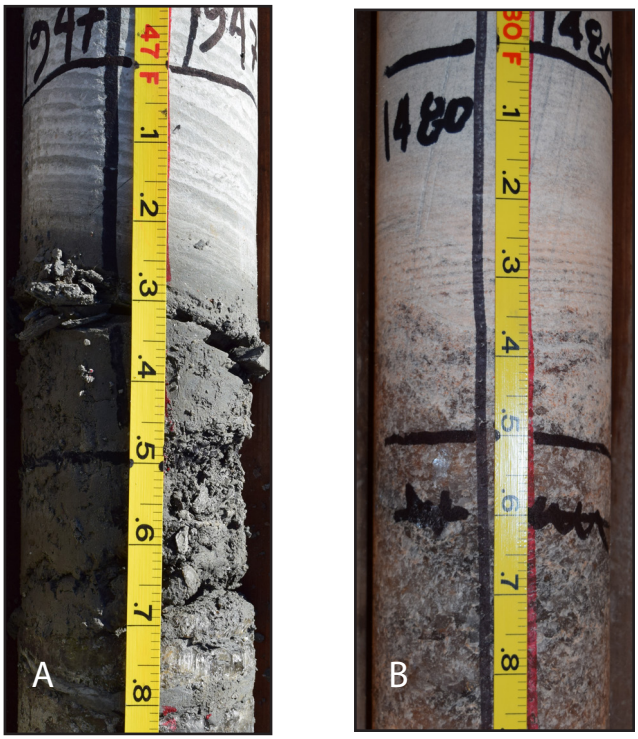


Figure 29 (above). Cores illustrating typical mudstone or claystone underlying sulfate bed (A) and the less typical sulfate transitioning from halite without mudstone (B). A is the base of MB 134; B is the base of MB 122.

GEOPHYSICAL LOGS OF C-3977

There are several iterations of geophysical logs that were obtained during the coring of C-3977.

At 200 ft, prior to installing and cementing the surface casing, JetWest obtained a suite of logs (see folder labelled "Geophysical Logs/C-3977_ JetWest200" on memory stick) that includes natural gamma, caliper, induction, resistivity, neutron-density, and 3 spectral gamma surveys at stationary points.

At 500 ft, JetWest obtained a deviation survey that is shown in a variety of formats ("Geophysical Logs/C-3977_JetWest500ft").

At 1000 ft, JetWest obtained a deviation survey that is also shown in a variety of formats ("GeophysicalLogs/C-3977_JetWest1000ft").

The JetWest deviation survey at 1500 ft is in numerous formats ("GeophysicalLogs/C-3977_ JetWest1500ft").

The Halliburton deviation survey at ~1850 ft is not included as there were errors in the computations that invalidated the survey.

The Halliburton deviation survey and other geophysical logs obtained after reaching TD are included in a separate file (GeophysicalLogs/C-3977_HalliburtonTD). Logs in differing formats and data files are included. Because of an obstruction in the hole, these logs did not reach TD. Some of these logs are only valid below the casing at ~200 ft.

Because of the length of the visual versions of these logs, only a reduced version of a basic log from JetWest above 200 ft and a basic log from Halliburton have been included in the body of the report (Figures 3 & 4).

Geophysical logs provide continuous data over intervals logged, and the depths recorded provide an excellent guide to the stratigraphy complementing the data from coring. The depth reference point for the final logging after reaching TD is the drilling floor, which is ~3 ft above ground level. One of the composite logs from this final logging event is annotated for marker bed depths (Appendix F), and the depths to major marker beds and other stratigraphic intervals on the geophysical logs are compared to the depths as marked on recovered cores. (Table 1). The differences are generally within 1-3 ft after correcting geophysical log depths for the 3 ft height above ground level.

The final deviation survey of C-3977, after coring to TD, was unable to reach TD because of an obstacle at ~2256 ft. The computed total deviation from surface was 20.87 ft at 2240 ft, the deepest point for the survey (Figure 30).

GEOTECHNICAL WORK ON CORES

Four monitor wells (C3976-1, -2, -3, and -4) were cored, logged, and completed as monitor wells for possible shallow (<200 ft; < 61 m) saturated zones. The geology and hydrological observations for those wells will be reported separately.

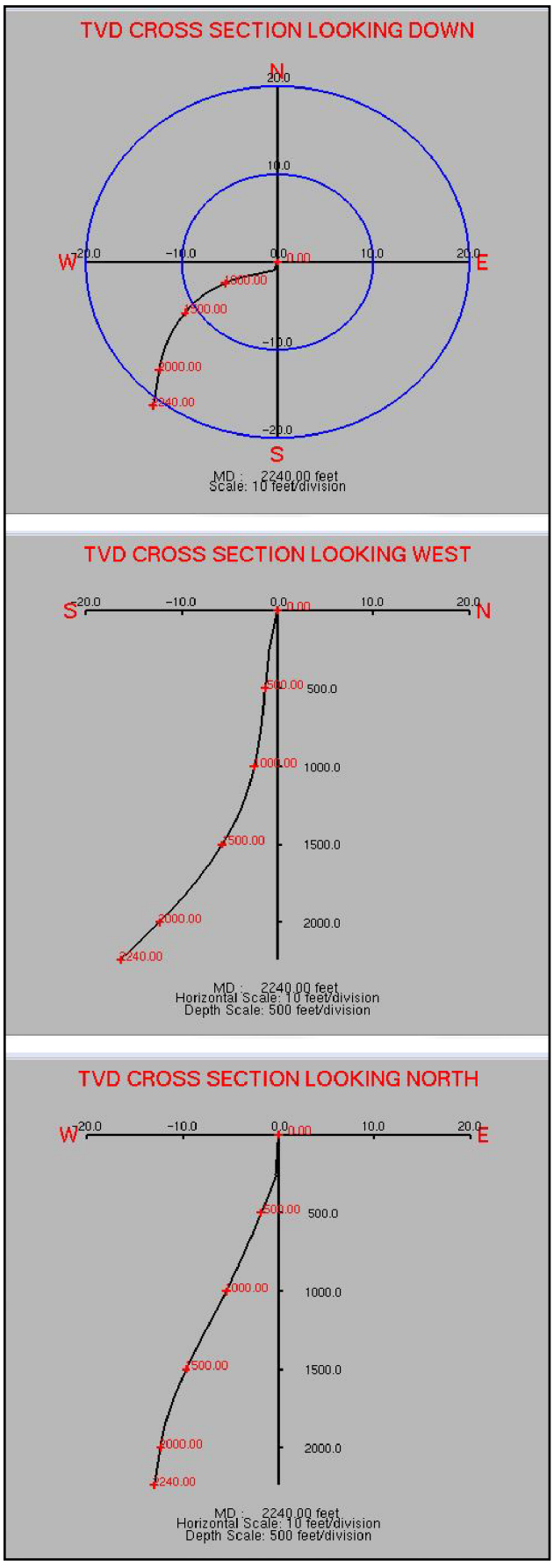
Short intervals (generally less than 3 ft) from each of these monitor wells were preserved for geotechnical work by wrapping and waxing soon after recovery. Fourteen short (1.1 ft - 3.8 ft; 0.34 m - 1.16 m) intervals from C3976-1 and C3976-2 were transported to Daniel B. Stephens and Associates lab in Albuquerque for testing. The tests have been completed, and those results have been reported (DBSA, 2017).

The suite of tests include: gravimetric moisture content (volume measurement method)

- particle size (wet sleeve, hydrometer)
- specific gravity
- Atterburg limits
- strength tests
  - unconfined compressive strength
  - unconsolidated undrained triaxial compression
  - consolidated undrained triaxial compression
  - consolidated drained triaxial compression
- slake durability

The tests have been completed and reported separately (DBSA, 2017).

Samples were selected from C-3977 for limited verification of rock properties (Appendix E). The data from this activity are available in Appendix F.



FIELD OBSERVATIONS RE SHALLOW GROUNDWATER

C-3977 was drilled to 250 ft with air. There were no observed groundwater inflows in that interval.

Each of the four monitor wells located around C-3977 was cored with air or air/mist. Two wells (C3976-2 and -4) were completed to monitor for shallow groundwater, especially the anthropogenic saline water or brine encountered near the site facilities. There was no evidence that such water was encountered during drilling, but monitoring continues. Two wells were completed to monitor for groundwater that might occur above the mineral cement changes in the Dewey Lake. Neither well encountered observable water during drilling, and monitoring of these wells also continues.

Data reports on the drilling, completion, and observations from these monitor wells will be reported separately.

Figure 30. The final deviation survey of C-3977 shows a total deviation of 20.87 ft at 2240 ft depth. The hole was blocked ~2256 ft, leaving ~50 ft unsurveyed. The survey in various formats is included in electronic files associated with the report.

SUMMARY POINTS

C-3977 was cored and logged to provide a record of the geology at the proposed UES location. The core was relatively large diameter (4 inches, 10 cm) to provide both a better record of larger sedimentary features and better recovery of continuous core through evaporites and overlying rocks. Core recovery was high, especially within the Salado. Most lost core occurred near surface. RQD was very good within the Salado, good within the Rustler, and generally very good within the Dewey Lake where it is cemented by sulfate.

The borehole was logged with a suite of geophysical tools. These logs generally corroborate rock type as well as depths that can be compared to the drilling and core marking depths.

The final deviation survey for C-3977 indicates a total deviation <21 ft at a depth of 2240 ft. An obstruction prevented logging to TD. A large-diameter shaft could be located such that C-3977 likely would be removed during construction.

During field examination of the core from C-3977, it was observed that stratigraphic markers were being encountered at lesser depths compared to those recorded for the AIS. This is an expectable consequence of the general eastward dip to the rocks in this area. In addition, there is some difference in the surface elevation of the AIS and the corehole.

There are some observable differences within various intervals when initial core observations are compared to the AIS mapping. Nevertheless, these differences appear to be within the variability of the lithofacies as mapped within the AIS.

There does not, at this time, appear to be natural water inflow in the upper 200 ft at the site.

The quality of rock improves considerably below depth of ~175 ft - 180 ft at this site due to natural cements in the Dewey Lake Formation and competence of most rocks at greater depths.

ACKNOWLEDGMENTS

Far too many people within Nuclear Waste Partnership (NWP) contributed to getting this project started and completed for us to acknowledge each. They know who they are, and we thank them. Rodney Whisenhunt and Ashleigh Pope provided management.

Stewart Brothers supervisors and drillers worked closely with us to obtain the cores and logging that was the objective of the program.

Michael Schuhen and Owen Lofton (Sandia National Laboratories) supplied critical support for core transport and handling. Sandia provided needed support in the form of storage at the secure, climate-controlled environment at Iron Mountain facilities in Carlsbad.

Andy Ward (DOE-Carlsbad) provided useful comments and discussions during planning as well as observation and discussion during the execution of the drilling.

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Stewart Brothers drilling rig on-site at C-3977 on second day of coring (December 28, 2016).



Stewart Brothers drilling rig on-site at C-3977 during night shift (January 28, 2017).



Picking up core barrel December 28, 2016.

APPENDIX A

PERMIT FOR C-3977

OFFICE OF STATE ENGINEER

NEW MEXICO

AND

PLUGGING RECORD

(STEWART BROTHERS DRILLING COMPANY)

Tom Blaine, P.E.
State Engineer

Roswell Office
1900 WEST SECOND STREET
ROSWELL, NM 88201

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Trn Nbr: 591765
File Nbr: C 03977

Aug. 22, 2016

GEORGE BASABILVAZO
ANDERSON WARD
US DEPARTMENT OF ENERGY
PO BOX 3090
CARLSBAD, NM 88221-3090

Greetings:

Enclosed is your copy of the above numbered permit that has been approved subject to the conditions set forth on the approval page. In accordance with the conditions of approval, the well can only be tested for 10 cumulative days, and the well is to be plugged on or before 08/31/2017, unless a permit to use the water is acquired from this office.

A Well Record & Log (OSE Form wr-20) shall be filed in this office within twenty (20) days after completion of drilling, but no later than 08/31/2017.

Appropriate forms can be downloaded from the OSE website www.ose.state.nm.us or will be mailed upon request.

Sincerely,

for

Juan Hernandez
(575)622-6521

Enclosure

explore

UNIQUE #	DOE U	DATE RECVD	ADDRESSEES
1602161	548780	AUG 26 2016	G Basabilvazo w/ Orig Att. A Ward

File No. C-3977

NEW MEXICO OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO DRILL A WELL WITH NO CONSUMPTIVE USE OF WATER

(check applicable box):

For fees, see State Engineer website: http://www.ose.state.nm.us/

Purpose:	☐ Pollution Control And / Or Recovery	☐ Geo-Thermal
■ Exploratory	☐ Construction Site De-Watering	☐ Other (Describe):
☐ Monitoring	☐ Mineral De-Watering	

A separate permit will be required to apply water to beneficial use.

☐ Temporary Request - Requested Start Date: Requested End Date:

Plugging Plan of Operations Submitted? ■ Yes ☐ No

STATE ENGINEER OFFICE ROSWELL, NEW MEXICO 2016 AUG 18 AM 11:21

1. APPLICANT(S)

Name: U.S.Department of Energy	Name: U.S. Department of Energy
Contact or Agent: George Basabilvazo check here if Agent ☐	Contact or Agent: Anderson Ward check here if Agent ☐
Mailing Address: P.O. Box 3090	Mailing Address: P.O. Box 3090
City: Carlsbad	City: Carlsbad
State: New Mexico Zip Code: 88221-3090	State: New Mexico Zip Code: 88221-3090
Phone: ☐ Home ☐ Cell Phone (Work): 575-234-7018	Phone: ☐ Home ☐ Cell Phone (Work): 575-234-7018
E-mail (optional): george.basabilvazo@cbfo.doe.gov	E-mail (optional): Anderson.Ward@cbfo.doe.gov

FOR OSE INTERNAL USE Application for Permit, Form wr-07, Rev 6/14/12

File No.: C-3977	Trn. No.: 591765	Receipt No.: 2.32434
Trans Description (optional):	POD1	
Sub-Basin: CUB	PCW/LOG Due Date: 8-31-17	

2. WELL(S) Describe the well(s) applicable to this application.

Location Required: Coordinate location must be reported in NM State Plane (NAD 83), UTM (NAD 83), or Latitude/Longitude (Lat/Long - WGS84).
District II (Roswell) and District VII (Cimarron) customers, provide a PLSS location in addition to above.

■ NM State Plane (NAD83) (Feet)
☐ NM West Zone
■ NM East Zone
☐ NM Central Zone

☐ UTM (NAD83) (Meters)
☐ Zone 12N
☐ Zone 13N

☐ Lat/Long (WGS84) (to the nearest 1/10th of second)

Well Number (if known):	X or Easting or Longitude:	Y or Northing or Latitude:	Provide if known: -Public Land Survey System (PLSS) (*Quarters or Halves , Section, Township, Range)* OR - Hydrographic Survey Map & Tract; OR - Lot, Block & Subdivision; OR - Land Grant Name
#1	103 degrees 47' 56.99"	32 degrees 22' 21,88"	

NOTE: If more well locations need to be described, complete form WR-08 (Attachment 1 – POD Descriptions)
Additional well descriptions are attached: ■ **Yes** ☐ **No** **If yes, how many** 1

Other description relating well to common landmarks, streets, or other:
Well coordinates are the center of the well pad for which these wells will be located. Corehole will be located east of the WIPP site adjacent to the WIPP North Access Road.

Well is on land owned by: U.S. Department of Energy

Well Information: NOTE: If more than one (1) well needs to be described, provide attachment. Attached? ☐ **Yes** ■ **No**
If yes, how many_____

Approximate depth of well (feet): 2250 Feet	Outside diameter of well casing (inches): NA
Driller Name: Not Determined yet	Driller License Number: TBD

3. ADDITIONAL STATEMENTS OR EXPLANATIONS

See attached scope of work and diagram. This is an exploratory corehole, not a well. Will be plugged and abandoned upon completion. No pump testing will occur. Only used to define stratigraphy and obtain lithologic core samples. See plugging plan.

FOR OSE INTERNAL USE — Application for Permit, Form wr-07

File No.: C-3977	Trn No.: 591765

Page 2 of 3

4. SPECIFIC REQUIREMENTS: The applicant must include the following, as applicable to each well type. Please check the appropriate boxes, to indicate the information has been included and/or attached to this application:

Exploratory:	**Pollution Control and/or Recovery:**	**Construction De-Watering:**	**Mine De-Watering:**
■ Include a description of any proposed pump test, if applicable.	☐ Include a plan for pollution control/recovery, that includes the following: ☐ A description of the need for the pollution control or recovery operation. ☐ The estimated maximum period of time for completion of the operation. ☐ The annual diversion amount. ☐ The annual consumptive use amount. ☐ The maximum amount of water to be diverted and injected for the duration of the operation. ☐ The method and place of discharge.	☐ Include a description of the proposed dewatering operation, ☐ The estimated duration of the operation, ☐ The maximum amount of water to be diverted, ☐ A description of the need for the dewatering operation, and, ☐ A description of how the diverted water will be disposed of.	☐ Include a plan for pollution control/recovery, that includes the following: ☐ A description of the need for mine dewatering. ☐ The estimated maximum period of time for completion of the operation. ☐ The source(s) of the water to be diverted. ☐ The geohydrologic characteristics of the aquifer(s). ☐ The maximum amount of water to be diverted per annum. ☐ The maximum amount of water to be diverted for the duration of the operation. ☐ The quality of the water. ☐ The method of measurement of water diverted. ☐ The recharge of water to the aquifer. ☐ Description of the estimated area of hydrologic effect of the project. ☐ The method and place of discharge. ☐ An estimation of the effects on surface water rights and underground water rights from the mine dewatering project. ☐ A description of the methods employed to estimate effects on surface water rights and underground water rights. ☐ Information on existing wells, rivers, springs, and wetlands within the area of hydrologic effect.
Monitoring: ☐ Include the reason for the monitoring well, and, ☐ The duration of the planned monitoring.	☐ The method of measurement of water produced and discharged. ☐ The source of water to be injected. ☐ The method of measurement of water injected. ☐ The characteristics of the aquifer. ☐ The method of determining the resulting annual consumptive use of water and depletion from any related stream system. ☐ Proof of any permit required from the New Mexico Environment Department. ☐ An access agreement if the applicant is not the owner of the land on which the pollution plume control or recovery well is to be located.	**Geo-Thermal:** ☐ Include a description of the geothermal heat exchange project, ☐ The amount of water to be diverted and re-injected for the project, ☐ The time frame for constructing the geothermal heat exchange project, and, ☐ The duration of the project. ☐ Preliminary surveys, design data, and additional information shall be included to provide all essential facts relating to the request.	

ACKNOWLEDGEMENT

I, We (name of applicant(s)), George T. Basabilvazo
Print Name(s)

affirm that the foregoing statements are true to the best of (my, our) knowledge and belief.

George T. Basabilvazo
Applicant Signature

Applicant Signature

STATE ENGINEER OFFICE
ROSWELL, NEW MEXICO
2016 AUG 18 AM 11:21

ACTION OF THE STATE ENGINEER

This application is:

☒ approved ☐ partially approved ☐ denied

provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare and further subject to the attached conditions of approval.

Witness my hand and seal this 22 day of August 20 16, for the State Engineer,

Tom Blaine, P.E., State Engineer

By: _____ _____
Signature Print

Title: Juan Hernandez, Engr Specialist Supervisor
Print

FOR OSE INTERNAL USE — Application for Permit, Form wr-07

File No.: C-3977 Trn No.: 591765

NEW MEXICO STATE ENGINEER OFFICE
PERMIT TO EXPLORE

SPECIFIC CONDITIONS OF APPROVAL

2 The well shall be constructed to artesian well specifications and the State Engineer shall be notified before casing is landed or cemented

4 No water shall be appropriated and beneficially used under this permit.

6 The well shall be plugged upon completion of the permitted use, and a plugging report shall be filed with the State Engineer within 10 days.

7 The Permittee shall utilize the highest and best technology available to ensure conservation of water to the maximum extent practical.

B The well shall be drilled by a driller licensed in the State of New Mexico in accordance with Section 72-12-12 New Mexico Statutes Annotated.

C Driller's well record must be filed with the State Engineer within 20 days after the well is drilled or driven. Well record forms will be provided by the State Engineer upon request.

C2 No water shall be diverted from this well except for testing purposes which shall not exceed ten (10) cumulative days, and well shall be plugged or capped on or before , unless a permit to use water from this well is acquired from the Office of the State Engineer.

Trn Desc: C 03977 POD1

File Number: C 03977
Trn Number: 591765

page: 1

NEW MEXICO STATE ENGINEER OFFICE
PERMIT TO EXPLORE

SPECIFIC CONDITIONS OF APPROVAL (Continued)

G If artesian water is encountered, all rules and regulations pertaining to the drilling and casing of artesian wells shall be complied with.

P The well shall be constructed, maintained, and operated to prevent inter-aquifer exchange of water and to prevent loss of hydraulic head between geologic zones.

Q The State Engineer retains jurisdiction over this permit.

R Pursuant to section 72-8-1 NMSA, the permittee shall allow the State Engineer and his representatives entry upon private property for the performance of their respective duties, including access to the ditch or acequia to measure flow and also to the well for meter reading and water level measurement.

LOG The Point of Diversion C 03977 POD1 must be completed and the Well Log filed on or before 08/31/2017.

IT IS THE PERMITTEES RESPONSIBILITY TO OBTAIN ALL AUTHORIZATIONS AND PERMISSIONS TO DRILL ON PROPERTY OF OTHER OWNERSHIP BEFORE COMMENCING ACTIVITIES UNDER THIS PERMIT.

SHOULD THE PERMITTEE CHANGE THE PURPOSE OF USE TO OTHER THAN MONITORING PURPOSES, AN APPLICATION SHALL BE ACQUIRED FROM THE OFFICE OF THE STATE ENGINEER.

Trn Desc: C 03977 POD1 File Number: C 03977
Trn Number: 591765

page: 2

NEW MEXICO STATE ENGINEER OFFICE
PERMIT TO EXPLORE

ACTION OF STATE ENGINEER

Notice of Intention Rcvd:	Date Rcvd. Corrected:
Formal Application Rcvd: 08/18/2016	Pub. of Notice Ordered:
Date Returned - Correction:	Affidavit of Pub. Filed:

This application is approved provided it is not exercised to the detriment of any others having existing rights, and is not contrary to the conservation of water in New Mexico nor detrimental to the public welfare of the state; and further subject to the specific conditions listed previously.

Witness my hand and seal this 22 day of Aug A.D., 2016

Tom Blaine, P.E., State Engineer

By: Juan Hernandez

Trn Desc: C 03977 POD1

File Number: C 03977
Trn Number: 591765

page: 3

Locator Tool Report

General Information:

Application ID: 29 Date: 08-22-2016 Time: 11:22:30

WR File Number: C
Purpose: OTHER

Applicant First Name: USDOE-G BASABILVAZO
Applicant Last Name: USDOE-A WARD

GW Basin: CARLSBAD
County: EDDY

Critical Management Area Name(s): NONE
Special Condition Area Name(s): NONE
Land Grant Name: NON GRANT

PLSS Description (New Mexico Principal Meridian):

NW 1/4 of NW 1/4 of SW 1/4 of SE 1/4 of Section 20, Township 22S, Range 31E.

Coordinate System Details:

Geographic Coordinates:

Latitude:	32 Degrees	22 Minutes	21.9 Seconds	N
Longitude:	103 Degrees	47 Minutes	57.0 Seconds	W

Universal Transverse Mercator Zone: 13N

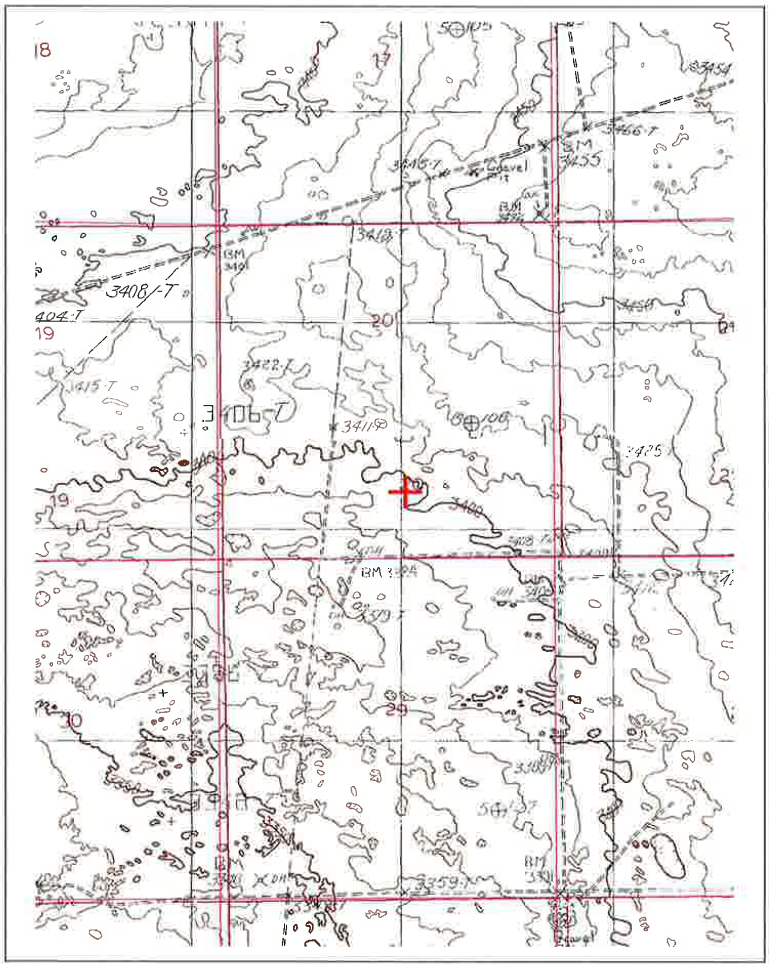
NAD 1983(92) (Meters)	N: 3,582,387	E: 612,968
NAD 1983(92) (Survey Feet)	N: 11,753,214	E: 2,011,045
NAD 1927 (Meters)	N: 3,582,185	E: 613,016
NAD 1927 (Survey Feet)	N: 11,752,551	E: 2,011,205

State Plane Coordinate System Zone: New Mexico East

NAD 1983(92) (Meters)	N: 152,323	E: 215,266
NAD 1983(92) (Survey Feet)	N: 499,748	E: 706,251
NAD 1927 (Meters)	N: 152,305	E: 202,713
NAD 1927 (Survey Feet)	N: 499,687	E: 665,069

NEW MEXICO OFFICE OF STATE ENGINEER

Locator Tool Report



WR File Number: C Scale: 1:28,736

Northing/Easting: UTM83(92) (Meter): N: 3,582,387 E: 612,968

Northing/Easting: SPCS83(92) (Feet): N: 499,748 E: 706,251

GW Basin: Carlsbad

OFFICE OF THE STATE ENGINEER/INTERSTATE STREAM COMMISSION – ROSWELL OFFICE

OFFICIAL RECEIPT NUMBER: 2 - 37434 DATE: 8-18-16 FILE NO.: C-Basin

TOTAL: 5.00 RECEIVED: Field DOLLARS CHECK NO.: _____ CASH: ✓

PAYOR: US Dept. of Energy ADDRESS: PO Box 3090 CITY: Carlsbad STATE: NM

ZIP: 88221 RECEIVED BY: ZM

INSTRUCTIONS: Indicate the number of actions to the left of the appropriate type of filing. Complete the receipt information. **Original** to payor; **pink** copy to Program Support/ASD; and **yellow** copy for Water Rights. If a mistake is made, void the original and all copies and submit to Program Support/ASD as part of your daily deposit.

A. Ground Water Filing Fees

___	1. Change of Ownership of Water Right	$ 2.00
___	2. Application to Appropriate or Supplement Domestic 72-12-1 Well	$ 125.00
___	3. Application to Repair or Deepen 72-12-1 Well	$ 75.00
___	4. Application for Replacement 72-12-1 Well	$ 75.00
___	5. Application to Change Purpose of Use 72-12-1 Well	$ 75.00
___	6. Application for Stock Well/Temp. Use	$ 5.00
___	7. Application to Appropriate Irrigation, Municipal, or Commercial Use	$ 25.00
___	8. Declaration of Water Right	$ 1.00
___	9. Application for Supplemental Non 72-12-1 Well	$ 25.00
___	10. Application to Change Place or Purpose of Use Non 72-12-1 Well	$ 25.00
___	11. Application to Change Point of Diversion and Place and/or Purpose of Use from Surface Water to Ground Water	$ 50.00
___	12. Application to Change Point of Diversion and Place and/or Purpose of Use from Ground Water to Ground Water	$ 50.00
___	13. Application to Change Point of Diversion of Non 72-12-1 Well	$ 25.00
___	14. Application to Repair or Deepen Non 72-12-1 Well	$ 5.00
1	15. Application for Test, Expl. Observ. Well	$ 5.00
___	16. Application for Extension of Time	$ 25.00
___	17. Proof of Application to Beneficial Use	$ 25.00
___	18. Notice of Intent to Appropriate	$ 25.00

B. Surface Water Filing Fees

___	1. Change of Ownership of a Water Right	$ 5.00
___	2. Declaration of Water Right	$ 10.00
___	3. Amended Declaration	$ 25.00
___	4. Application to Change Point of Diversion and Place and/or Purpose of Use from Surface Water to Surface Water	$ 200.00
___	5. Application to Change Point of Diversion and Place and/or Purpose of Use from Ground Water to Surface Water	$ 200.00
___	6. Application to Change Point of Diversion	$ 100.00
___	7. Application to Change Place and/or Purpose of Use	$ 100.00
___	8. Application to Appropriate	$ 25.00
___	9. Notice of Intent to Appropriate	$ 25.00
___	10. Application for Extension of Time	$ 50.00
___	11. Supplemental Well to a Surface Right	$ 100.00
___	12. Return Flow Credit	$ 100.00
___	13. Proof of Completion of Works	$ 25.00
___	14. Proof of Application of Water to Beneficial Use	$ 25.00
___	15. Water Development Plan	$ 100.00
___	16. Declaration of Livestock Water Impoundment	$ 10.00
___	17. Application for Livestock Water Impoundment	$ 10.00

All fees are non-refundable.

C. Well Driller Fees

___	1. Application for Well Driller's License	$ 50.00
___	2. Application for Renewal of Well Driller's License	$ 50.00
___	3. Application to Amend Well Driller's License	$ 50.00

D. Reproduction of Documents

___ @ 0.25¢ $_____

___ Map(s) $_____

E. Certification $_____

F. Other $_____

G. Comments:

Fed Ex

PLUGGING RECORD

NOTE: A Well Plugging Plan of Operations shall be approved by the State Engineer prior to plugging - 19.27.4 NMAC

I. GENERAL / WELL OWNERSHIP:

State Engineer Well Number: C-3977

Well owner: U.S. Dept of Energy Phone No.: _____

Mailing address: PO Box 3090

City: Carlsbad State: NM Zip code: 88221

II. WELL PLUGGING INFORMATION:

1) Name of well drilling company that plugged well: Stewart Brothers Drilling Co

2) New Mexico Well Driller License No.: WD-331 Expiration Date: 8/13/17

3) Well plugging activities were supervised by the following well driller(s)/rig supervisor(s): _____
William Brunson

4) Date well plugging began: 3-4-17 Date well plugging concluded: 3-4-17

5) GPS Well Location: Latitude: 32 deg, 22 min, 21.88 sec
Longitude: 103 deg, 47 min, 56.99 sec, WGS 84

6) Depth of well confirmed at initiation of plugging as: 2308 ft below ground level (bgl),
by the following manner: Tagging

7) Static water level measured at initiation of plugging: 354 ft bgl

8) Date well plugging plan of operations was approved by the State Engineer: 3-2-17

9) Were all plugging activities consistent with an approved plugging plan? yes If not, please describe differences between the approved plugging plan and the well as it was plugged (attach additional pages as needed):

Version: September 8, 2009
Page 1 of 2

10) Log of Plugging Activities - Label vertical scale with depths, and indicate separate plugging intervals with horizontal lines as necessary to illustrate material or methodology changes. Attach additional pages if necessary.

For each interval plugged, describe within the following columns:

Depth (ft bgl)	Plugging Material Used (include any additives used)	Volume of Material Placed (gallons)	Theoretical Volume of Borehole/ Casing (gallons)	Placement Method (tremie pipe, other)	Comments ("casing perforated first", "open annular space also plugged", etc.)
	Class C cement from 0 to 710 ft	2171		tremie	
	710 ft to 2308 ft class C cement with 35 percent salt	2 700		tremie	

MULTIPLY		BY		AND OBTAIN
cubic feet	x	7.4805	=	gallons
cubic yards	x	201.97	=	gallons

III. SIGNATURE:

I, W L Brunson, say that I am familiar with the rules of the Office of the State Engineer pertaining to the plugging of wells and that each and all of the statements in this Plugging Record and attachments are true to the best of my knowledge and belief.

W L Brunson — Signature of Well Driller

3-18-17 — Date

Version: September 8, 2009
Page 2 of 2



Geology crew and assistants prepping upper Dewey Lake core for marking and descriptions. Andy Ward (DOE, second from left in foreground) observing. December 29, 2016.





Night shift geology crew and assistants prepping Dewey Lake core for marking and description. January 28 and 29, 2017.

APPENDIX B

GEOLOGIC LOGS

FROM

SURFACE TO TOP OF SALADO FORMATION

About Rustler Descriptions

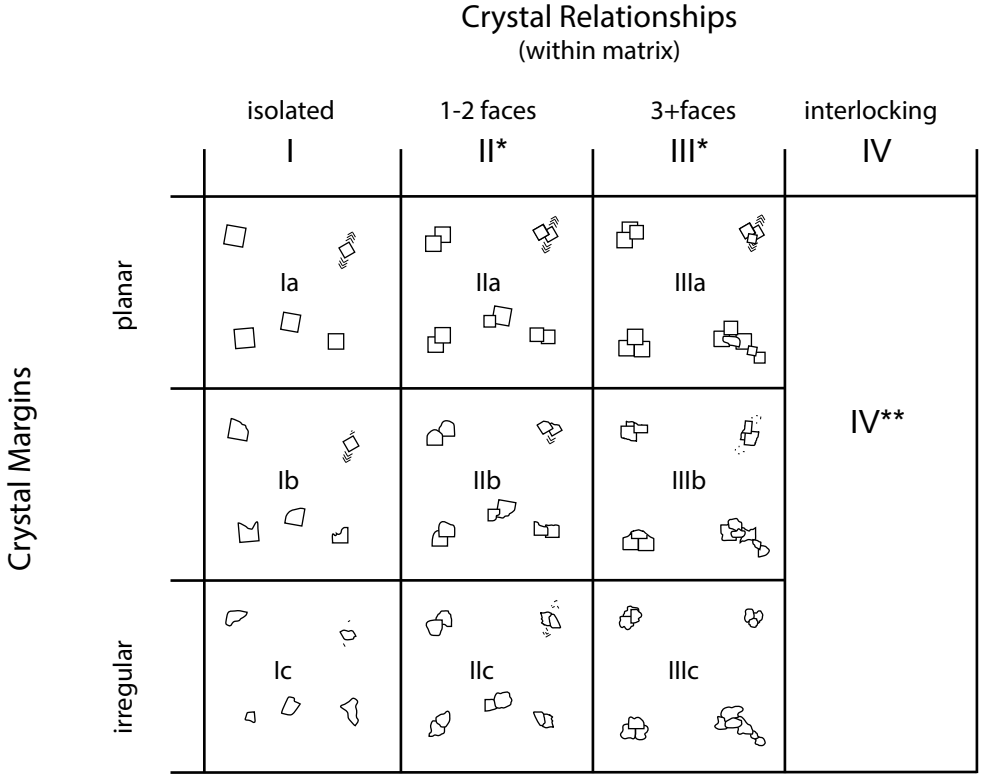
The geology of the formations above the Salado are more variable in lithology, and halite is present at C-3977 only in the Los Medaños Member of the Rustler Formation. The geologic logs differ in format from those used for the Salado (Appendix C) in that none of the characteristics of the halite beds are graphically presented here.

In addition, the formats used for the units above 200 ft (where the corehole was reamed and cased) were adjusted somewhat by the geology team to provide a more convenient record.

Some symbols, features or abbreviatioins used in common for all geologiclogs may differ between Salado and supra-Salado formations

---

Halite crystal forms in the lower Rustler (Los Medaños Member) (and Salado) are most easily described with a basic template for textures developed by Holt and Powers (1990). The principal factors are the crystal-crystal relationship (isolated to sharing faces) and the nature of the crystal faces.



*Internal boundaries may be more planar for growth of individual displacive crystals. Internal boundaries are more irregular with multiple solution/growth episodes and rapid growth into porosity.

**interlocking textures in dominantly halite rock may exhibit a variety of margin relationships.

Features and Structures

$f_g/_{0°}$ $f_h/_{75°}$ fracture with fill (gypsum or halite) and dip

slump or clast of sandstone

ic_{slt} ic_g intraclasts of gypsum or siltstone

sl pedogenic slickensides

1.0+' desiccation crack (some with height indication)

bioturbation

soft sediment deformation

bedding drapes

small cross-bedding

ripple bedding

wavy bedding

laminar bedding (~horizontal)

smeared intraclasts

pores with small fractures or horizontal bedding (in Culebra Dolomite Member)

stylolites (in sulfate beds)

solution/infiltration cracks (top of Rustler)

sulfate breccia

nodular textures, sulfate

crushed prisms, prismatic features (gypsum)

bottom-grown gypsum, mounded

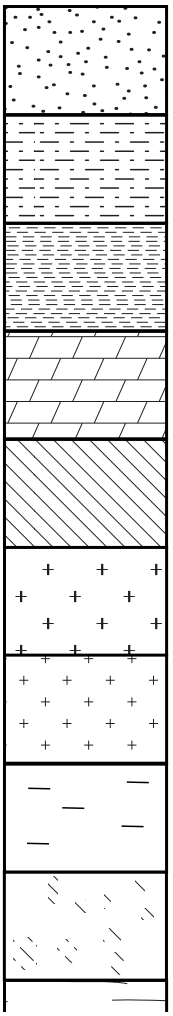
bottom-grown gypsum, pseudomorphed by halite

Contacts and Bedding

sharp contact or erosional surface within unit

gradational contact or erosional surface within unit

Lithologies



CORE LOG

Sheet 1 of 60

Hole ID: C3977

Location: sw 1/4, section 20, T22S, R31E, Eddy County, NM

Drill Date: 12/27/2016 begin

Drill Crew: Mike King and crew (Stewart Brothers Drilling Company)

Drill Method: rotary with air; core with air

Hole Diameter: cored interval: 6.25 inch

Hole Depth: 2308 ft

Hole Orient: vertical

Drill Make/Model:

Barrel Specs: 4: core; 6.25 in hole

Drill Fluid: air; air-mist; brine

Core Preserv: waxed core box

Logged by: DW Powers and others

Date: 12/27/16-3/2/17

Scale: 1 inch = 5 feet

	Northing	Easting	Elevation
Survey Coordinate: (m)			gl: 3400.38 ft amsl

Comments: lat 32˚ 22' 21.8757" (32.37274325˚); log -103˚ 47' 56.9829" (-103.799167˚)

Run Number	Depth (feet)	Recovered (ft/ft cored)	RQD (ft/ft)	Description	Remarks
N/A; reamed to 12 ft for temp casing; reamed after coring to 205 ft for large casing.	0			Pad Construction materials; dune sand	
	5			No cuttings retained	
	10	NA	NA	10 ft Mescalero caliche; calcareous sandstone	
	12			No recovery 12' - 20.3'	
	15				
		5.7	0.7		
		15.0	5.7		
1	20			20.3' 2.5Y8/2 pale brown	
				20.3-27.5: Ss, light gray to reddish brown to pale brown upward; large siltst intraclasts at 27.3'; subang - subround sand; qtz and 0.5-1 % opaques; r-b zone includes probable mica and silt; poorly bedded to laminar, some wavy laminae; calc, increases upward; generally poorly indurated to friable, short length is mod indurated	assigned core to bottom of interval
	25				
	27			ic 2.5YR4/4 reddish brown	
				ic 5Y7/1 light gray	begin marking core #2 @ 27 ft
	30				

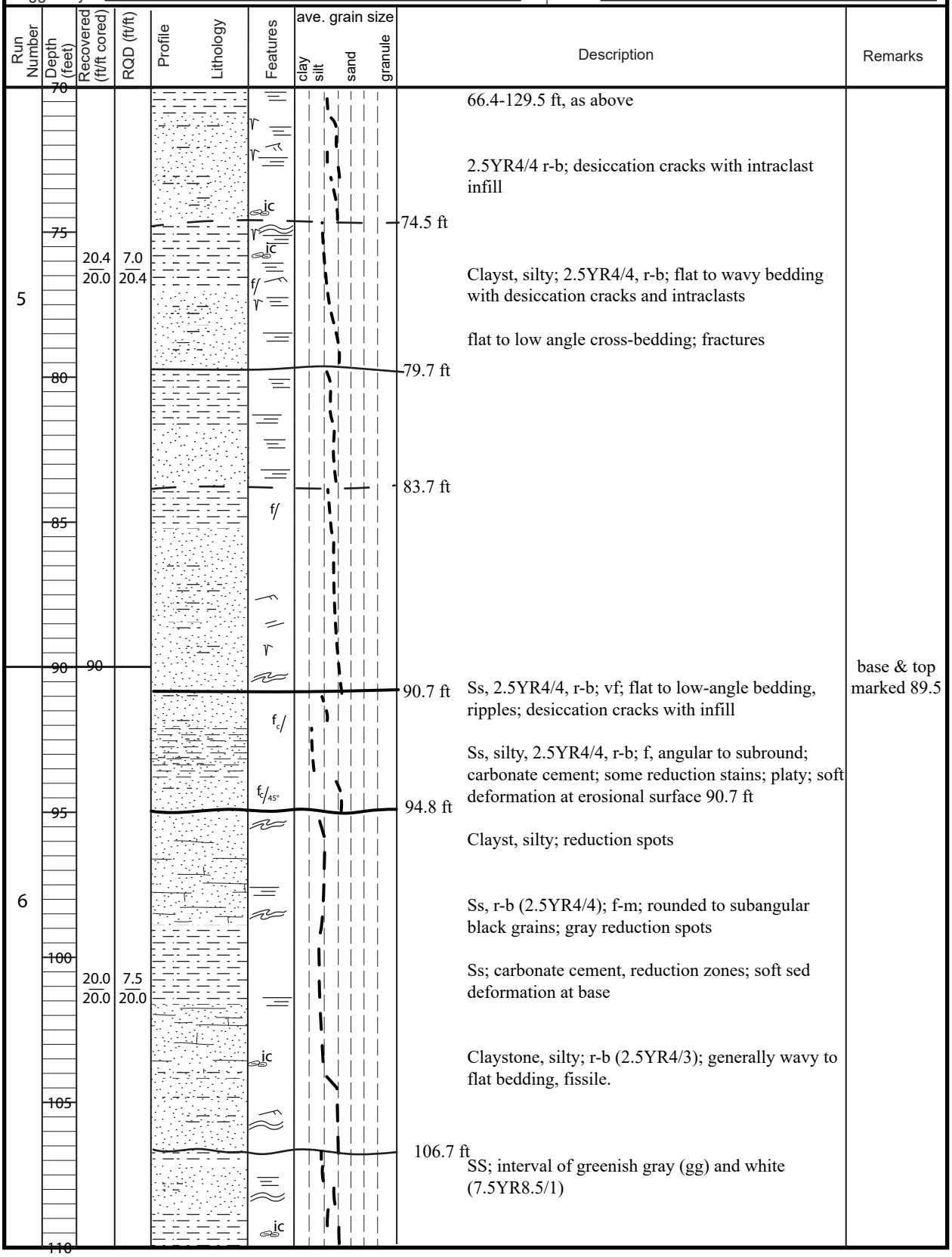
Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 2 of 60

Logged by: geological team Date: 12/28/2016

Run Number	Depth (feet)	Recovered (ft/ft cored)	RQD (ft/ft)	Description	Remarks
	30			cm-scale porosity w/qtz linings 2.5YR4/4 (r-b) mottled 2.5YR8/1 (white)	Dockum Gp
				32.1 ft	32.1 ft top Dewey Lake Fm
				27.5-66.4 ft Series of: 2.5YR4/4 rb SS, generally r-b, vf-f, sub ang - subround; quartz with tr opaques, mod indurated, slightly calc; fining upward to silty clayst and arg sltst; mm scale laminae; desiccation cracks are displayed on some partings; some mica? flakes; non-calc to slightly calc; poor to mod induration; parts easily along laminae	
	35				
2		19.0 / 20.0	7.4 / 19.0	35.8 ft	
				gg	
	40			gg	
				2.5 YR3/4 dark r-b	
				42.5 ft	
				gg	
	45			2.5YR3/4 dark r-b	
	47			47.2 ft	#2 & #3 fit
3		3.3 / 2.5	1.0 / 3.3	5YR8/1 white	
	49.5				#3 & #4 fit
	50			2.5YR3/4 dark r-b gg r-b gg r-b	
				53.5 ft	
	55				
4				57.9 ft	
	60			Gley2 5BG8/1 light gg & 2.5YR4/4 r-b	
		19.7 / 20.5	16.6 / 19.7	60.7 ft	
				gg 5YR4/4 rb	
	65			gg white N8/	
				66.4 ft Claystone, silty; r-b; flat bedded to low angle cross-cutting beds; includes intraclasts	#4 & #5 fit base #4 marked 69.0
				2.5YR3/4 dark r-b	
	70	70			

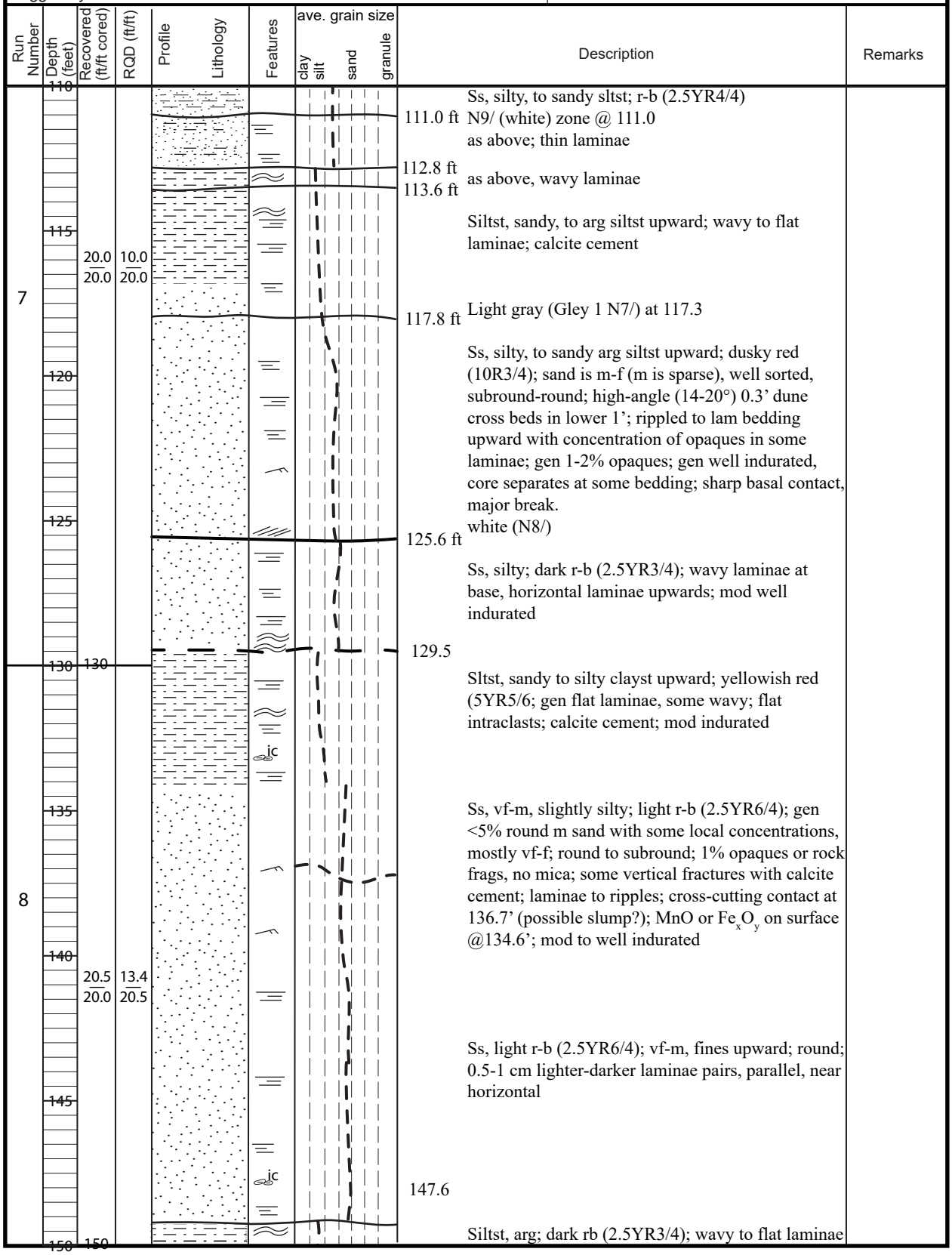
Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 3 of 60

Logged by: geological team Date: 12/28/2016



Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 4 of 60

Logged by: geological team Date: 12/28/2016



Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 5 of 60

Logged by: geological team Date: 12/28-29/2016

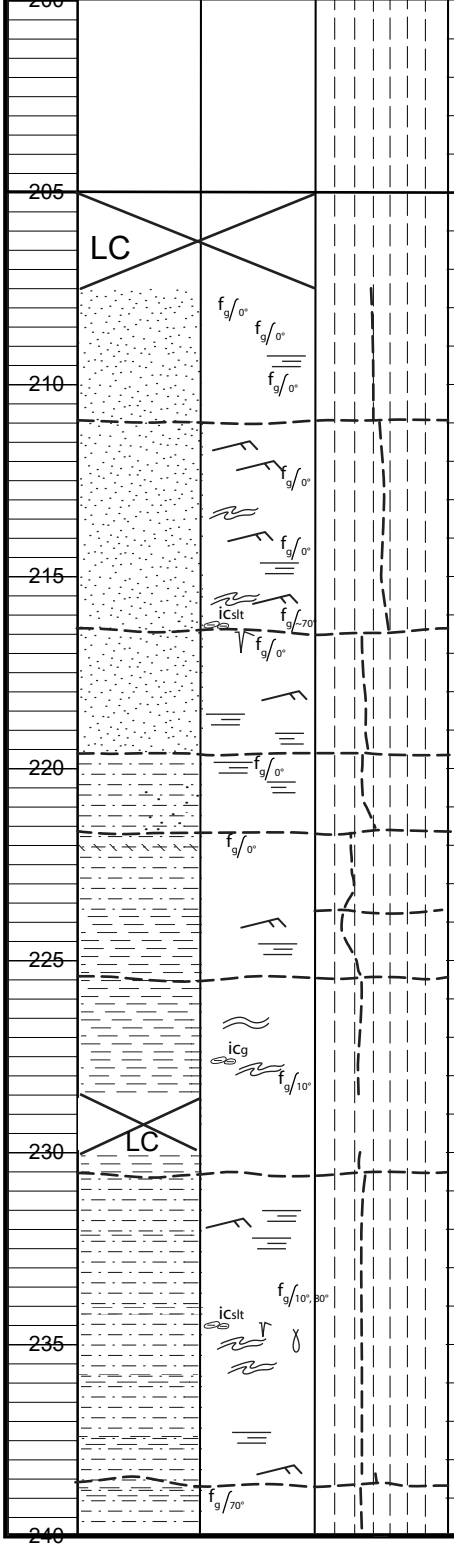
Run Number	Depth (feet)	Recovered (ft/ft cored)	RQD (ft/ft)	Description	Remarks
	150			Ss, to sltst upward, red (2.5YR5/8) with some gg reduction spots; subhoriz to wavy lam; poorly ind; tr calcareous veins @151.7'.	
	155				
		19.7 / 20.0	10.5 / 19.7	155.9 ft Ss, silty, to sandy sltst upward; vf sand, subround, <1% opaques; poorly expressed lam lower part, bedding clearer upwards, ripples wavy lam, slight cross-cutting; intraclasts at base.	
9	160			160.1 ft Siltst, some sandy gg laminae and spots; thin horizontal beds and laminae; some small intraclasts; tr calcite in veins	
	165			Ss, r-b (2.5YR3/4); f-m, round to subround, ~ 5 to10% round m sand grains, more common upward; ~2% opaques or rock frags, tr muscovite, grains coated red; sltst intraclasts at 166' and base; porous zone, slightly calcareous above change at 167.5' to 167.5 ft sulfate cement and separations filled with gypsum; some unfilled seps show apparent fine-grained fill; 169.3 ft gen mod indurated	
	170	170		SS, becomes more silty, arg upward to sandy siltst; r-b (2.5YR5/4) with some small reduction spots; vf-f, subround; ~1% opaques; cross beds and small gypsum or anhydrite clast near base, small ripples and thin laminae; vertical seps from 176.6-171.6', mod ind.	
	175			176.2 ft	
10	180			Ss, rb (2.5YR5/4) to silty ss to siltst, red (2.5YR5/6); sand is vf-f, 1-2% opaques; climbing ripples near base, horizontal to wavy lam upward; mm-cm scale laminae differentiated by color.	
		20.2 / 20.0	17.0 / 20.2		
	185			184.2 ft Ss, silty, at base to claystone, silty; dark red (2.6YR3/6); siltst clasts at base and locally in interval; desiccation crack at 186.2 filled with siltst clasts with gg color; truncated at top; local small gg spots as well as irregular zones	
	190	190		188.5 ft see next page for description below 188.5'	

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 6 of 60

Logged by: geological team Date: 12/28-29/2016

Run Number	Depth (feet)	Recovered (ft/ft cored)	RQD (ft/ft)	Profile / Lithology	Features	ave. grain size: clay silt sand granule	Description	Remarks
11	190	11.0 / 12.0	5.0 / 11.0		sl		192.1 ft Ss to sltst upward, r-b; tr mica, ~1% opaques concentrated on stoss-side ripples and climbing surfaces; ripples to 2 cm high Ss, silty, light r-b to r-b (2.5YR6/3-4/3) to arg sltst, rb (2.5YR4/4); erosional surf within ss at 199.2'; lower sand is vf, subround, well sorted, 1% opaques, tr mica; v thin laminae, horiz to subhorizontal, low angle cross-beds, some ripples; well indurated; upper sand vf-f, subround, well sorted; concentrated opaques on ripples near top; low angle cross-stratification; pedogenic slickensides near top of sand; sltst is laminated (to 2 cm thick), some wavy bedding; sltst intraclasts.	
	195				sl			
	200						201.3 ft Sltst, arg, light r-b (2.5YR4/3);	
		Depth cored 202'						
	205							

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 7 of 60



Description

205.0 Begin coring after drilling and reaming to set surface casing 7 to ~200 ft.

205.0-207.5: lost core

207.5-210.9: Ss, yellowish red (5YR5/6) with small greenish gray reduction spots (note: these are numerous throughout the Dewey Lake and are not included in most descriptions); vf ss; horizontal – subhorizontal laminae; numerous mm-cm scale subhorizontal separations with gypsum that commonly appears to be fibrous; apparent erosional basal contact.

210.9-216.3: Ss, dark r-b (2.5YR3/4) with some greenish gray hues in upper half foot; generally vf-f, fining upward; abundant f laminae that are generally ~horizontal with ripples more abundant upward; some soft sed def; siltst intraclasts (ic) near erosional basal contact.

216.3-219.6: Ss, r-b; vf sand, abundant lam, some ripples; fibrous gypsum filling horiz separations; probable erosional basal contact.

219.6-221.6: Sltst, sandy, r-b (2.5YR4/4) to red (2.5YR3/6) upward; f lam; horizontal gypsum-filled separation near top; erosional basal contact.

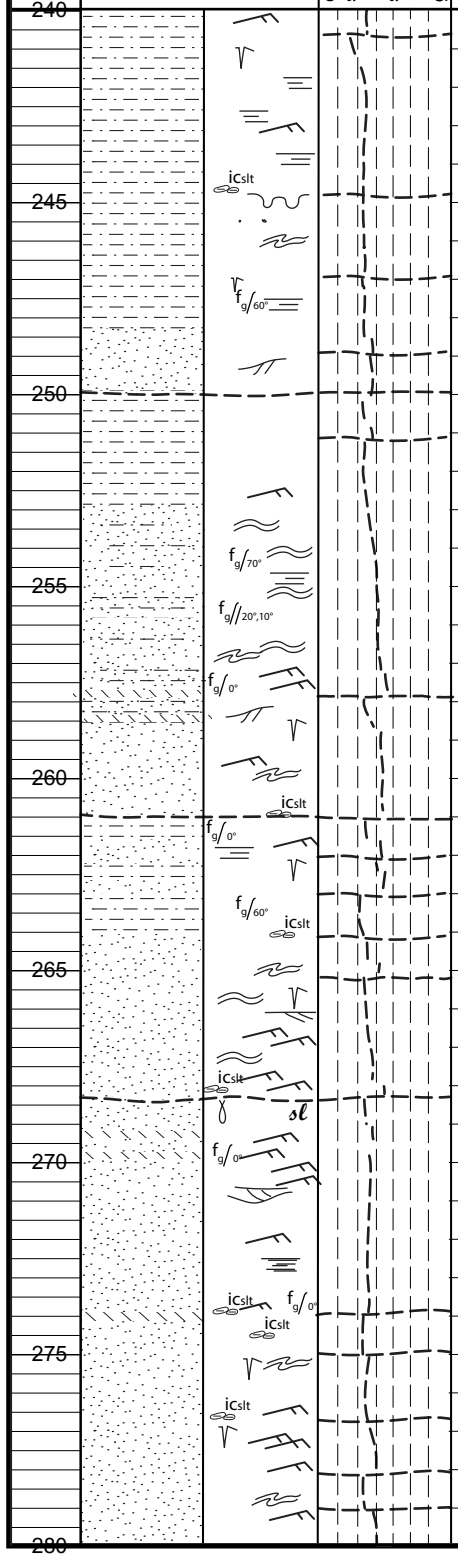
221.6-225.4: Sltst, arg, red (2.5YR4/6) to dark r-b (2.5YR3/3-3/4) to light r-b (2.5YR6/4) upward, gg zone in lower part; horizontal gypsum-filled separation at 222.0; f laminae, small ripples; sharp basal contact.

225.4-230.5: Sltst, arg, sandy, r-b (2.5YR4/4), 1 cm gg zone just above base; thin laminae, horizontal to wavy with some soft sed def; possible small gypsum clasts 227.5-227.8; sharp basal contact.

230.5-238.6: Sltst, sandy, r-b (2.5YR4/4); thin laminae, small ripples mainly in upper part; small cylindrical burrow at 234.9; some brecciation/slump at 233.75; sharp basal contact.

Remarks

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 8 of 60



Description

238.6-249.9: Ss, r-b (2.5YR4/4) at base, overlain by sltst, red (2.5YR6/4), with arg interlaminae; ss shows low angle x-lam; lam bedding and small ripples are common in the sltst along with zones of soft sed def and slumping; three lesser erosional surfaces occur at 248.8, 246.8, 245.0, and 240.6 ft; local separations are filled with fibrous gypsum; small desiccation cracks underlie the surfaces at 246.8 and 240.6; sltst ic overlie the surface at 245.0; basal contact sharp.

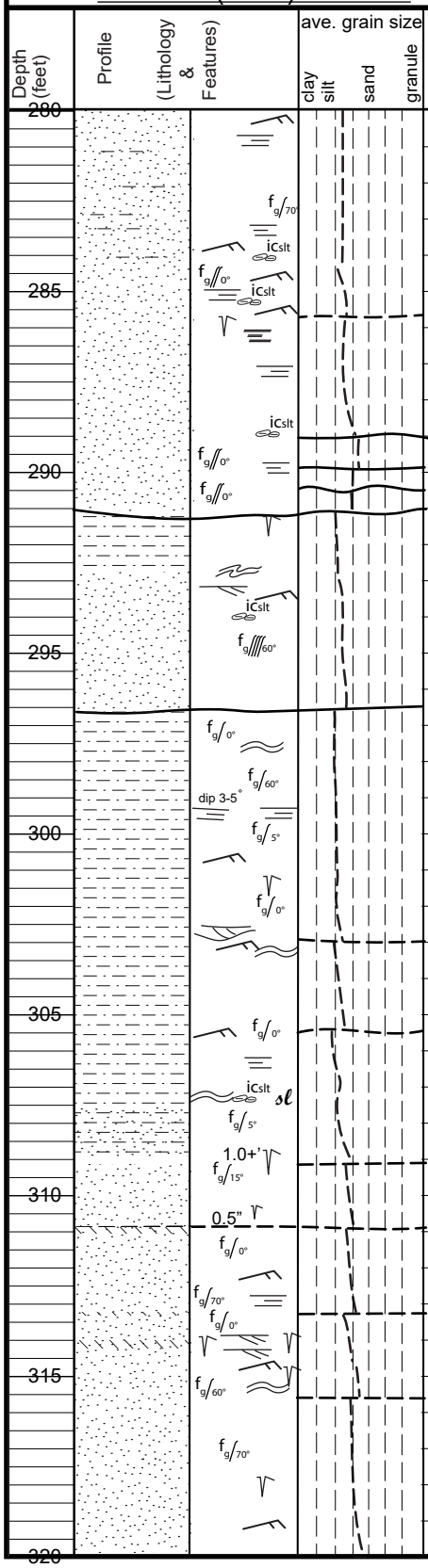
249.9-260.9: Ss, silty, dark r-b (2.5YR3/4), below 253, overlain by sltst, arg, dark r-b (2.5YR2.5/4); gen vf sand; displays abundant ripples (~1 cm high) and some low angle x-lam in lower ss, becomes more wavy lam upward and subhorizontal lam in more arg zones; soft sed def 1-2 ft above base; sltst ic at base; lesser erosional surfaces at 257.9 and 251.2, desiccation crack at ~258.3; subvertical gypsum-filled f in mid-interval and two thicker horizontal gypsum-filled seps in lower part of ss; erosional sharp basal contact.

260.9-268.3: Ss, silty, red (2.5YR4/4), overlain by ss, silty, dark r-b (2.5YR3/3); gen vf sand; abundant ripples and wavy lam in lower half, less distinct upward; some low-angle x-lam; some local soft sed def at 264.7-264.85; upper half of interval shows four lesser erosional surfaces with some upward fining in each subinterval; sltst ic at base of interval and on one other erosional surface; desiccation cracks under some erosional surfaces; gypsum-filled seps more common in upper half; basal contact sharp, erosional.

268.3-291.0: Ss, silty, r-b (2.5YR5/4-4/4), dark r-b (2.5YR3/4), local gg zones; vf sand; interval is marked by numerous lesser surfaces; ripples and wavy lam are most abundant sed structures, and ripples at ~277.5 show some very low angle climb and local concentration of dark grains on lee side; low angle x-lam are observed in the upper subinterval; some soft sed def occurs in the upper part of the interval below one lesser surface; sltst clasts overlie several surfaces, and some surfaces overlie desiccation cracks; probable bioturbation and pedogenic slickensides occur near the top of the interval; gypsum-filled separations occur in the interval and range from horizontal to near-vertical; erosional basal contact.

Remarks

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 9 of 60



Description

REPEAT 268.3-291.0: Ss, silty, r-b (2.5YR5/4-4/4), dark r-b (2.5YR3/4), local gg zones; vf sand; interval is marked by numerous lesser surfaces; ripples and wavy lam are most abundant sed structures, and ripples at ~277.5 show some very low angle climb and local concentration of dark grains on lee side; low angle x-lam are observed in the upper subinterval;some soft sed def occurs in the upper part of the interval below one lesser surface; sltst clasts overlie several surfaces, and some surfaces overlie desiccation cracks; probable bioturbation and pedogenic slickensides occur near the top of the interval; gypsum-filled separations occur in the interval and range from horizontal to near-vertical; erosional basal contact.

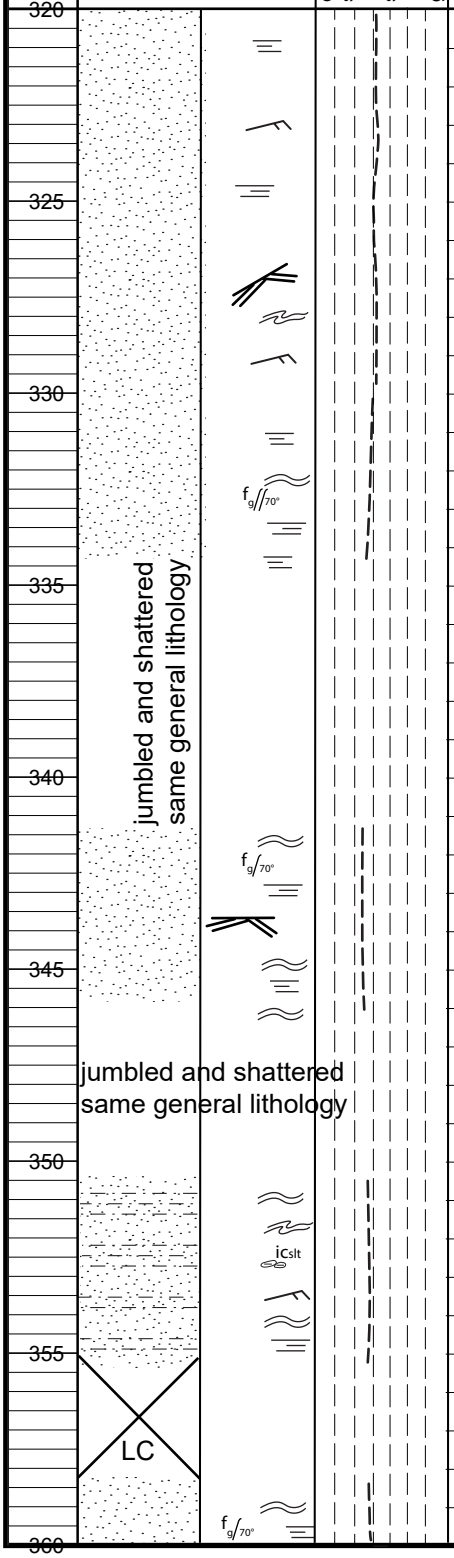
291.0-296.6: Ss, light r-b (2.5YR6/4) grading into/overlain by sltst; vf; stratification and sedimentary structures poorly displayed in lower 3 ft, ripples and low-angle x-lam occur in the upper ss to sltst; som soft sed def; sltst ic in upper ss; multiple gypsum-filled separations in lower part of ss; desiccation crack from upper surface; sharp basal contact.

296.6-310.9: Ss, light red (2.5YR6/6) overlain by thick sltst, red (2.5YR4/6-5/6); ss is f-vf; bedding is poorly shown in ss, main feature is desiccation crack >1 ft deep; sltst interval has lam, wavy bedding, and ripples throughout, with local dips of 3-5 deg and some low angle x-lam with scour; a zone at ~307.5 exhibits sltst ic and pedogenic slickensides; some near-horizontal gypsum-filled seps are present as are a few sub-vertical gypsum-filled seps; sharp basal contact with horizontal gypsum filled separation.

310.9-383.7: Ss, silt inc upward, gen r-b; very thick ss with zones of shattered core; basal 1 ft zone of coarser ss, grains to 1 mm; sand gen f-m lower becoming f-vf upward, subround to round, ~1% opaques with local zones up to ~3%; m sand up to ~50% in thin lam to 2-3 cm thick, mod well sorted; lam slightly wavy with some local soft sed def; lam dip to ~10 deg locally, mainly ~horizontal; some low angle x-lam; gypsum-filled separations mainly subhorizontal 370-384.5, near-vert gypsum-filled separations more common above ~370; sharp, erosional basal contact.

Remarks

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 10 of 60



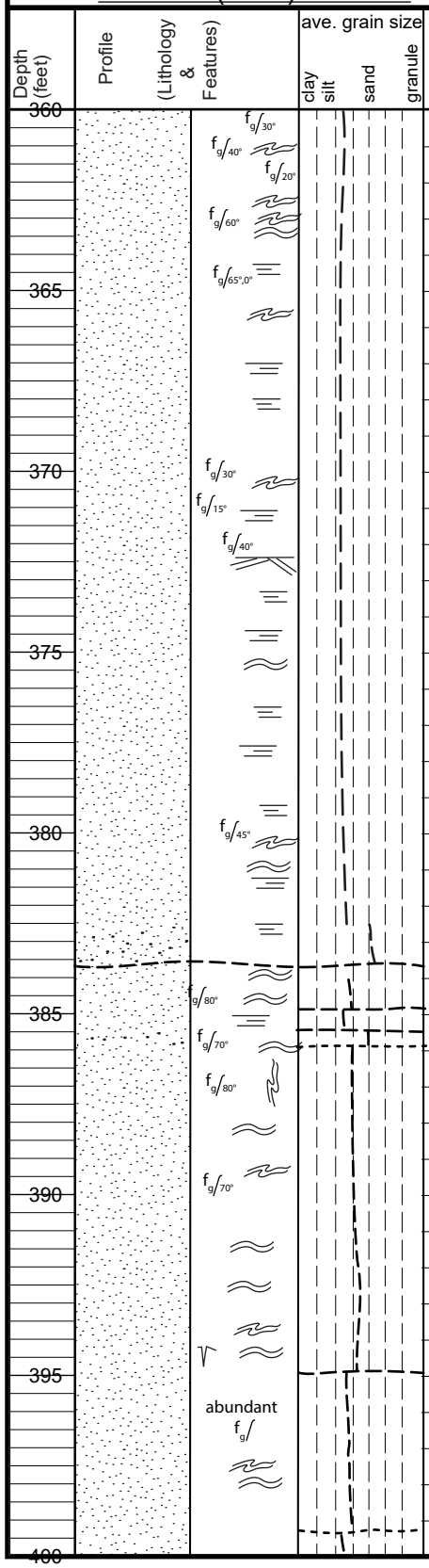
Description

REPEAT DESCRIPTION

310.9-383.7: Ss, silt inc upward, gen r-b; very thick ss with zones of shattered core; basal 1 ft zone of coarser ss, grains to 1 mm; sand gen f-m lower becoming f-vf upward, subround to round, ~1% opaques with local zones up to ~3%; m sand up to ~50% in thin lam to 2-3 cm thick, mod well sorted; lam slightly wavy with some local soft sed def; lam dip to ~10 deg locally, mainly ~horizontal; some low angle x-lam; gypsum-filled separations mainly subhorizontal 370-384.5, near-vertical gypsum-filled separations more common above ~370; sharp, erosional basal contact.

Remarks

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 11 of 60



Description

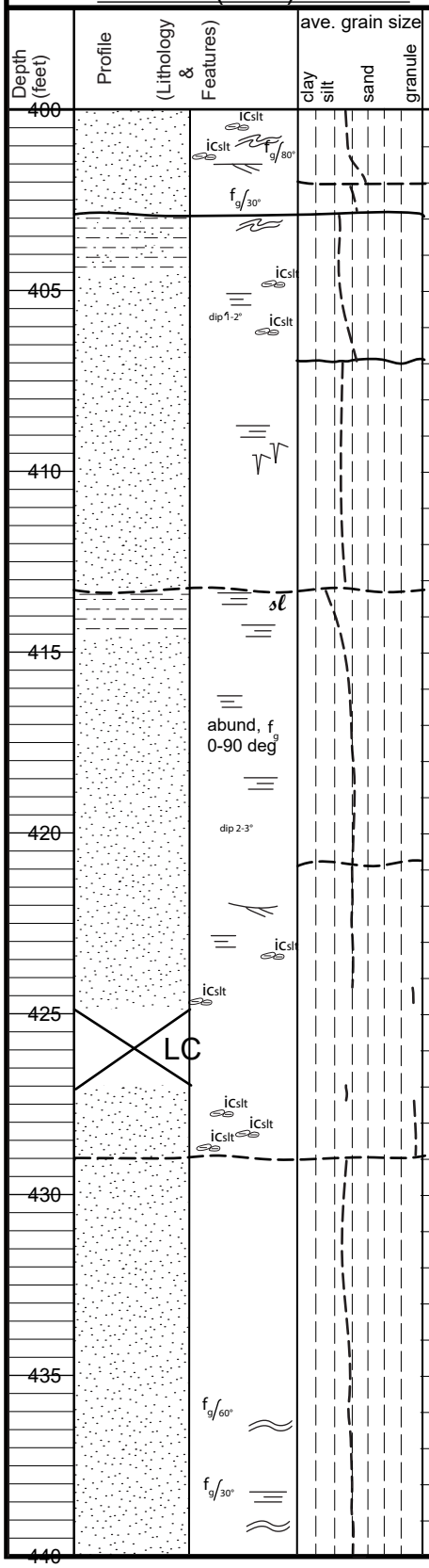
REPEAT DESCRIPTION

310.9-383.7: Ss, silt inc upward, gen r-b; very thick ss with zones of shattered core; basal 1 ft zone of coarser ss, grains to 1 mm; sand gen f-m lower becoming f-vf upward, subround to round, ~1% opaques with local zones up to ~3%; m sand up to ~50% in thin lam to 2-3 cm thick, mod well sorted; lam slightly wavy with some local soft sed def; lam dip to ~10 deg locally, mainly ~horizontal; some low angle x-lam; gypsum-filled separations mainly subhorizontal 370-384.5, near-vertical gypsum-filled separations more common above ~370; sharp, erosional basal contact.

383.7-402.9: Ss, silty, gen r-b (e.g., 5YR4/3); intervals of white or gg as well as the more common small gg spots; thick ss with lesser surfaces showing some changes in features or grain size; zones between surfaces show variable grain sizes of f-m, f, vf-f; grains are subround to round, mod sorting; upper part of interval shows local lam with 50% m sand; lam bedding predominates, mainly wavy, some parallel and ~horizontal; x-lam at ~401.5; interval from 385.9-402.9 includes zones of moderate to severe soft sed def; desiccation crack at ~394; sltst ic at ~401.5-402.0; gypsum/sulfate-filled separations are abundant but very thin (<<1mm) in most examples. sharp basal contact with relief.

Remarks

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 12 of 60



Description

REPEAT DESCRIPTION

383.7-402.9: See previous page for description

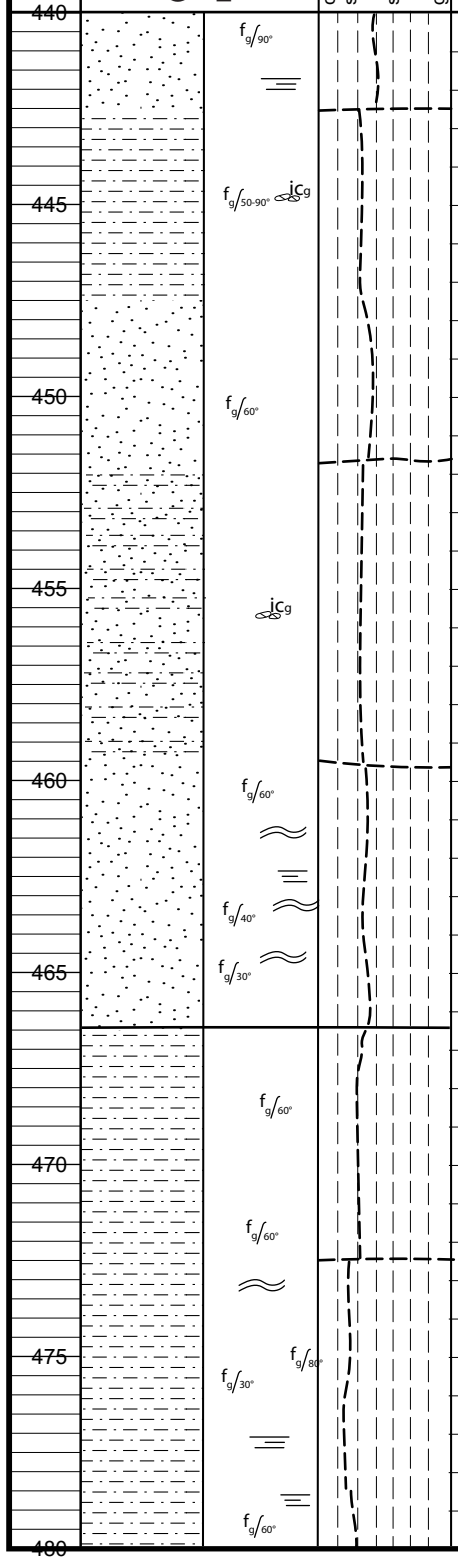
402.9-413.3: Ss, rb (2.5YR5/4) with sltst, sandy, r-b (2.5YR5/3) at top of interval; surface at 406.8 separates interval; sltst ic above this surface; lam are present, but bedding is unclear in much of the interval; soft sed def immediately under upper contact; desiccations cracks ~409; from 407-~411, core surface shows a brecciated or crackle texture with darker sediment surrounding these "clasts," may be pedogenic; very large (~6 cm) gg reduction spot with small dark gray center at 410.6; basal contact form is indeterminate.

413.3-429.0: Ss, red (2.5YR5/6), with thin upper sltst, r-b (2.5YR4/4); similar to interval 402.9-413.3; lam bedding generally ~horizontal, some x-lam ~422, poorly defined bedding below erosional surface at middle of interval; abundant sltst ic at base of interval, also at 424, above lost core interval; pedogenic slickensides at top of interval; v thin gypsum-filled separations are abundant and range from vertical to subhorizontal.

429.0-466.5: note overlap in core footage markings at ~466 from successive core runs; series of ss to sandy sltst and sltst zones that are ~10 ft thick or less; gen r-b to red (e.g., 2.5YR4/4 and 2.5YR4/6); through this interval, bedding is poorly defined to laminar, some wavy; there are two thin zones with probable gypsum clasts; gypsum-filled separations are generally very thin, oriented from ~vertical to horizontal; tiny (<1 mm) apparent pores above 466.0 in core from subsequent core run.

Remarks

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 13 of 60



Description

REPEAT DESCRIPTION

429.0-466.5: note overlap in core footage markings at ~466 from successive core runs; series of ss to sandy sltst and sltst zones that are ~10 ft thick or less; gen r-b to red (e.g., 2.5YR4/4 and 2.5YR4/6); through this interval, bedding is poorly defined to laminar, some wavy; subintervals defined on grain size and general lith changes; there are two thin zones with probable gypsum clasts; gypsum-filled separations are generally very thin, oriented from ~vertical to horizontal; tiny (<1 mm) apparent pores above 466.0 in core from next core run.

466.5-503.7: Sltst, arg, gen r-b (e.g., 2.5YR4/4-5/4); bedding poorly displayed, some lam, wavy lam in upper part; gypsum-filled separations are common, ranging from ~vertical to subhorizontal, mostly < 1 mm; some internal divisions based on grain size changes; lower 3 ft show brecciation at 1-5 cm scale, with many clasts outlined by gypsum; basal contact sharp, erosional.

Remarks

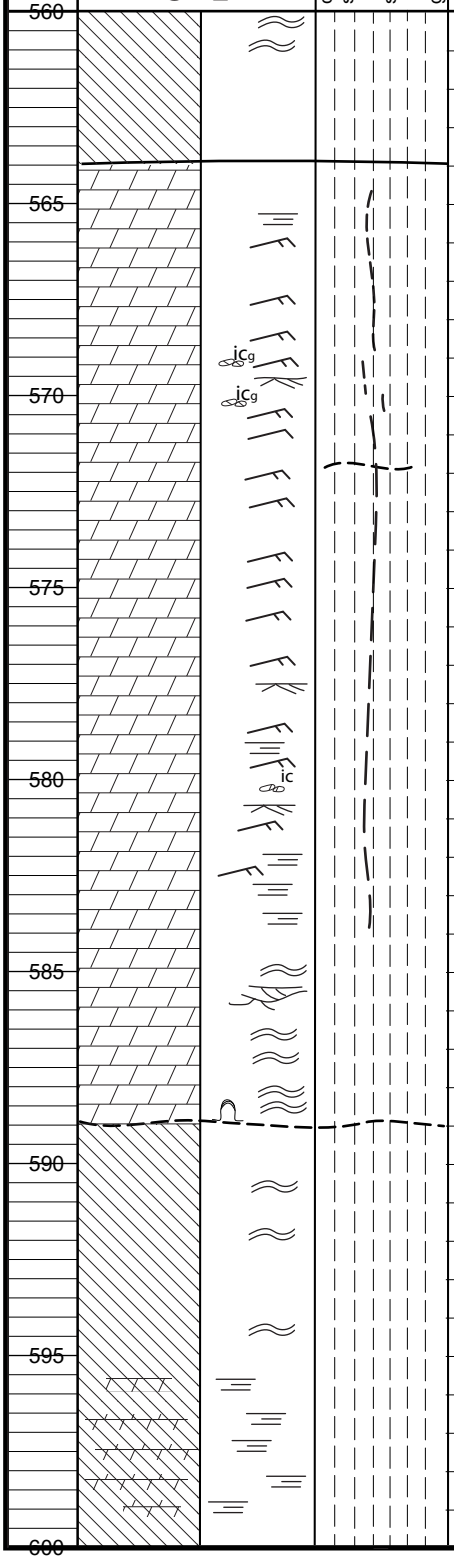
Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 14 of 60

Depth (feet)	Profile (Lithology & Features)	ave. grain size: clay silt sand granule	Description	Remarks
480			REPEAT DESCRIPTION	
			466.5-503.7: Sltst, arg, gen r-b (e.g., 2.5YR4/4-5/4); bedding poorly displayed, some lam, wavy lam in upper part; gypsum-filled separations are common, ranging from ~vertical to subhorizontal, mostly < 1 mm; some internal divisions based on grain size changes; lower 3 ft show brecciation at 1-5 cm scale, with many clasts outlined by gypsum; basal contact sharp, erosional.	
485				
490				
495				
500				
			base of Dewey Lake Formation top of Rustler Formation, Forty-niner Member	
505			503.7-533.4: Anydrite, white (N8) on surface, generally gray on fresh surface; characterized by zones of gypsum (or anhydrite) "swallowtails," crude bedding in the lower part at 3-5 cm, "bedded nodular" sulfate 520-525, lam to wavy bedding above 520; upper surface shows solution along channels to depth of ~2 ft with infiltrated red silt; sulfate is brecciated below infiltration zone; possible desiccation crack at 507.6 and 509.9; sulfate swallowtails across possible mound at ~507.6; upper 10 ft includes separations/fractures filled with sulfate; small possible stylolites ~528; apparent collapse feature at 525.8; sharp basal contact.	
510				
515				
520				

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 15 of 60

Depth (feet)	Profile (Lithology & Features)	ave. grain size: clay silt sand granule	Description	Remarks
520			REPEAT DESCRIPTION	
525			503.7-533.4: Anydrite, white (N8) on surface, generally gray on fresh surface; characterized by zones of gypsum (or anhydrite) "swallowtails," crude bedding in the lower part at 3-5 cm, "bedded nodular" sulfate 520-525, lam to wavy bedding above 520; upper surface shows solution along channels to depth of ~2 ft with infiltrated red silt; sulfate is brecciated below infiltration zone; possible desiccation crack at 507.6 and 509.9; sulfate swallowtails across possible mound at ~507.6; upper 10 ft includes separations/fractures filled with sulfate; small possible stylolites ~528; apparent collapse feature at 525.8; sharp basal contact.	
530				
535			533.4-544.0: Sltst, arg, r-b (2.5YR4/4), to mudstone at top; very thin gray mudstone at top at contact with anhydrite; bedding poorly displayed on core surface; some wavy lam near top; soft sed def at 536.7; some irregular bedding above 538 at cm scale; possible smeared intraclast zone 535-536.3; gradational basal contact.	
540	LC			
545			544.0-545.7: Sltst, arg, v slightly sandy, gypsif, gray (Gley 1 N5/); lam to wavy bedding at mm-cm scale; some soft sed def; well indurated; basal contact sharp, erosional. 545.7-563.9: Anhydrite and gypsum, gray; local thin gray and brown lam, wavy; well laminated upper 1 ft is deformed and truncated by erosion; bedded nodular fabric and possible nodules 548-554; brown lam do not effervesce; subhorizontal separations 557-559 filled with fibrous vertical gypsum; very small nodules or clasts in lower 1 ft'; sharp basal contact.	
550				
555				
560				

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 16 of 60



Description

545.7-563.9: see previous page for description

base of Forty-niner Member (Rustler Formation)
top of Magenta Doloomite Member (Rustler Formation)

563.9-588.8: Dolomite, gypsiferous, light gray to gray to light olive gray (5Y7/1-6/1-6/2); mainly wavy lam from near base up to 584, ~horizontal lam and ripples to 578, ripples to 566, and horizontal lam near top; local basal 0.5 ft displays clear stromatolitic structures, and much of wavy bedding appears to be preserved and enhanced by algal binding; a zone from 578.7-571.8 displays small pores on the core surface; basal contact gradational.

base of Magenta Doloomite Member (Rustler Formation)
top of Tamarisk Member (Rustler Formation)

588.8-646.9: Anhydrite and gypsum, gray (e.g., Gley 1 N 5/) to white (e.g., Gley 1 N 8/) with zones that are light brown; basal 10 ft include: thin brown carbonate lam that are wavy in the upper part, some brecciated sulfate, crushed prisms, and gypsum-filled separations; from 631.6-623, lam and wavy lam are interspersed with pseudomorphs after very small gypsum swallowtail crystals and some crushed prisms; above 623, bedding is variably expressed, with possible bedded nodular fabric and crushed prisms abundant; upper 10 ft includes more dolomite lam and wavy lam (upper 3 ft); some stromatolitic fabrics occur in the upper 1 ft below dominant dolomite of overlying Magenta; basal contact not preserved continuous core.

Remarks

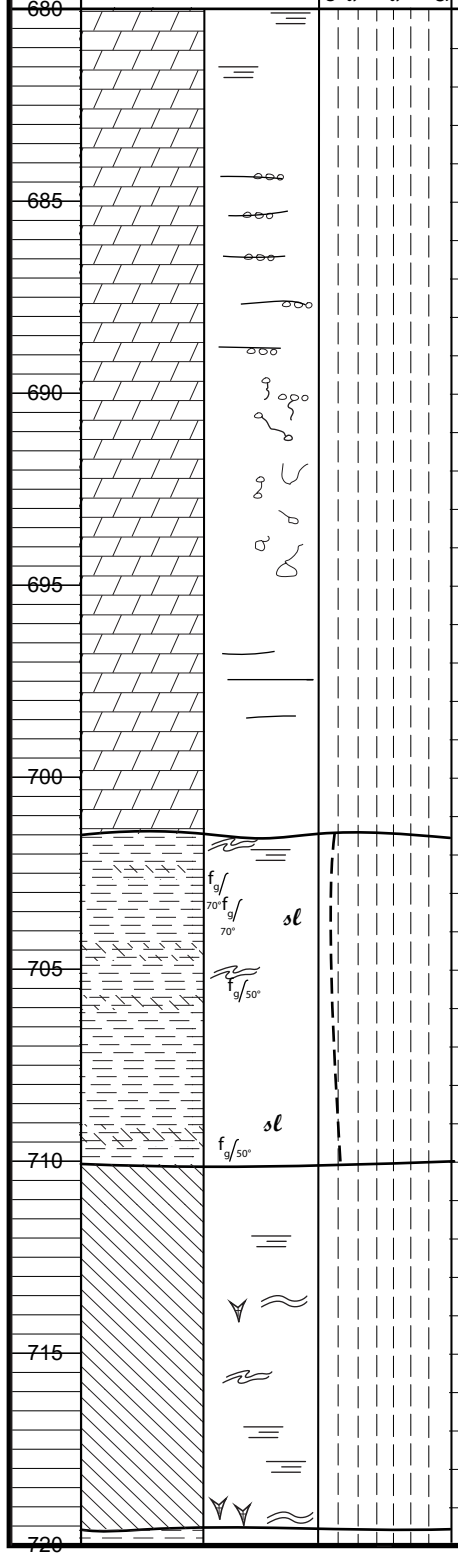
Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 17 of 60

Depth (feet)	Profile (Lithology & Features)	ave. grain size: clay silt	sand	granule	Description	Remarks
600					REPEAT description from previous page 588.8-646.9: Anhydrite and gypsum, gray (e.g., Gley 1 N 5/) to white (e.g., Gley 1 N 8/) with zones that are light brown; basal 10 ft include: thin brown carbonate lam that are wavy in the upper part, some brecciated sulfate, crushed prisms, and gypsum-filled separations; from 631.6-623, lam and wavy lam are interspersed with pseudomorphs after very small gypsum swallowtail crystals and some crushed prisms; above 623, bedding is variably expressed, with possible bedded nodular fabric and crushed prisms abundant; upper 10 ft includes more dolomite lam and wavy lam (upper 3 ft); some stromatolitic fabrics occur in the upper 1 ft below dominant dolomite of overlying Magenta; basal contact not preserved in continuous core.	
605						
610						
615						
620	f/healed					
625	f/healed					
630						
635	icg/carb					
640						

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 18 of 60

Depth (feet)	Profile (Lithology & Features)	ave. grain size: clay silt	sand	granule	Description	Remarks
640					REPEAT description from previous page	
					588.8-646.9: Anhydrite and gypsum, gray (e.g., Gley 1 N 5/) to white (e.g., Gley 1 N 8/) with zones that are light brown; basal 10 ft include: thin brown carbonate lam that are wavy in the upper part, some brecciated sulfate, crushed prisms, and gypsum-filled separations; from 631.6-623, lam and wavy lam are interspersed with pseudomorphs after very small gypsum swallowtail crystals and some crushed prisms; above 623, bedding is variably expressed, with possible bedded nodular fabric and crushed prisms abundant; upper 10 ft includes more dolomite lam and wavy lam (upper 3 ft); some stromatolitic fabrics occur in the upper 1 ft below dominant dolomite of overlying Magenta; basal contact not preserved continuous core.	
645						
650					646.9-654.5: Claystone/mudstone and arg sltst, dark gray with light gray at top and some r-b mottling lower part; upper ~2 ft ranges from deformed/brecciated bedding to breccia at top; remaining unit shows some mottling and possible small clasts mixed in matrix; sedimentary structures and fabrics mainly obscured by surface smearing of core; base is indistinct due to core surface.	
655					654.5-665.0: Claystone/mudstone, conglomerate at base, gen r-b, with large clast of sulfate 656.9-657.5; clast shows high angle bedding, distorted lam, tiny bottom growth sulfate; mudstone below large clast shows clasts of r-b and gray mudstone to 1 cm, some gypsum clasts to 2 cm, and gypsum clasts increasing toward base; basal contact is sharp, has relief of ~0.5 ft.	
660						
665					665.0-679.7: A, gray (Gley 1 N 5/), gypsiferous at upper contact; lam to wavy lam (mm scale) common below ~668, with deformed mm-scale beds (stromatolites?) 670.8-671.5; brown sltst/carbonate 669-669.9; minor def just above base; upper 5 ft of interval displays some lam in the lower part, less distinct upward; upper part also shows crushed prism features, some large (ft); probable erosional contact 671.6; base of interval sharp, no apparent erosion.	
670						
675						
680					base of Tamarisk Member/top Culebra Dolomite Member	

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 19 of 60



Description

679.7-701.6: Dolomite, gypsiferous, dk reddish gray (top) 5YR4/2) to brown (7.5YR5/2) and pinkish gray (7.5YR6/2) to white (lower part) (10YR8/1);

Unit 1 [679.7-688.3] (Holt, 1997)

679.7-680.7: dark reddish gray; mm-scale lam, wavy or stromatolitic at top; sandy, probably organic-rich; small (1 mm) pores in lower 0.5 ft, some cm-scale pores; sharp, nearly flat base;

680.7-681.7: pinkish gray to brown upward; some bedding; sandy with v small (<< 1 mm) pores near base, larger pores upward;

681.7-684.5: light gray; rare cm-scale vugs (?open) in upper part; short, high angle separation disappears upward, some gypsum on separation; bedding faint to not apparent;

684.5-688.7: white; thin (2-5 cm) bands of concentrated vugs (1-4 mm), some filled with silt; bedding along vuggy zones.

Unit 2 [688.7-696.8]: v large vugs (up to 4-5 cm), some filled with silt, some (rare) with gypsum; red staining of silt fill below 691.6; network of subvertical hairline cracks between vugs or splayed out from some vugs; gypsum vug fill increases downward; some gypsum shows crystallographic continuity; rubble below 692.5

Unit 3 [696.8-699.7] light gray; mm-scale vugs as well as larger irregular vugs; smaller vugs more abundant along probable bedding planes; both silt and gypsum filled vugs; larger cracks (can exceed 0.5 ft in length) are common, and small cracks are abundant; lower part appears brecciated but with fragments generally in place

Unit 4 [699.7-701.6] brown to gray at base; brecciated zone, no large vugs and small vugs are not abundant; shows basal contact at an angle on underlying mudstone of Los Medaños Member.

base of Culebra Dolomite Member (Rustler Formation)

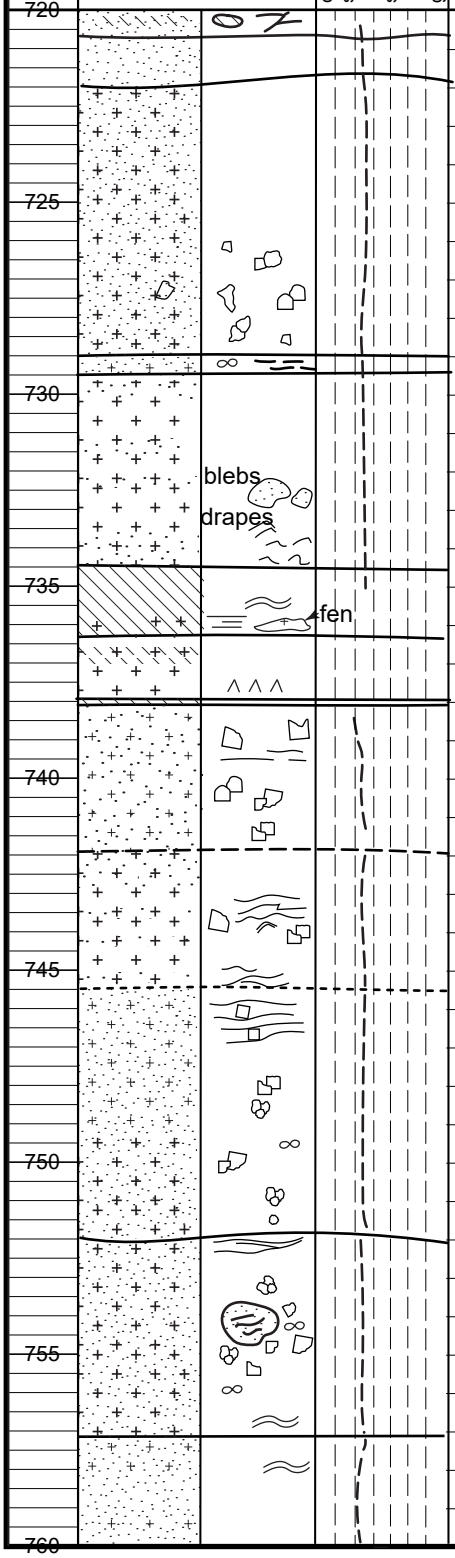
top of Los Medaños Member (Rustler Formation)

701.6-710.2: Mudstone to silty claystone lower 2-3 ft, bluish black (Gley 2 5B 2.5/1) at contact to bluish gray downward (Gley 2 5B 5/1) at 703.2; dark reddish gray to weak red to dusky red (10R3/1, -5/4, -3/2) from 704 to ~705; dark greenish gray (Gley 2 10BG4/) at 705-705.3; rb with gray below 705.3; dark r-b (10R3/2) 708 to base; main features are weak bedding, deformation at the upper contact, clasts of gypsum and possible disrupted thin gypsum beds, large slickensides, possible intraclasts or smeared intraclasts at 710, and some high-angle gypsum-filled separations; basal contact undulatory, sharp, probably erosional.

710.2-719.7: Anhydrite and gypsum; light red (7.5R6/3) to ~713, gen white (5YR8/1) below 713; lam to slightly wavy lam through most of unit, with some zones of weak bedding, some slight x-cutting relationships; small possible swallowtail sulfate near base and at ~713.5; mm-scale vugs 715.0-715.5 in ?gypsum clasts; basal 0.3 ft is porous, cracked; sharp basal contact.

Remarks

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 20 of 60



Description

719.7-720.7: Ss, r-b (2.5YR4/3), locally sulfatic, white (N8); hints of stratification, some show soft sed shear; local nodules/clasts of sulfate to 1 cm x 3 cm; upper contact shows color change; basal contact sharp.

720.7-722.0: Ss, halitic, light r-b (2.5YR6/3); vf; halite content increases upward; mostly f H, I-IIc; basal contact sharp.

722.0-729.0: H, sandy; ss light r-b (2.5YR6/3), locally white (2.5YR8/1); H mostly clear; large blebs of ss and displaced/disrupted beds of ss; H content decreases upward & xtl size decreases upward, c at base, f-m at top; irregular boundaries with ss blebs, some blebs have c Ic xtls, H is mostly IV to IIIc; basal contact sharp, irreg over 2+ cm.

729.0-729.5: Ss, halitic; ss is light r-b to r-b (2.5YR6/3-5/3); some disrupted thin lam; local sic; local horiz zones of m IIIC H; sharp basal contact.

729.5-734.5: H, sandy; ss is r-b hues (2.5YR8/1-6/3-4/3); H is c xtls at base, m-f at top; mostly IV with abundant clear cements; locally abundant xtl drapes and stringers of ss in lower part; xtl drapes and stringers of sulfate in lower 2 ft; large blebs of displaced ss beds to 3 cm across.

734.5-736.3: A, halitic; white (N8); microxtln; H local, H-filled fenestral fabrics; wavy micro-lam to thin lam, some showing soft sed def; sharp basal contact.

736.3-737.9: H, anhydritic; H clear to light red (10R7/6), A white (N9-N8); m-c IV, some BG H, some cements; thin lam, stringers, and blebs of A; sharp basal contact.

737.9-738.0: A, white (N9-N8); thin laminated bed of microxtln A, sharp basal contact.

738.0-741.9: Ss, halitic (below 738.6) to H, with sandy blebs (above 738.6); light r-b (2.5YR7/4); vf H at base, coarsens upward to f-m; most I-IIb, with some IIIb; upper H fines up from m-c IIIc-IV xtls at base to f-m I-IIIc xtls at top; ss drapes on some xtls; basal contact gradational.

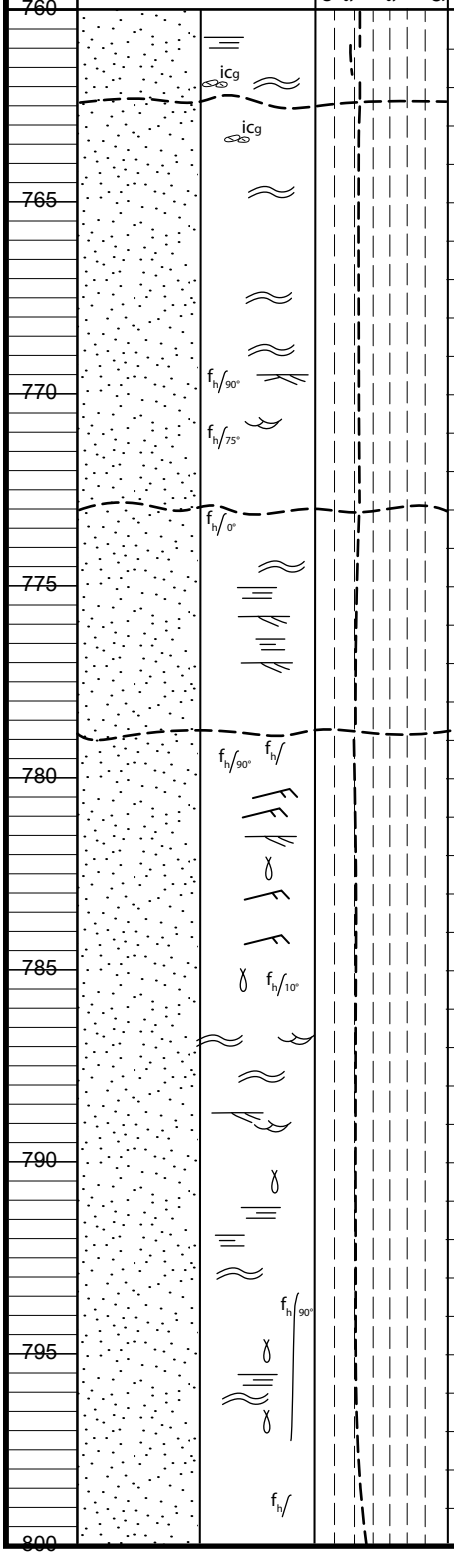
741.9-745.5: H, sandy at base, grading upward to ss, halitic, in zones 1.6 ft thick at base and 0.4-0.8 ft thick at top; light r-b (2.5YR7/4-6/4); some possible corroded BG H in sandy H (local m-c IV), local I-IIIb,c; halitic ss contains f-m H, I-IIIa-c; zone of white (N9) at top; some irreg sulfate stringers to 2 mm thick near base; gradational basal contact.

745.5-752.0: H, sandy at base, grading to ss, halitic at top; r-b (2.5YR5/4); ss occurs in irreg zones and disrupted beds (or sic) (some to 5+ cm) at base, bounded by f-c II-IIIb,c, with local Ia-b; H xtl size decreases upward to mainly f with some m at top; local v thin beds to thick lam of ss near upper contact containing m H Ia-b; gradational basal contact.

752.0-757.2: Ss, halitic to local H, sandy; r-b (2.5YR5/4-4/4) with thin light blue (Gley2 7/1) lam at top; ss occurs in irreg zones and disrupted lam, some incipient sic; m-c H I-IIa-b; halitic zones are irreg, include incipient sic, with f-m H I-IIIb-c; disrupted (soft sed def) thin lam of ss at top; H decreases upward; sharp to gradational basal contact based on H content.

Remarks

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 21 of 60



Description

757.2-762.4: Siltst and vf ss; r-b to weak red (2.5YR4/4-5/2); laminated, parallel and ~horizontal, wavy to contorted with local soft sed def; basal 0.5 ft includes mm-cm scale white sulfate clasts or nodules; apparent erosional basal contact.

762.4-773.0: Ss, halitic upper part; r-b (5YR4/4) lower, with pinkish gray (7.5YR7/2) upper part; vf sand; larger cross-bedding (like small troughs) and crosscutting beds in the lower part, subhorizontal to wavy laminae in upper part; H in v small pores (< 1 mm) in upper part; v thin subhorizontal H along bedding planes, some subvertical H-filled f; mm-scale sulfate clasts or nodules in thin zones 763.2-763.5; apparent erosional surface at base.

773.0-778.8: Ss, halitic cements (not shown on graphic); greenish gray (Gley 1 5GY 5) lower to gray (5Y5/1) upward; mm-scale lam, with cross-cutting relationships for cm-dm sets of parallel lam that variably dip in the lower part, subhorizontal to wavy lam upward; this interval generally has larger cross-bedding compared to other parts of the member; change in sedimentary structures mark apparent basal erosional surface.

778.8-821.9: Ss and silty ss, with basal anhydritic zone; light gray (Gley 1 7/N) in basal 3 ft, gray (Gley 1 6/N) trending to greenish gray (Gley 1 10Y5 to Gley 1 5GY/5); basal zone shows deformed A lam over sharp contact with upper Salado; basal zone displays erosional surfaces and some clasts (pebble lag); bedding in lower part is thin lam, generally parallel and horizontal to subhorizontal with some cross-cutting (note: some bedding appears better defined months later by tiny ridges of salt efflorescence), some bedding shows soft sed def; ripples are more common in the upper part; small burrows or bioturbation is distributed through much of this interval; longer, ~vertical halite-filled f are observed in the lower two-thirds of this interval.

Remarks

Hole ID: C-3977 (PSC) CORE LOG (cont. sheet) Sheet 22 of 60

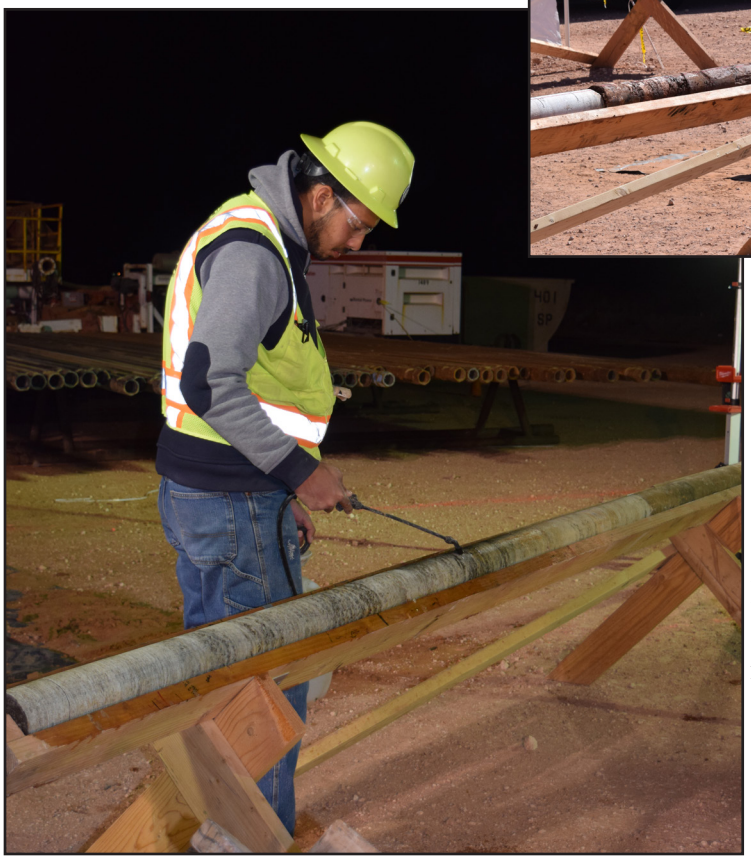
Depth (feet)	Profile (Lithology & Features)	ave. grain size (clay silt sand granule)	Description	Remarks
800			(repeat from page 21 778.8-821.9: Ss and silty ss, with basal anhydritic zone; light gray (Gley 1 7/N) in basal 3 ft, gray (Gley 1 6/N) trending to greenish gray (Gley 1 10Y5 to Gley 1 5GY/5); basal zone shows deformed A lam over sharp contact with upper Salado; basal zone displays erosional surfaces and some clasts (pebble lag); bedding in lower part is thin lam, generally parallel and horizontal to subhorizontal with some cross-cutting (note: some bedding appears better defined months later by tiny ridges of salt efflorescence), some bedding shows soft sed def; ripples are more common in the upper part; small burrows or bioturbation is distributed through much of this interval; longer, ~vertical halite-filled f are observed in the lower two-thirds of this interval.	22
805	f_h			
810				
815	f_h			
	f_h			
820	f_h ic_{slt}		819.0 erosional surface 820.5 erosional surface	
			821.9 base of Rustler Formation/top of Salado Formation	
825				
830				
835				
840				



Extracting part of Salado marker bed (sulfate) core from core catcher.



Describing Rustler core (above).



Lightly spraying Salado core with fresh water to removeve drilling residue.

APPENDIX C

GEOLOGIC LOGS

FROM

TOP OF SALADO FORMATION TO TOTAL DEPTH

About Salado Descriptions

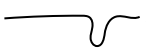
The geologic descriptions of the Salado Formation core are informed by our geologic mapping of the Air Intake Shaft (AIS) at the WIPP (Holt and Powers, 1990). In the AIS, we washed a portion of the shaft walls with fresh water, yielding unprecedented exposures of the Salado. Mapping these high quality exposures revealed previously unreported sedimentary structures and textures within the Salado (e.g., Holt and Powers 1990a,b; Holt, 1993).

While many of these features occur at a scale larger than that of 4-inch core, they can be readily identified in core with an understanding of their scale and characteristics. Many of the Salado geologic units identified in AIS have been recognized in this Salado core. In the following descriptions, however, some geologic units are grouped to represent depositional cycles within the Salado (e.g., Holt and Powers 1990a,b; Holt, 1993). A guide to the map depths of eqivalent units (or groups of units) has been provided.

The form of the geologic log for the Salado differs from that used in the overlying formations. Halite dominates the Salado, and we characterize average crystal size, amount of water insolubles (sulfate and siliciclastics), and relative proportions of sulfate and siliciclastics ("clay") using line graphics. These graphic representations are similar to those used in the AIS report (Holt and Powers, 1990).

Overlapping high-resolution photographs of the core taken in the field and lab are available separately as the files are too large to be incorporated. The lab photos are generally taken at ~0.25 intervals and are indexed by core depth to the nearest 0.25 ft center.

Contacts and Bedding


ES exposure surface/contact with dissolution pipe

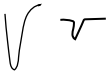
ES exposure surface is depositional unit contact

depositional unit contact


bedding (increasing development upward)

Features and Structures


indeterminate feature or texture


dissolution pipe or pit (depth to scale)


ripple or slight cross-cutting beds


podular area or zone


macropore (MP), filled with halite

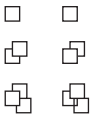

breccia

smeared intraclasts

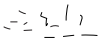

nodular textures, anhydrite or polyhalite


bottom-grown gypsum, including pseudomorphs


bottom-grown (BG) halite


displacive halite forms


boxwork fabric


blebs of varying orientation

pos pile-of-sticks texture

hab hygroscopically-altered bed

Lithologies

Halite (blank)

Anhydrite

Polyhalite

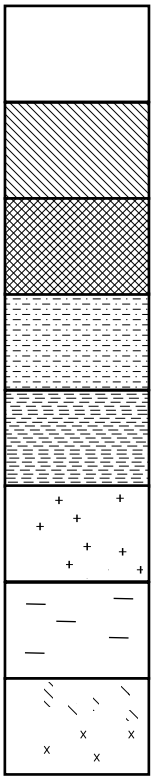
Siltstone

Mudstone

Halitic

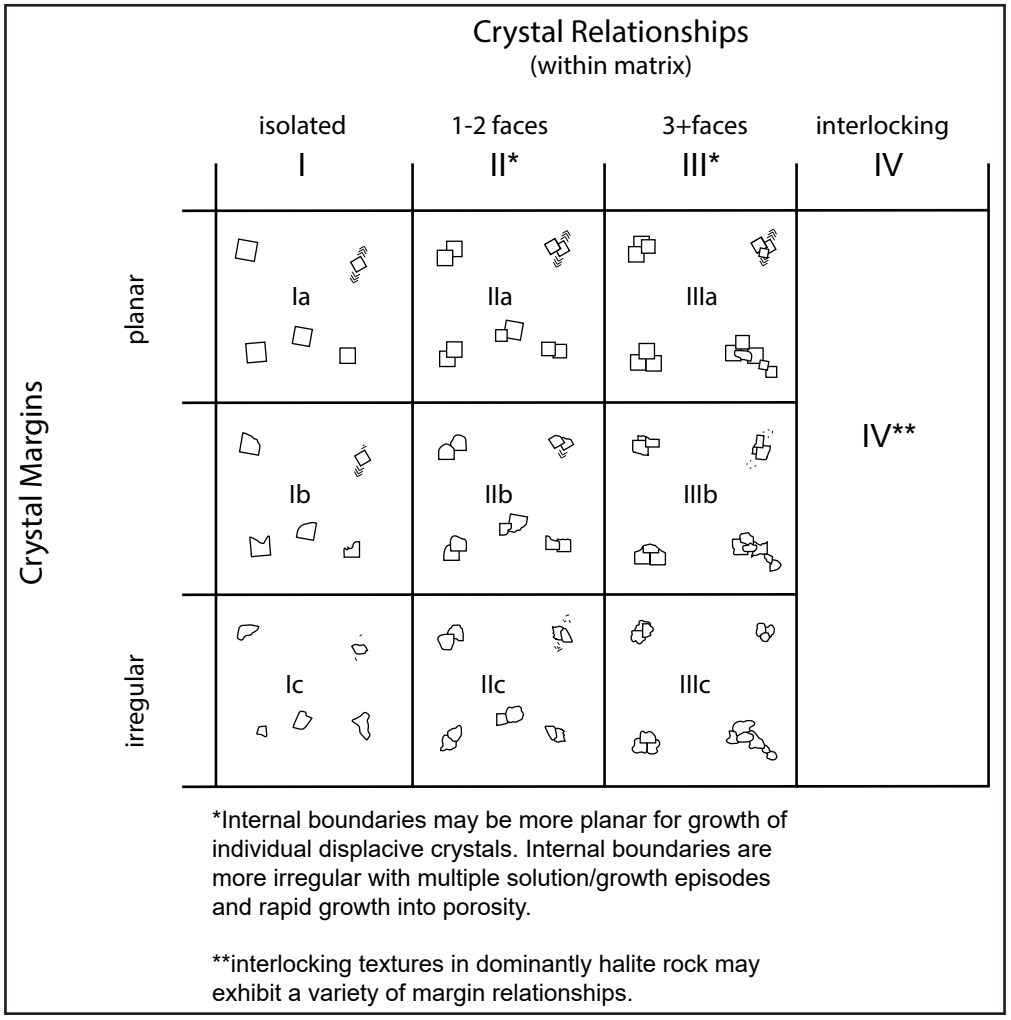
Muddy

Anhydritic
Polyhalitic

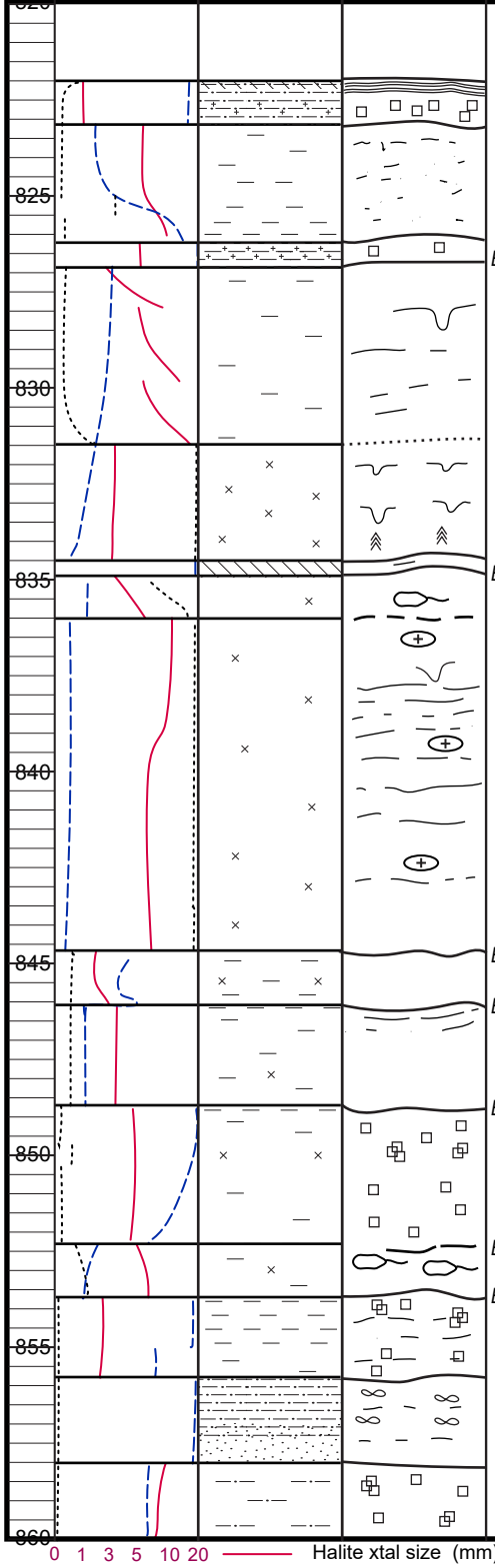


& = and
A = anhydrite
A'tic = anhydritic
abund = abundant
Arg = argillaceous
B = bloedite (blödite)
B-G (bottom-growth)
bet = between
bwn = brown
c = coarse
cmt = cement
cmts = cements
cont = contact
dec's = decreases (dec = decrease)
desic = desiccation
disc = discontinuous
disp = displacive
diss'n = dissolution
dissem = disseminated
eff = efflorescent
eq = equant
f = fine
grad = gradational
gy = gray
H = halite
H'tic = halitic
HAB = hygroscopically-altered beds
horiz = horizontal
inc = increase
insol = insoluble
irreg = irregular
L = langbeinite
lam = laminae
laminated = lam'd (microlam'd, interlam'd)
lng = lining
m = medium
m'xtln = microcrystalline
MP = macropore
mod = moderate
mod'ly = moderately
Mudst = mudstone
P = polyhalite
P'tic = polyhalitic
PAGS = pseudomorphs after gypsum swallowtails
POS = pile of sticks
poss = possible
r-b = reddish-brown
SIC = smeared intraclast
Ss = sandstone
Sltst = siltstone
sol = solution
stgr = stringer (stgrs = stringers)
subhoriz = subhorizontal
tr = trace
trans'd = translocated
trans'n = translocation
V-O = vertically-oriented
vert = vertical
w/ = with (w/in = within)
xtl = crystal,
xtls = crystals
xtn = ctystalline

Halite crystal forms in the Salado (and lower Rustler) are most easily described with a basic template for textures developed by Holt and Powers (1990). The principal factors are the crystal-crystal relationship (isolated to sharing faces) and the nature of the crystal faces.



Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 23 of 60



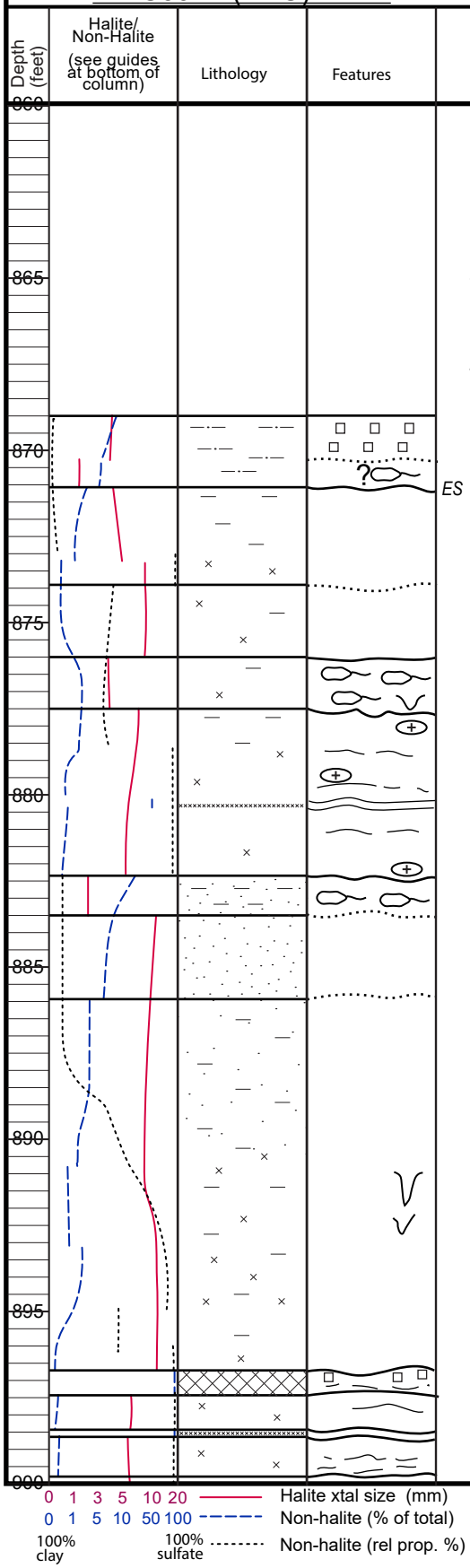
Description	AIS depth
821.9-823.2: H'tic Sltst (10R 3/2), f I a near base, becoming A'tic upward; microlam'd to very thinly bedded, some deformation, A strata near top.	
823.2-826.3: H, m-c IV; contains blebs & stgrs of Mudst (10R 6/3), most Mudst boundaries are irreg; lower 0.5' consist of Arg H w/ tr II-III c.	
826.3-826.8: H'tic Mudst (2.5YR 4/6), m I c, some irreg H xtls ~ 1 cm, SIC.	
826.8-831.5: Arg H (10R 6/3 - 4/1), c -vc IV at base, m IV at top; poss diss'n pit at 827.5 - 828.5; Mudst blebs, drapes, & lngs inc upward; upper cont is a diss'n surface.	
831.5-834.5: H, IV, vert elongate xtls at the base, xtls become more eq upward; tr P blebs (10R 8/4), some P drapes & lngs near top.	
834.5-834.9: A (5YR 8/1), microxtln, w/ irreg zones of H, showing poss internal collapse; lower 0.1' consists of Mudst w/ SIC.	
834.9-844.7 SMPH 836.0-844.7: H, f-m IV, local zones of cloudy H, less abund upward; some small < 0.1' deep sol pits, local macropores to ~ 0.1' diameter, macropores more abund above 839.0; disc to continuous P stgrs (5YR 6/6 – 10R 6/8) draping some surfaces; upper cont E/S surface.	
844.7-846.1: H, m IV, w/ irreg zones of f-m III c; mod clay (5YR 4/4) as small blebs & irreg zones, upper cont E/S surface.	
846.1-848.7: H, f-c IV; tr P & some clay (5YR 4/4) as small blebs & disc stgrs.	
848.7-853.3: Arg H at base w/ f-c II-III a-b & local zones of IV, grading upward to H'tic Mudst w/ I-III a,b; clay content incs upward.	
853.3-855.7: Arg H, m-c IV; tr P; some clay, Mudst stgrs near top.	
855.7-858.0: Silty Ss at base; sandy Sltst at top; weak stratification & SIC; H'tic, tr sulfate (5YR 4/6).	
858.0-863.7: Silty H, m-c IV, w/ some I-III a-b; Sltst in large blebs, some to 0.1' diameter.	

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 24a of 60

Depth (feet)	Halite/ Non-Halite (see guides at bottom of column)	Lithology	Features	Description	AIS depth
860					
865			ES	863.7-866.2: H, f-m IV; tr irreg P & clay stgrs, local P blebs. 866.2-866.7: H, f IV, in pods; slightly Arg (2.5YR 4/6). 866.7-870.0: H, f-c IV, some cmts, some cloudy H; tr P blebs, 0.1' thick P bed at base.	
870				870.0-871.5: Arg H, f-c II-III c w/ some IV, in pods; Ss in upper 0.1'. OVERLAP-SEE NOTES NEXT SHEET	
875					
880					
885					
890					
895					
900					

0 1 3 5 10 20 Halite xtal size (mm)
0 1 5 10 50 100 Non-halite (% of total)
100% clay 100% sulfate Non-halite (rel prop. %)

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 24b of 60



Description

AIS depth

This log sheet reflects actual core markings where two successive core runs had overlapping markings for footage.

869.0-871.1: Silty H, m I-III a-c, Sltst shows incipient peds bounded by H coatings; below 870.3, poss podular textures.

871.1-873.9: H, m-c IV; Arg in the upper part w/ local I a in stgrs/ blebs of Sltst; stgrs/blebs of P below 873.2.

873.9-876.0: H, m-c IV, abund cmt, some disp boundaries w/ tr amounts of clay & P.

876.0-877.5: H, f-m IV, some passive cmts; tr P blebs/disc stgrs; some clay (5YR 4/4) in large blebs, appears trans'd

.

877.5-882.3: H, m-c IV, abund cmt, cloudy H in lower part; tr P blebs & crustal drapes below 878.5; above 878.5, tr Sltst an as disc stgrs & blebs to 1" diameter, some xtl drapes, tr P.

882.3-883.5: H, f-m IV in pods; stgrs & irreg zones of sand & clay (2.5YR 4/4-5G 7/1 in upper 0.1').

883.5-885.9: Sandy H (5YR 4/6), c-vc I-III a-b; contains Ss blebs/ irreg zones; lower cont grad.

885.9-896.7: H, m-vc IV, most vc, abund cmt, tr to some cloudy H near base, local macropores & some diss'n pits; below 890.5, P'tic w/ disc stgrs, blebs, & xtl drapes; above 890.5, becomes Arg & sandy (5YR 4/6) in blebs & irreg zones, some poss vert trans'n in two pits, some disp margins.

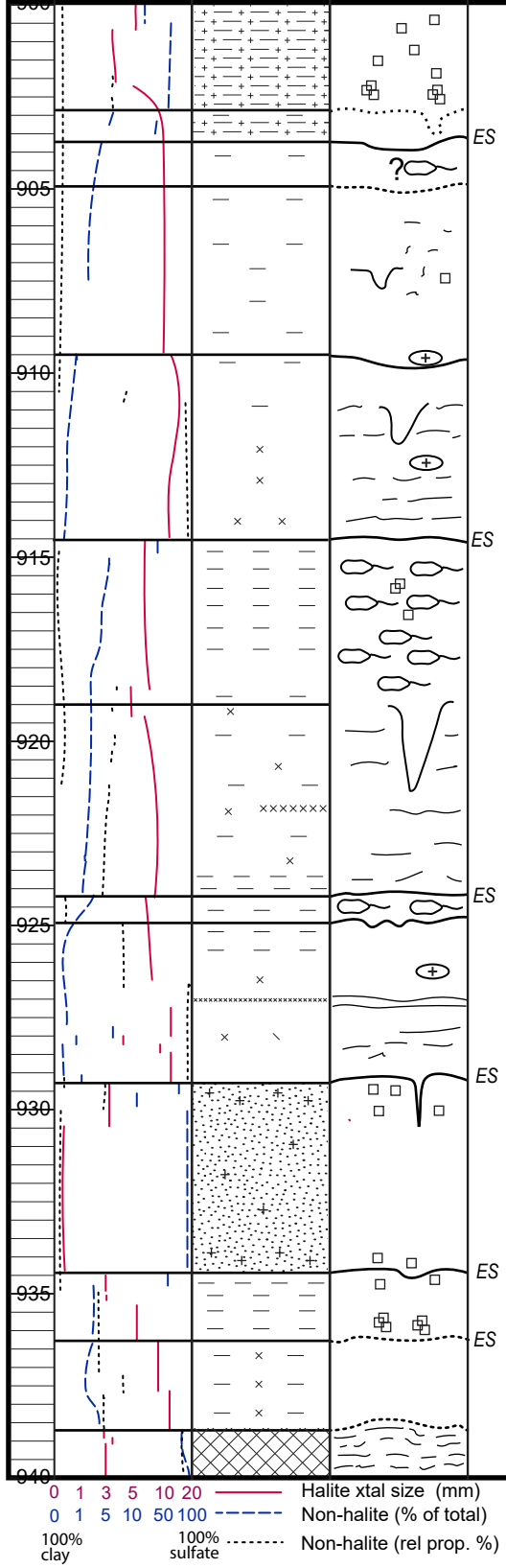
896.7-897.4: P (5YR 8/4), microxtln, hint of stratification, H'tic in upper part.

897.4-898.4: H, m-c IV; P'tic as stgrs & xtl lngs.

898.4-898.6: P, microxtln, hint of stratification, H'tic.

898.6-899.8" H, m IV; local P blebs.

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 25 of 60



Description

899.8-902.8: H'tic Mudst (2.5YR 4/4), shows incipient peds & SIC; rare to abund f-c I-III b-c, fines upward, H stgrs fill voids between peds; local stgrs of A.

902.8-903.7: Arg H, f-c, IIIc to IV, mostly cmts, xtl size decreases upward; mud blebs & stgrs w/ some trans'n; A stgrs

903.7-904.9: H, f-c IV, poss pods; slightly Arg; tr A & stgrs & blebs, stgrs show some trans'n.

904.9-909.5: H, m-c IV, abund cmts, local disp boundaries, some I a; mod'ly Arg in small to large blebs & stgrs, mud content incs upwards, some trans'n into pits, irreg zones of mud in upper 1'.

909.5-914.5: H, m-vc IV, f IV in lower 0.3', stratified at base w/ abund cloudy H, some cmts increasing upward, some large MP; P has stgrs & blebs.

914.5-919.0: Arg & silty H, f IV, irreg pods of H bounded by stgrs & irreg zones of Mudst (5YR 5/4), local I-II b-c in muddy zones; below 917.3, clay content decreases, mud lags & some A & P stgrs are present; upper 0.4' consists of H'tic Mudst w/ f-m I-II a-c.

919.0-924.2: H, m-vc IV, mod cmts that base, becoming abund at top; 2' deep pit w/ c-vc IV cmt; P occurs below 921.0 as disc stgrs, blebs, & sol lags; clay in lower 1.5' occurs as blebs & stgrs.

924.2-924.9: Arg H, f-m IV in pods, rare f I a-c in sol lag at base.

924.9-929.3: H, m-c IV, vc IV as cmts, local MP; below 926.8, P'tic w/ some A, H'tic P & A bed 927.85-928.0; above 926.8, Arg (2.5YR 4/4, locally 5GY 7/1) & P'tic as blebs & stgrs, some w/ disp margins.

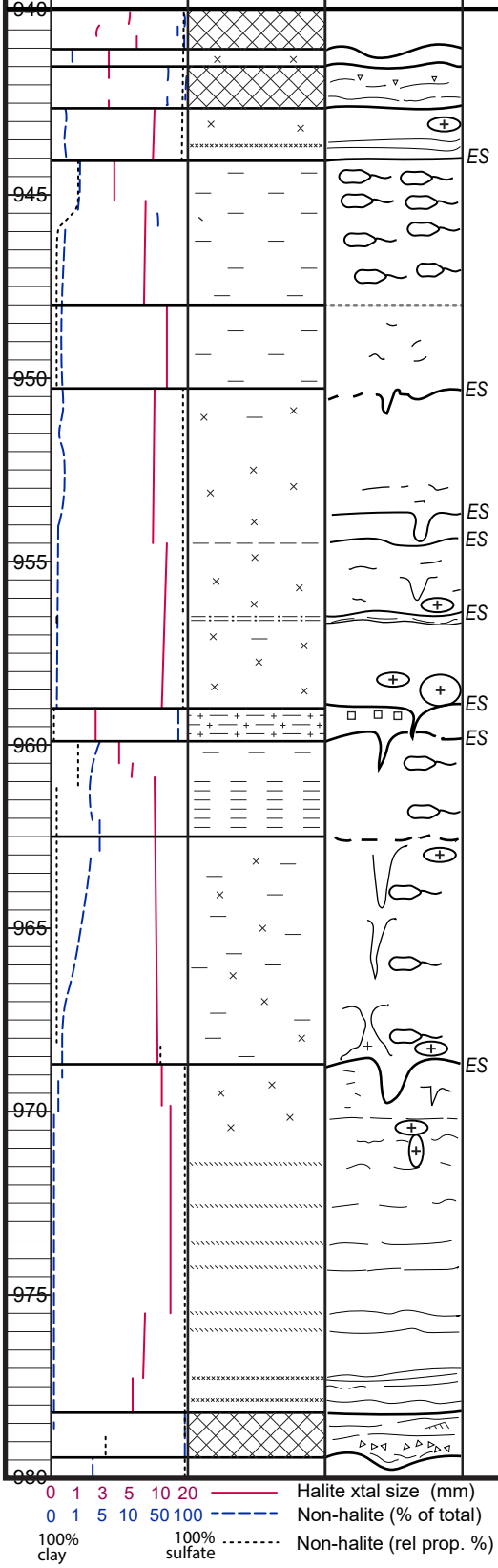
929.3-934.4: Ss (5YR 6/6), very fine to fine, well sorted, eq, w/ rounded to angular grains; 98% quartz, 2% dark grains, some orange quartz; 2.5Y 8/1 in irreg zones near top & local 1 mm reduction spots; tr to some f I a-b; 0.6' deep, H-filled desic crack at upper cont.

934.4-936.3: Arg H at base grading to H'tic Mudst at top, m-c II-III b-c at base, m-c I a in upper 0.5'.

936.3-938.7: H, m-vc IV, mod'ly abund cmts; mud & P as blebs & disc stgrs; local disp margins w/ clay; gy clay & P at lower cont.

AIS depth

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 26 of 60



Description

938.7-944.1: P, microxtln, hint of subhoriz strata; separated into two beds by a 0.4' thick bed of H, A'tic near the top of each bed, lower bed contains 3 mm high H PAGS in mounds near the top of the bed; H also occurs in thin, disc subhoriz lam & irreg zones. Between 942.7 – 944.1: H, m-vc IV, mod'ly abund cmts, some MP; P occurs as blebs, sol lags, xtl drapes, & thick lam; P bed occurs 943.7 – 943.9.

944.1-948.0: H, f-m IV, in pods; Arg, clay & stgrs & blebs; upper cont E/S.

948.0-950.3: Arg H, IIIc, abund expansive cmts; w/ blebs & local disc stgrs of clay; upper cont diffuse.

950.3-959.0: H, m-vc IV, small pits & abund cmt near top, local MP & diss'n pits to 0.5' deep, poss eff crusts w/ clay stgrs/drapes 944.5-950.0; P'tic as irreg stgrs & drapes; local E/S, some w/ clay concentrations (944.5) & 0.1' of H'tic Sltst w/ some thin lam (956.5); tr clay drapes & stgrs below 956.5; upper cont dilated E/S.

959.0-959.9: H'tic Mudst; upper half contains abund f Ia-c (5YR 5/4 – 5G 7/1); lower part has less H & contains f-m Ib-c; unit cut by H-filled desic crack; upper cont E/S.

959.9-962.5: Arg H, f-m IV in pods bounded by Mudst zones (2.5YR 4/4) containing m-c I-IIIa-c; local subvert H-filled fractures, 0.4' deep H-filled desic crack originates at upper cont.

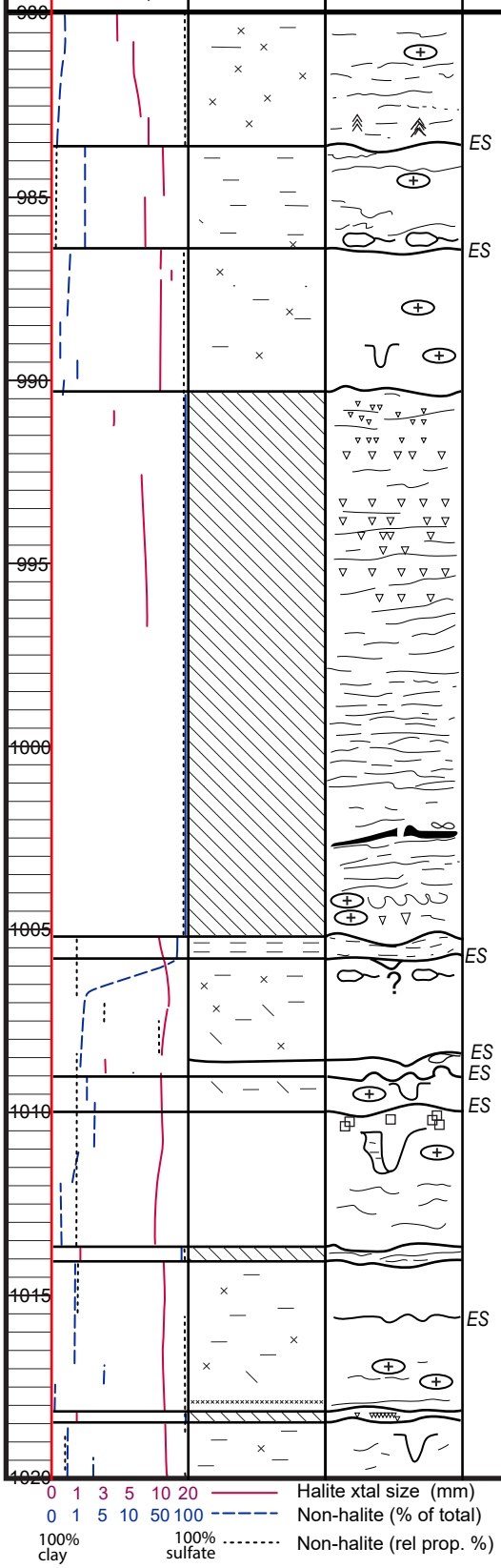
962.5-968.7: H, f-m IV in pods; c-vc IV in pits, MP, & zones of cmt; local sol pits & MP; tr P as blebs & disc stgrs locally concentrated in pods; tr to some Mudst (2.5 YR 4/4) as irreg blebs & disc lam & stgrs, some w/ m-c I-IIa-b, some blebs show vert trans'n; upper cont E/S.

968.7-978.3: H, m-vc IV, some VO MP near top, abund cmts; P below 977.6 & above 971.0, occurs dissem disc stgrs & blebs, some lam in the upper part; A lam, stgrs, blebs occur from 971.5-976.0, content decreases upward; upper cont E/S w/ clay-lined pit to 1.0' deep.

978.3-979.4: P, microxtln, 2.5YR 7/6, thin lam to lam, local cross lam, lower part deformed; lower 0.2' consists of Mudst (5G 7/1) mixed w/ angular pebble-size clasts of P (breccia due to syndepositional diss'n & collapse); upper cont sharp.

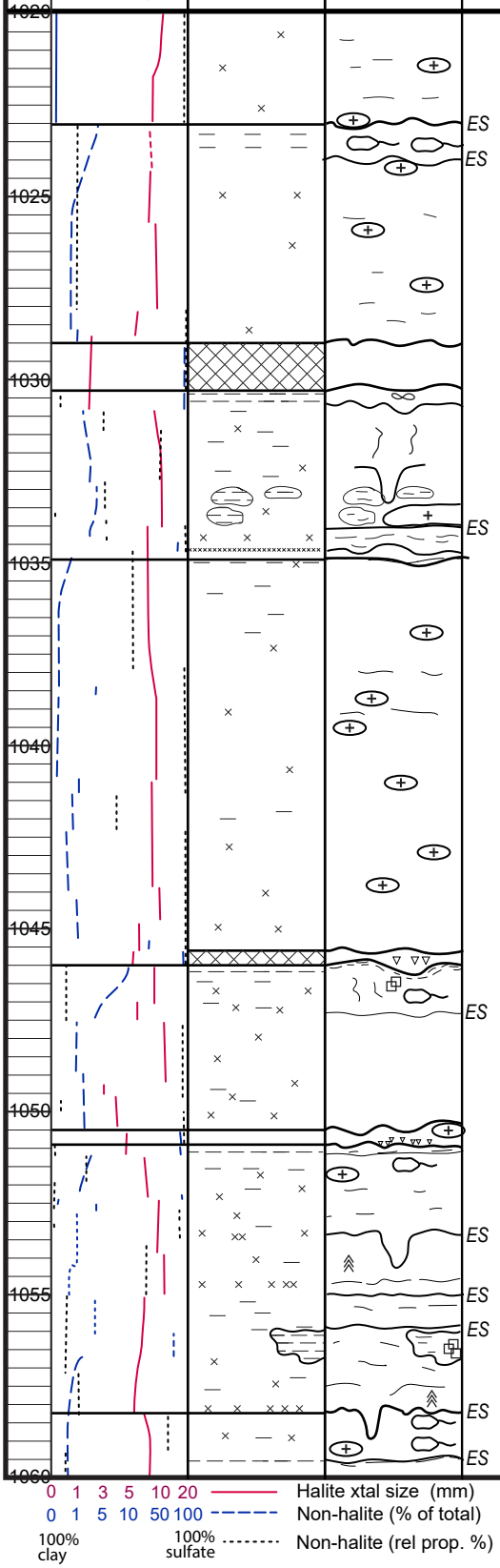
AIS depth

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 27 of 60



Description	AIS depth
979.4-983.6: H, m-c IV at base, m IV at top, poss VO prismatic H at base, some H cmts; E/S near top overlain by f IV (eff crust?), truncated by the upper cont; contains tr P as subhoriz stgrs & local blebs; upper cont sharp.	
983.6-986.4: H, m-vc IV, most clear w/ large fluid inclusions, local MP, some pods of f-m IV near base; tr P near base; irreg lam of Mudst (2.5YR 4/4) drapes E/S, some Mudst stgrs & blebs, H shows some disp growth at Mudst conts; upper cont sharp,	
986.4-990.3: H, m-vc IV, cmts become abund upward, local VO MP, rare sol pits; tr P as irreg blebs; tr clay (2.5YR 4/4, w/ local 5GY 6/1) as blebs; upper cont E/S marked by gy clay.	
990.3-1005.2: A, microxtln. 990.3-997.5: H PAGS are abund , 1-3 mm tall above 991.5, 0.25”-1” tall 991.5 & 996.5, occur in mounds below 993.5; A shows wavy to locally contorted thin lam to thin beds, poss stylolites below 996.5. 997.5-1001.4: horiz thin lam at base grading to wavy thick lam at top, strata are locally convoluted, carbonate-rich at the base & mainly A at the top of strata. Below 1004.4: slumped strata above poss teepee structure at 1002.5, wavy lam below 1002.5, carbonate-rich & porous from 1001.9-1004.7, soft sediment deformation in breccia mixed w/ red claystone (10R 4/3) at the base.	
1005.2-1005.8: Mudst (5R 6/1 w/ irreg zones of 10R 4/3), hints of irreg micro-thin lam, some subhoriz to subvert H-filled fractures.	
1005.8-1008.5: H, m-c IV, poss pods w/ f-m IV near top, abund cmt; local P blebs & xtl drapes; Arg above 1007.7, clay content incs upward, clay occurs as blebs & disc stgrs, poss clay-filled diss’n pipe at top.	
1008.5-1008.9: H, f-c IV, poss pods, mostly m-c cmt.	
1008.9-1010.0: H, m-vc IV, abund cmt, f IV near top; A content incs upward, xtl lngs & blebs; clay occurs as dissem blebs & irreg lam.	
1010.0-1013.7: H, c-vc IV, mostly cmt; Arg (7.5YR 5/3 w/ local 5G 6/1) in upper 0.5’ w/ c-vc I-IIIa-b; ~1.5’ deep pipe & large macropore near middle of unit; A stgrs & blebs w/ P blebs in the lower part of unit.	
1013.7-1014.1: A, microxtln, wavy lam to thin beds, poss H PAG sand near base, no clay at base.	
1014.1-1018.3: H, m-c IV in upper part w/ tr P blebs, c-vc IV below E/S w/ tr disc A stgrs, H cmts become more abund upward, local MP near the base; disc 0.05’ thick A bed at base.	
1018.3-1018.6: A, microxtln, H PAGS to 0.5” tall, tr gy clay at base.	

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 28 of 60



Description

1018.6-1023.0: Above 1019.8: H, c-vc IV, abund cmt; tr clay as blebs, disc stgrs, some with dispe boundaries. Below 1019.8: H, m-c IV, vc IV in MPs; trace P blebs at base, content decs upward.

1023.0-1029.0: H, m-c IV, local vc IV in MP, pods of f-m IV above 1024.0; tr clay (2.5YR 4/4) as irreg stgrs and blebs, some w/ displ boundaries, clay content incs above 1029.0; tr P as blebs.

1029.0-1030.3: P (2.5YR 7/6), microxtln; upper 0.2' appears to be a sol lag accumulated over a core of m IV P'tic H; remainder shows parallel, wavy to contorted lam to thin beds; lower 0.3' contains carbonate interbeds; unit underlain by thin bed of clay (5G 7/1).

1030.3-1034.8: Upper 0.4': Mudst (5YR 4/4-5G 7/1), w/ some SIC & peds. Below 1030.7: H, m-c IV w/ vc IV in MPs & pit; P xtl drapes, stgrs, & blebs, some vert trans'd, shows some disp margins; clay as blebs & infiltrated material into paleokarst; paleokarst zones show some m Ia-b; below 1033.8, shows subhorizontal, disc P stgrs; lower 0.1' consists of structureless P w/ irreg conts.

1034.8-1045.6: H, m-c IV, vc IV in MP, f-m IV w/ P xtl lngs below 1045.0; tr P blebs & disc stgrs, large blebs at 1038.5 & 1041.1; 1041.3-1042.3: tr clay blebs & disc stgrs, no P.

1045.6-1046.0: P (2.5YR 7/6), microxtln; H PAGS to 3 mm; thin lam to very thin beds, slumped over lower cont.

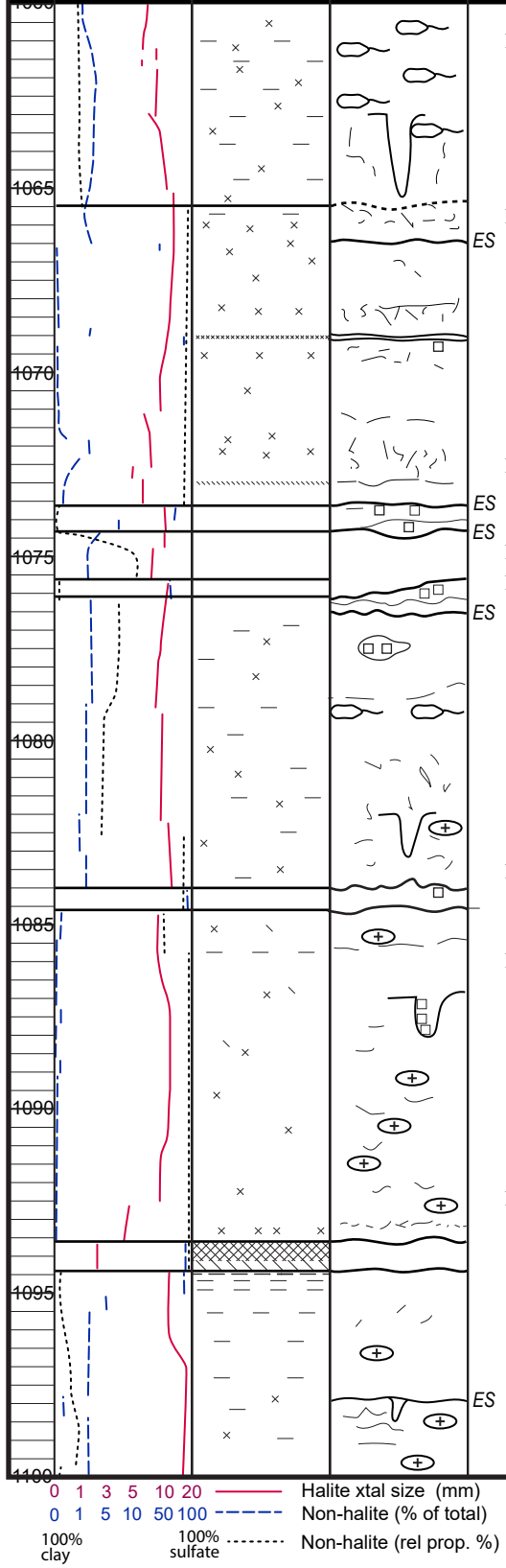
1046.0-1050.5: H. Above 1053.4: f-c IV w/ local II-IIIc, some pods, some disp cmts; some vert trans'd clay & P blebs. Below 1053.4: m-c IV in three sequences; each sequence: tr P at base w/ tr clay at top, cmts are abund in the upper part of sequences.

1050.5-1050.9: P, microxtln; upper part is a sol lag overlying a core of f IV H; 2-5 mm H PAGS in middle of unit; A in irreg zones in the lower part.

1050.9-1058.2: H, m-c IV, some cmt, some primary H; tr P & clay as blebs & disc strings; E/S at 1053.4 draped w/ P, E/S at 1055.0 & 1055.9 draped w/ clay; clay blebs & stgrs w/ mod H cmt 1055.0-1055.9; mud-filled cave w/ m-c I-IIa occurs 1056.0-1056.7; lower cont marked by P sol lag.

AIS depth

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 29 of 60



Description

1058.2-1065.5: H, f-m IV in pods, H bounding pods & below 1064.0 is m-c IV cmt; P & clay blebs & stgrs occur w/in & bound pods; below 1064.0, clay occurs as blebs, sol lags, & disc stgrs, many showing vert trans'n.

1065.5-1073.6: H, m-c IV, vc IV in probable pits or MP; tr to some P; tr A near base. Some P blebs, sol lags & xtl lngs 1065.5-1066.4. 1066.4-1069.1: 0.1' thick P bed at base; overlain by 1' zone of poss pit filling w/ large P blebs & sol lags dilated by H cmts w/ some disp margins; remainder shows tr P blebs & disc stgrs. 1069.1-1071.5: poss pipe fill w/ large blebs of P w/ irreg-angular margins w/ vc IV, some Ib w/in blebs; lower 1' shows tr P blebs & subhoriz stgrs. 1071.5-1073.6: vc IV, probable pit filling w/ sol lags & blebs of P w/ disp margins, some I-IIa-c; some stgrs & xtl drapes of P.

1073.6-1074.3: H'tic Mudst (2.5YR 4/1-5G 7/1) in upper 0.2' w/ m-c I-IIa-c near top; lower cont irreg over 0.1'. Lower part is Arg H w/ f IV, clay is dissem; lower cont an E/S surface w/ clay.

1074.3-1075.6: H, m-c IV, w/ P blebs, stgrs, & xtl lngs.

1075.6-1084.0: Above 1078.5: H m-vc IV, abund cmt; contains large blebs (to 0.5"- 1") of clay (2.5YR 4/1-5G 7/1) with f-m Ia-b; P occurs as sol lags and large blebs; some P and A stgrs. Between 078.5-1079.0: H, f IV in pods, bounded by stgrs and zones of r-b clay. Below 1079.0: H, m-vc IV, cmts dominate upward; tr P as blebs and stgrs; becomes arg above 1082.7 w/ small to large blebs and strgrs of gy clay.

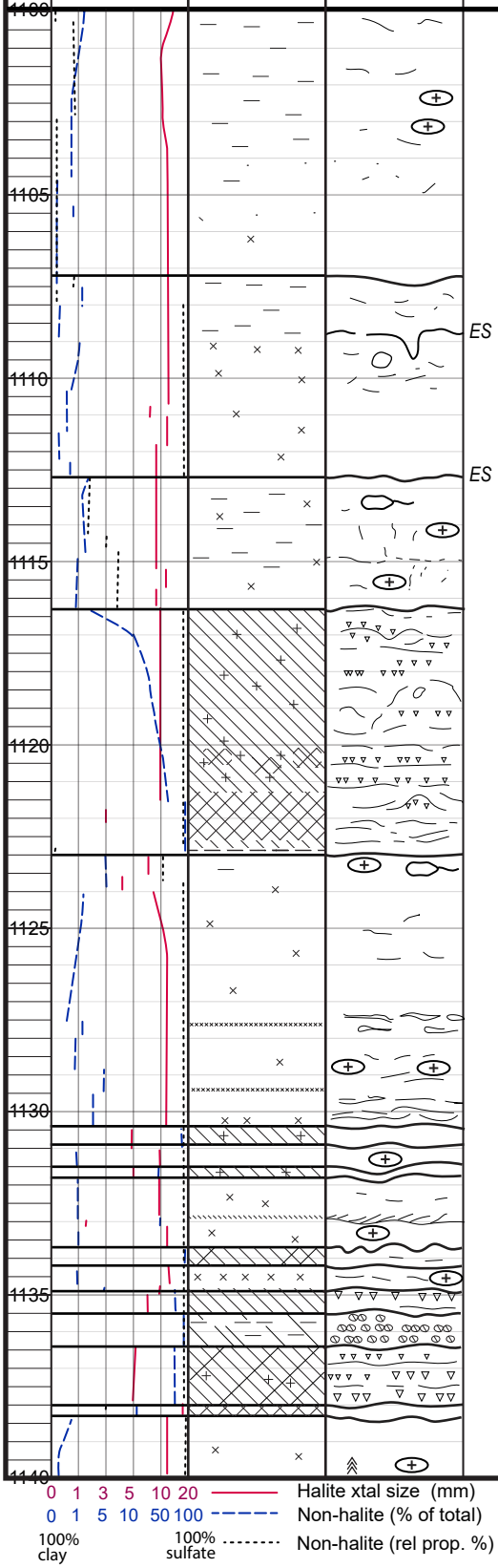
1084.0-1084.4: P (2.5YR 7/8-5/8), microxtln, appears to be collapsed, upper 0.1' appears dilated w/ m-c I-IIIb-c.

1084.4-1093.6: Above 1089.0: H, c-vc IV, abund clear cmt w/ large fluid inclusions; tr P as large blebs, disc stgrs, & a sol lag in pit; tr A blebs & stgrs. Below 1089.0: H (orange), m IV at base w/ abund cloudy H, c-vc IV at top w/ abund clear cmt; tr P blebs & stgrs.

1093.6-1094.4: P (2.5YR 7/8), microxtln; upper part shows fenistral fabrics w/ P PAG xtls growing into H-filled voids; lower part shows hints of wavy strata w/ poss soil textures (peds?) & local prism cracks; thin, irreg zone of H, f-m IV w/ xtl drapes overlies interlam'd A (greenish gy) & carbonate occur near the base; overlies gy clay.

AIS depth

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 30 of 60



Description

1094.4 -1107.3: Above 1095.2: arg H, m-c II-IIIb-c; upper cont marked by 1" thick fibrous H-filled fracture; lower cont grad. Below 1095.2: H, m-c IV, some MP; tr to some r-b clay, content incs upward, occurs as blebs and disc stgrs; E/S at 1098.0 marked by r-b clay, tr P blebs above and below the E/S.

1107.3-1112.7: H, m-vc IV; above 1108.2, tr r-b clay blebs, becoming large in upper 0.3'; color changes from orange below E/S at 1108.2 to transparent above; E/S marked by pits w/ trans'd P & P sol lag, gy clay occurs in the overlying H; below the E/S, tr P at base, content incs upward, some large P blebs w/ a-c margins; P sol lag at 1111.3; cloudy H abund in lower 0.5'; lower cont marked by E/S capped w/ P sol lag.

1112.7-1116.3: Above 1115.0: H, c-vc IV, abund clear cmts w/ large fluid inclusions, local pods of m IV; tr P blebs; some clay blebs & stgrs showing vert trans'n. Below 1115.0: H, m-c IV; tr to some P & r-b clay as blebs & sand-size breccia clasts?, blebs show vert alignment; lower cont grad.

1116.3-1123.0: A, microxtln; abund H above 1121.3, poss diss'n & collapse of H PAGS, bedding very contorted; interbedded w/ P 1120.0 & 1121.3; mainly P 1121.3-1122.5; wavy to contorted lam of P & A below 1122.5; H PAGS from 1/4"-2" tall, mound of H PAGS at 1122.1; lower 0.1' consists of gy clay.

1123.0-1130.4: Above 1124.0: H, c-vc IV overlying f IV pods. Below 1124.0: H, f-vc IV, mostly m-c IV; blebs & stgrs of P; poss potash minerals dissolved from core; 1127.3-1127.8, P sol lags w/ dilated fabric & disp margins w/ H; subhoriz P sol lags & stgrs below 1129.0, locally dilated w/ a-c H margins.

1130.4-1138.3: 1130.4-1131.0: A, microxtln, H in irreg zones. 1131.0-1131.5: H, m IV, tr P, local MP. 1131.5-1131.8: A, microxtln, hint of stratification, HPAG sand. 1131.8-1133.7: H, f-vc IV, some MP; some stgrs & blebs of A; irreg A bed at 1133.0; tr P; poss HPAG sand in upper 0.2'. 1133.7-1134.2: A, microxtln, tr P, irreg upper surface w/ poss sol lag. 1134.2-1134.9: H, m-vc IV, some MP, tr to some P as xtl lngs, stgrs, sol lags, & blebs w/ displace margins w/ H. 1134.9-1135.4: A, microxtln, H PAGS ¼" tall at base & 2" tall at top, hints of strata. 1135.4-1136.4: Arg A, nodular at base, isolated nodules at top, nodules 1/4"-1/2" diameter, clay is gy, lower cont grad. 1136.4-1138.0: A, microxtln, microlam'd to thinly lam'd, irreg to wavy; H PAGS 1/8"-1/2" tall; lower cont sharp, marked by gy clay.

1138.0-1138.3: Mix of P & H; P occurs as blebs & in irreg subhoriz zones & lam, appears slumped & disrupted, locally shows disp boundaries w/ H; H is c-vc IV.

AIS depth

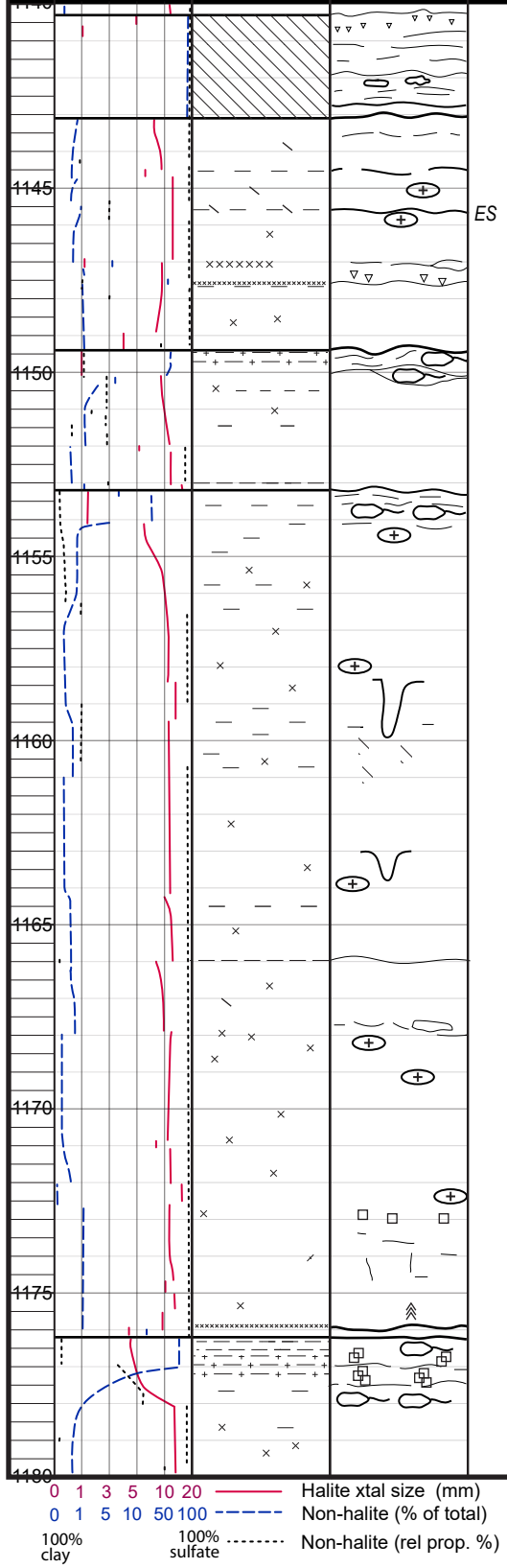
1132.5-1119.5

1137.5-1132.5

1141.5-1137.5

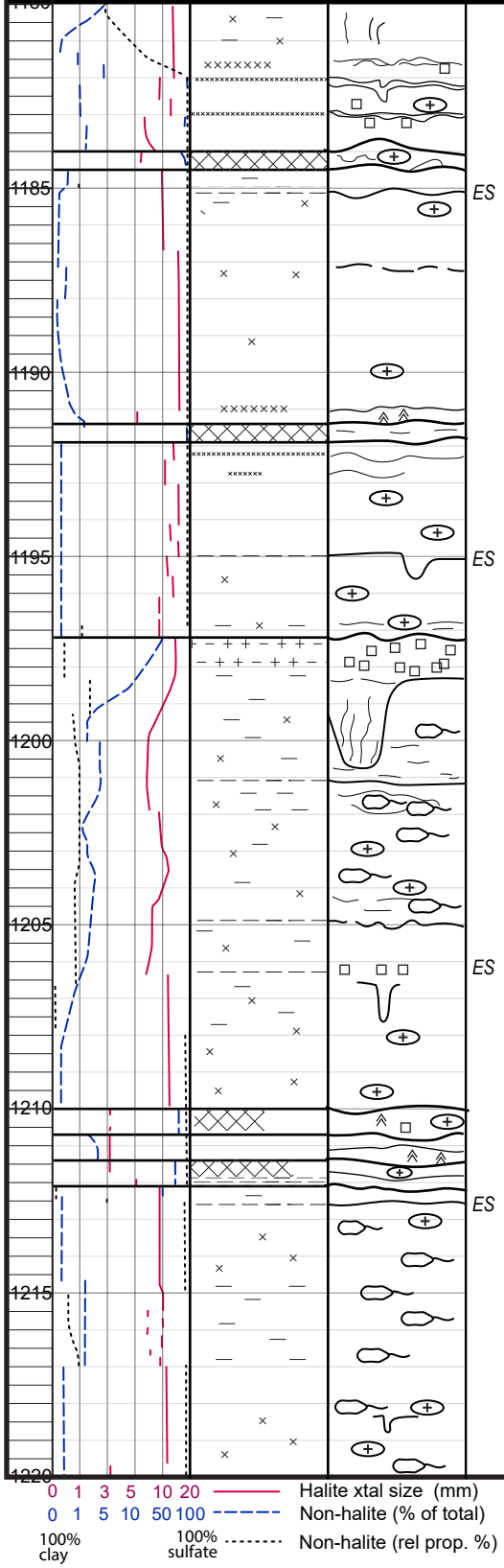
1147.5-1141.5

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 31 of 60



Description	AIS depth
1138.3-1140.3: H, c-vc IV, local MP; tr P as blebs & stgrs near top; A blebs & stgrs near base. 1140.3-1143.1: A, microxtln; locally thinly lam'd to lam'd, wavy; some poss nodules below 1142.0; gy clay parting at ~1143.0, strata locally disrupted; some f-m I-IIb-c in upper 0.2'.	1167-1164.5
1143.1-1149.4: H, m-c IV, vc IV in MPs; rare A blebs & stgrs above 1146.0, near the top some stgrs show dilation w/ local f-m I-IIa-b; irreg sol lag & stgrs of P below 1147.1 show disp boundaries; irreg lam of P w/ H PAGS to 1/4" tall at 1147.6 overlies thin lam of gy clay; tr P blebs & stgrs below 1147.6.	1174-1167
1149.4-1153.2: Above 1150.2: Arg H & H'tic Mudst, mostly f IV in pods; some thin (mm-scale) H filled fractures. Below 1150.2: H, m-c IV; above 1152.0, P & r-b clay as blebs & stgrs, some showing vert orientations, some P xtl lngs; tr P blebs & stgrs & some cloudy H in lower 1'. 1153.2-1176.2: Arg H in upper 0.3'. Above 1154.3, f-m IV in pods, poss clay-filled dessication crack; tr dissem r-b clay. Below 1154.3, H, m-vc IV, local MP w/ vc IV; tr r-b clay as blebs & stgrs 1159.0-1161.0 & above 1156.5; tr P blebs; large irreg blebs & sol lags of P 1164.5-1168.1, some w/ disp boundaries, some w/ V-O fabric; lower cont marked by 0.1' thick P bed, probable sol lag.	1200-1174
1176.2-1178.1: Arg H & H'tic Mudst, f IV in pods, zones of Mudst w/ f-m I-IIIb-c; mud is r-b; some P near base; lower cont grad. 1178.1-1184.0: H, m-c IV above 1180.0, m-vc IV below 1180.0; local P sol lags w/ I-IIIa-c; large clay (r-b) & P blebs show vert trans'n 1180.0-1181.0; P bed collapse into pits 1182.0-1182.2; slumped & collapsed P bed 1183.1-1183.3.	1208-1200

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 32 of 60



Description

1184.0-1184.5: P, microxtln, shows collapse features, disc zones of H near top, lower cont irreg.

1184.5-1191.4: H, m-vc IV, local MPs; E/S w/ gy clay at 1185.0, tr clay above E/S; tr P, P concentration incs ~1187.0-1187.4, poss E/S w/ dilation; P bed near base shows disp margins; primary H near base.

1191.4-1191.9: A'tic P, hint of subhoriz strata, some H in irreg zones.

1191.9-1197.2: H, m-vc IV, local large MP, some cloudy H near base; tr P blebs, irreg P lam near top; near 1195; clay occurs on dilated E/S; gy clay stgrs near the base.

1197.2-1210.0: Above 1198.3: arg H overlain by H'tic Mst, m-vc I-IIIa-c, mostly c, r-b. Between 1198.3-1204.8: H, f-vc IV; pods of f-m IV are bounded by irreg stgrs of bwn clay and P and zones of m-c IV cmt, cmts contain tr P and clay stgrs and blebs; above the E/S, large blebs and subhoriz stgrs of clay show a-b margins with H; core crosses the edge of a sol pit in the upper part of the unit, stgrs and blebs of clay and P are V-O w/in the pit, while stgrs of P and clay are subhoriz outside the pit. Below 1204.8: H, m-vc IV; local MP and pits; mod amounts of cloudy H in lower 1.5'; tr P as stgrs and blebs, some stgrs show disp "a" boundaries with H in lower 2'; tr clay (r-b, locally gy) above 1208.0 as irreg stgrs and some blebs; E/S at 1206.2 is marked by gy and r-b clay with some m-c I-IIIa; upper contact E/S marked by r-b clay.

1210.0-1212.1: Interbedded P & H. 2110.0-1210.7: P, microxtln, H'tic; contains disc zone of H of B-G m IV w/ P xtl drapes overlying I-IIIb-c at the base; P shows collapse textures where H is absent. 1210.7-1211.4: H, f-m IV, some V-O xtls (B-G?); P'tic as small blebs, xtl lngs, & an irreg lam near the base. 1211.4-1211.8: P, microxtln; contains local irreg cores of H bounded by P showing collapse fabrics. 1211.8-1212.1: Mudst, gy.

1212.1-1225.1: H, f-vc IV; pods of f-m IV occur above 1220.0 & are bounded c-vc IV passive cmts, expansive cmts occur 1214.5-1217.0; local MP & shallow pits; tr to some P (orange) & clay (gy) in alternating zones as blebs, disc stgrs & xtl drapes; local B-G H; sol lags of P & clay (brown to gy) occur on E/S at 1220.8 & 1222.3; the E/S clay (brown) & P occur as disc stgrs & sol lags; below 1222.3, H is orange & contains subhoriz stgrs & sol lags of P, local MP, mod cmts.

AIS depth

1208-1200

1215.5-1208

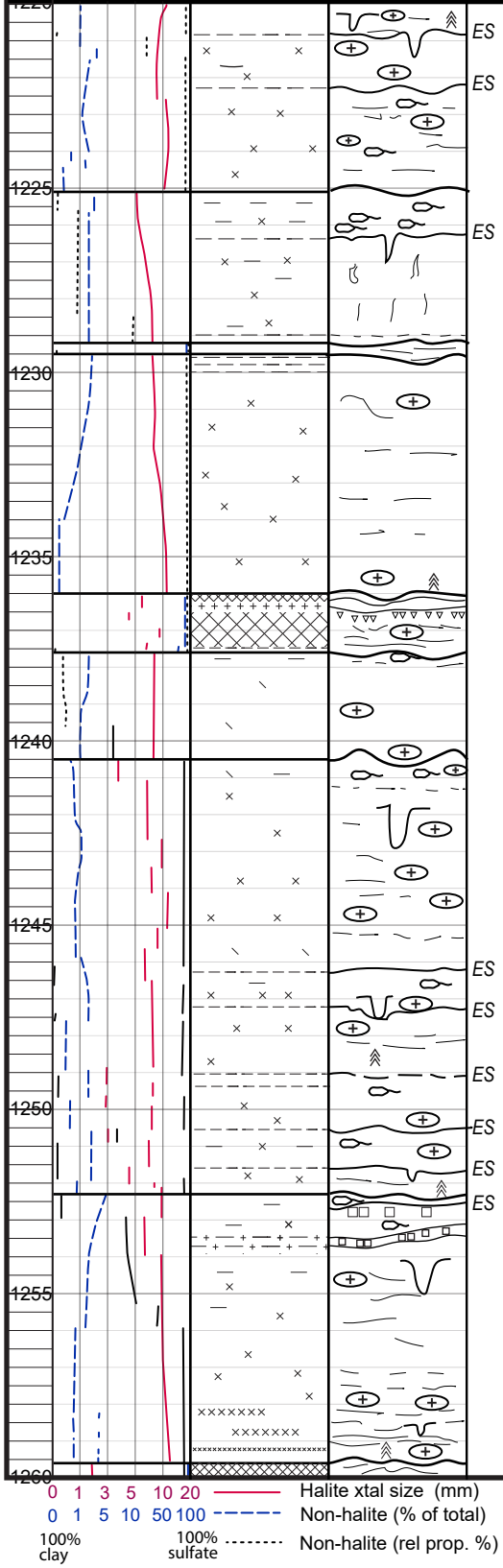
1221.5-1216

1233.5-1221.5

1235.5-1233.5

1249-1235.5

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 33 of 60



Description

1225.1-1229.2: H, f-c IV; above 1226.2, f IV pods containing dissem bwn clay are bounded by small blebs & zones of bwn clay w/ a tr of dissem P; 0.1' deep diss'n pits containing trans'd bwn clay & P originate at an E/S at 1226.2, clay overlies P; below 1226.2, tr to some bwn clay & P as VO blebs; upper cont E/S; bwn clay overlies lower cont.

1229.2-1229.5: P, microxtln, poss deformed strata, local crackle texture (sol lags?), overlies 0.1' of gy clay.

1229.5-1236.0: H, m-c IV w/ mod cmt above 1231.0, m-vc IV w/ abund vc cmts & poss MP below 1231.0, poss B-G H near base; P occurs as locally abund small to large blebs, some subhoriz blebby stgrs, some vert trans'd stgrs; tr gy clay near top.

1236.0-1237.6: P, microxtln; weak wavy thin lam to lam near base, strata slumped around H core; H & P PAGS 0.1" – 1" high near top; 1" thick bed of H underlies upper 1.5" of P; 0.1' thick bed of gy clay at base.

1237.6-1240.5: H, m-c IV, abund cmts, tr cloudy H, some MP; tr A blebs; 0.2' of f IV in pods near top.

1240.5-1252.3: 1240.5-1241.2: H, f IV in pods; tr A & gy clay, some small MP. 1241.2-1245.3: H, m-vc IV, orange, some cmts, mostly in pits & MP, some cloudy H; tr to some P as blebs, blebby stgrs, & stgrs, some w/ displace boundaries, P content decreases above 1242.4. 1245.3-1246.2: H, m-vc IV, abund cmt; tr A. 1246.2-1247.2: H, m-c IV, P'tic at base, as blebs & xtl lngs; Arg at top (gy clay) in irreg pods of f-m IV; upper E/S is marked by gy clay. 1247.2-1249.0: H, m-vc IV, orange, some cloudy H; tr to some P, content incs upward, P occurs as blebs & stgrs, some w/ disp boundaries; upper E/S marked by gy clay. 1249.0-1250.4: H, f-c IV, some MP & mod amount of cloudy H below 1249.5; f-m IV in pods w/ c IV passive cmts in upper 0.5'; tr bwn (base) to gy (top) clay in upper 0.5'; upper E/S is dilated & marked by tr gy clay. 1250.4-1251.7: H, f IV in pods w/ local MP at top, c-vc IV cmts abund at base; tr P as blebs & xtl lngs; tr dissem gy clay; upper E/S is dilated. 1251.7-1252.3: H, m-c IV, tr P as subhoriz stgrs & blebs; upper E/S shows small pit & gy clay & P sol lags.

1252.3-1259.6: H, m-vc IV, local MP & diss'n pits, some primary H below 1258.4, mod'ly abund cmts become more common upward; above E/S at 1253.6, f-m IV in pods & m-vc I-IIIa-b in H'tic Mudst (brown) & Arg H; 1253.6- 1257.5, tr to some subhoriz to subvert P stgrs w/ blebs & xtl drapes; below 1257.5, P lam, blebby lam, & stgrs are spaced 3"-4"; potash minerals (?) dissolved by drilling fluids above 1256.0; upper E/S is sharp.

1259.6-1260.5: P, microxtln, wavy strata near base; irreg zones of P'tic H; poss HPAG sand grains; upper cont sharp & irreg, depositionally continuous w/ the overlying unit; lower cont sharp, no clay.

1260.5-1262.6: H, m-c IV, w/ some vc IV, some cmts & cloudy H,

AIS depth

1249-1235.5

1252.5-1249

1260-1253

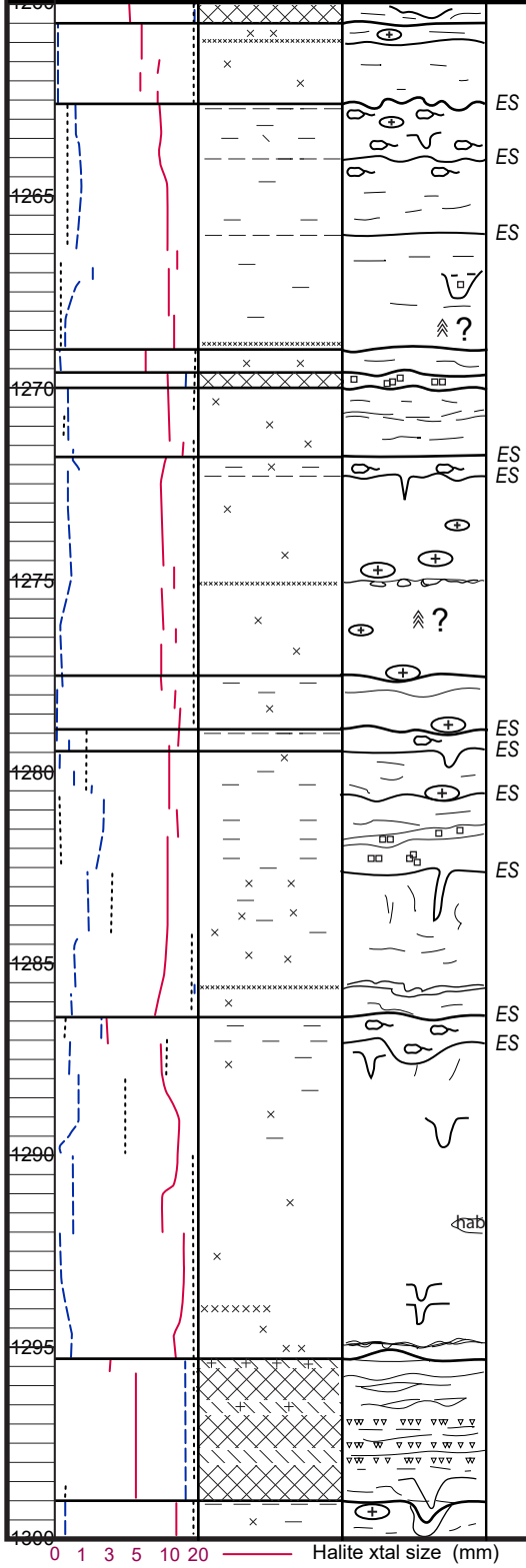
1261-1260

1264.5-1261

1275.5-1264.5

1283-1275.5

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 34 of 60



Description

local MP; tr P as blebs & xtl innings in lower part; some P in upper part as lam & subhoriz stgrs.

1262.6-1269.0: H, m-c IV, w/ local vc IV in MPs & pits, equal parts cloudy H & cmts, poss B-G H near base, cmts more abund & show dilation (?) above 1267.6; tr to some clay above 1264.5 w/ pods of f-m IV, w/ some MPs & pits; clay in lower part mostly consists of blebs & xtl lngs; poss potash dissolved out of clay blebs by drilling fluids above 1267.6; in lower part, pit filled w/ bwn clay shows disp H boundaries; lower cont marked by P lam; upper cont E/S.

1269.0-1269.6: H, m-c IV, abund cloudy H, some cmts; tr P as subhoriz stgrs.

1269.6-1270.0: P, microxtln, contains H as f I-IIIa-b in irreg zones; conts irreg & dilated.

1270.0-1271.8: H, m-c IV, tr vc IV, abund cloudy H, some H cmts, poss preserved eff crust near base; tr P as local blebs, xtl lngs, & continuous to disc subhoriz stgrs.

1271.8-1277.5: Above E/S at 1272.2: H, f IV in pods bounded by zones of m-c IV cmts; slightly Arg & P'tic; diss'n pit at lower E/S is 0.2' deep & contains trans'd clay. Below 1272.5: H, m-c IV, tr poss primary H in lower part of unit, some vc IV as cmts & in MPs; tr to some P as blebs, xtl lngs, & blebby lam, some show disp boundaries.

1277.5-1278.9: Upper 0.3': H, f-m IV, poss pods (?). Remainder: H, m-c IV, local vc IV in MP, tr P blebs.

1278.9-1279.6: Above E/S at 1279.6: H, f IV in pods bounded by c-vc IV cmts, overlies m-c IV w/ some cmt; tr gy clay near top; upper cont E/S w/ gy clay.

1279.6-1286.4: 1279.6-1281.3: H, m-vc IV, abund cmts; mod'ly abund bwn clay blebs near base, clay content decreases upward; tr to some P near top; upper cont E/S w/ ~0.3' of relief. 1281.3-1282.6: Arg H (DMRH), f-c II-IIIa-c, clay occurs as blebs & irreg zones, some w/ a V-O fabric. Below E/S at 1282.6: P'tic H, m-c IV, abund c-vc IV cmts; P occurs as irreg blebs & disc stgrs, some blebs show vert trans'n near top; tr to some clay showing vert trans'n into pits, bwn above 1284.7, gy 1284.7-1285.3; disrupted, irreg bed of P 1285.6-1285.7.

1286.4-1295.3: Above 1287.0: Arg H, f IV, in pods, tr c IV cmt, upper cont E/S. E/S at 1287.0 shows 0.3' relief. 1287.0-1289.3: H, m-c IV; tr bwn clay & P blebs, clay content incs upward, some vert trans'n fabrics near top. 1289.3-1292.0: H, c-vc IV, mostly cmt; tr P blebs. Below 1292.0: H, vc IV, mainly cmt; tr to some large blebs & blebby lam of P, some showing vert trans'n into pits; local zones of poss eff crust preserved near 1292.

1295.3-1299.0: P, microxtln, locally interbedded w/ A; local irreg zones of H & H PAGS, upper 0.1' appears to be HPAG sand, H PAGS to 1/8" – 1/2" high in locally domed beds; lower part contains irreg zones of H bounded by P w/ disrupted & collapsed bedding; collapsed zone 0.3' deep into underlying unit; irreg zone of gy clay at base.1299.0-1300.8: H, m-c IV, abund cmt, come vc IV in MP near top; tr gy clay above 1299.5; tr P as blebs, xtl drapes, & a 0.1' thick collapsed bed.

AIS depth

1292.5-1286

1301-1292.5

1301-1296

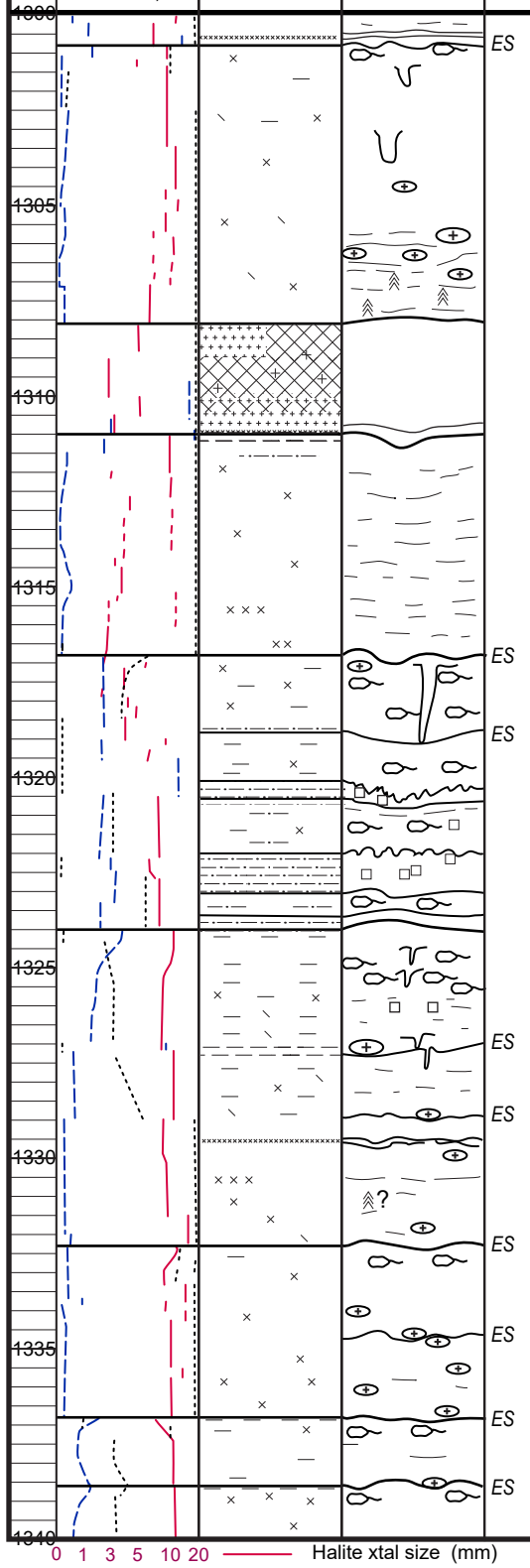
1306.5-1301

1309.5-1306.5

1318.5-1309.5

1322-1318.5

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 35 of 60



Description

1300.8-1308.1: H, f-vc IV; above 1301.7, pods of f-m IV bounded by zones of m-c IV cmt. 1301.7-1302.7: H, m-c IV, c-vc IV cmts mod'ly abund . 1302.7-1305.7: H m-c IV, mod'ly abund cmts, some MP & pits filled w/ c-vc IV, tr A & P stgrs & xtl drapes. 1305.7-1308.1: H, f-m IV; abund primary H at base, content decreases upward; cmts are rare at the base, become more common upward; shows B-G H at base & MPs at top.

1308.1-1311.0: P, microxtln, interbedded w/ irreg H beds 1/4" to 0.1' thick; H is f-m IV showing P xtl drapes; local H PAGS 1/4" high near the middle of the unit; 0.4' thick bed of m IV H overlies 0.1' thick bed of P at the base, H shows poss B-G; lower cont slumped into pit & marked by irreg lam of gy silt.

1311.0-1316.8: H, m-c IV, some to abund primary near base, primary content decreases upward, cmts & small MPs inc upward, cmt mod'ly abund near top; tr P as continuous to mainly disc subhoriz stgrs & zones (0.1' thick) of blebs; alternating zones of P'tic H & clear H forms beds 0.2'-0.5' thick; upper cont irreg over 0.1'.

1316.8-1324.0: H, f-m IV in pods, some c-vc IV cmts; in place at top & occurs as irreg blocks floating in a bwn H'tic Sltst (cave?); Sltst contains m-vc I-IIIa-b; lower cont a very irreg sol boundary w/ 0.2' of relief.

1324.0-1332.3: Above 1326.0: H, f-m IV in pods bounded by vc IV cmt; mod'ly abund Sltst blebs trans'd into pits, shows strong vert fabrics; mod'ly abund P as irreg blebs; upper surface possibly dissolved syndepositionally (poss cave floor?). 1326.0-1329.0: H, m-vc IV, abund H cmt; Arg & silty as large irreg blebs trans'd into pits near top. Below 1329.0: P'tic H, m-c IV; vc IV in MP, poss primary H near base, cmt content incs upward; P occurs as rare blebs (some w/ disp margins), disc subhoriz stgrs, blebby lam, & an irreg thin (0.1') bed; upper E/S marked by a P str; some A near base.

1332.3-1336.8: H, m-c IV, some vc IV in MP, tr primary H, abund cmts; tr P as rare blebs & xtl drapes; orange color below 1334.2; above 1333.0, H occurs as f-m IV in pods w/ tr clay & P stgrs; E/S at 1334.7 has no clay; upper cont an E/S.

1336.8-1338.6: H, m-c IV, some vc IV in MP, cmts abund ; some f-m IV pods near top.

AIS depth

1331.5-1323.5.

1334-1331.5

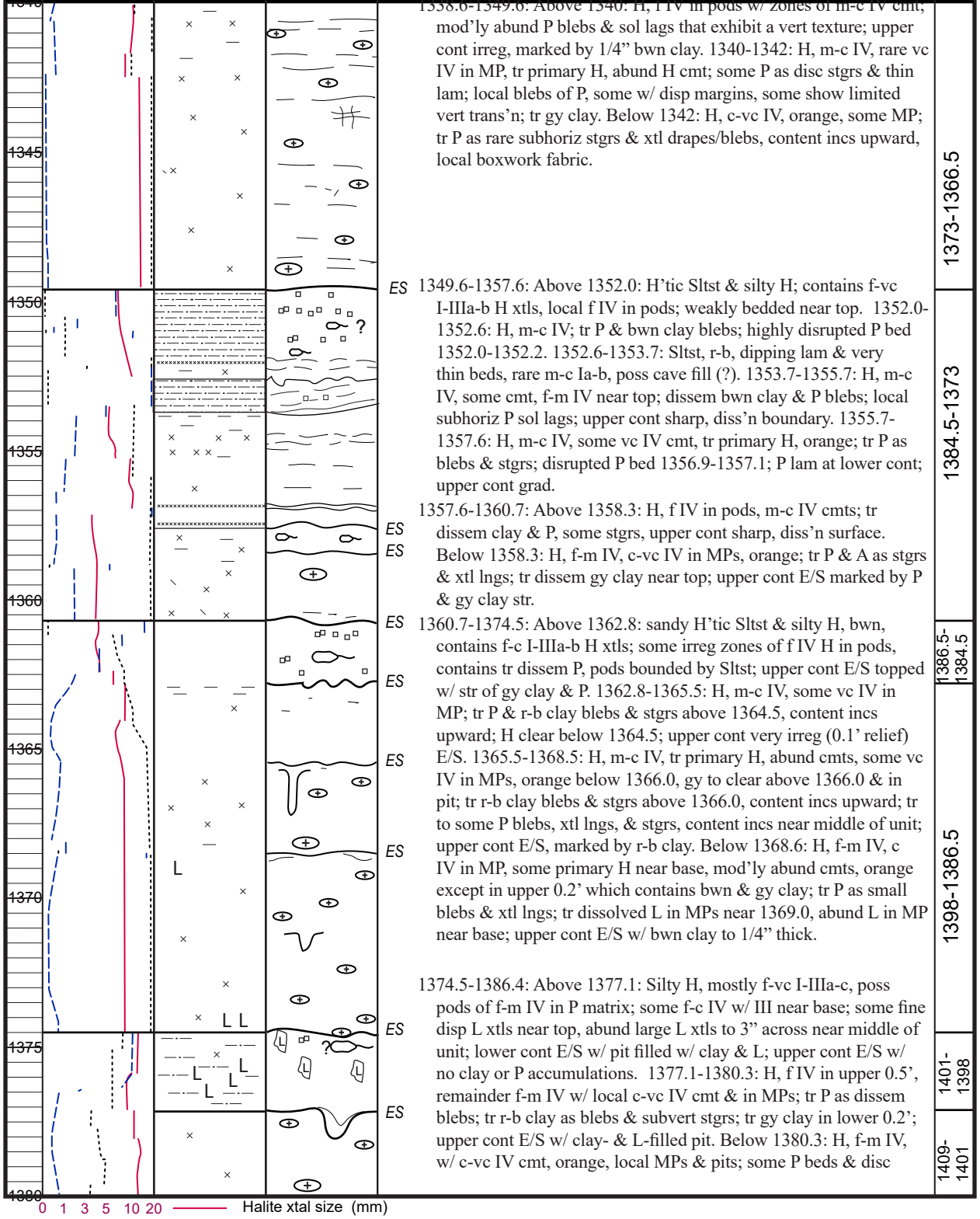
1340-13434

1347.5-1340

AIS relationships undertain

1373-1366.5

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 36 of 60



Description

1358.6-1349.6: Above 1340: H, f IV in pods w/ zones of m-c IV cmt; mod'ly abund P blebs & sol lags that exhibit a vert texture; upper cont irreg, marked by 1/4" bwn clay. 1340-1342: H, m-c IV, rare vc IV in MP, tr primary H, abund H cmt; some P as disc stgrs & thin lam; local blebs of P, some w/ disp margins, some show limited vert trans'n; tr gy clay. Below 1342: H, c-vc IV, orange, some MP; tr P as rare subhoriz stgrs & xtl drapes/blebs, content incs upward, local boxwork fabric.

1349.6-1357.6: Above 1352.0: H'tic Sltst & silty H; contains f-vc I-IIIa-b H xtls, local f IV in pods; weakly bedded near top. 1352.0-1352.6: H, m-c IV; tr P & bwn clay blebs; highly disrupted P bed 1352.0-1352.2. 1352.6-1353.7: Sltst, r-b, dipping lam & very thin beds, rare m-c Ia-b, poss cave fill (?). 1353.7-1355.7: H, m-c IV, some cmt, f-m IV near top; dissem bwn clay & P blebs; local subhoriz P sol lags; upper cont sharp, diss'n boundary. 1355.7-1357.6: H, m-c IV, some vc IV cmt, tr primary H, orange; tr P as blebs & stgrs; disrupted P bed 1356.9-1357.1; P lam at lower cont; upper cont grad.

1357.6-1360.7: Above 1358.3: H, f IV in pods, m-c IV cmts; tr dissem clay & P, some stgrs, upper cont sharp, diss'n surface. Below 1358.3: H, f-m IV, c-vc IV in MPs, orange; tr P & A as stgrs & xtl lngs; tr dissem gy clay near top; upper cont E/S marked by P & gy clay str.

1360.7-1374.5: Above 1362.8: sandy H'tic Sltst & silty H, bwn, contains f-c I-IIIa-b H xtls; some irreg zones of f IV H in pods, contains tr dissem P, pods bounded by Sltst; upper cont E/S topped w/ str of gy clay & P. 1362.8-1365.5: H, m-c IV, some vc IV in MP; tr P & r-b clay blebs & stgrs above 1364.5, content incs upward; H clear below 1364.5; upper cont very irreg (0.1' relief) E/S. 1365.5-1368.5: H, m-c IV, tr primary H, abund cmts, some vc IV in MPs, orange below 1366.0, gy to clear above 1366.0 & in pit; tr r-b clay blebs & stgrs above 1366.0, content incs upward; tr to some P blebs, xtl lngs, & stgrs, content incs near middle of unit; upper cont E/S, marked by r-b clay. Below 1368.6: H, f-m IV, c IV in MP, some primary H near base, mod'ly abund cmts, orange except in upper 0.2' which contains bwn & gy clay; tr P as small blebs & xtl lngs; tr dissolved L in MPs near 1369.0, abund L in MP near base; upper cont E/S w/ bwn clay to 1/4" thick.

1374.5-1386.4: Above 1377.1: Silty H, mostly f-vc I-IIIa-c, poss pods of f-m IV in P matrix; some f-c IV w/ III near base; some fine disp L xtls near top, abund large L xtls to 3" across near middle of unit; lower cont E/S w/ pit filled w/ clay & L; upper cont E/S w/ no clay or P accumulations. 1377.1-1380.3: H, f IV in upper 0.5', remainder f-m IV w/ local c-vc IV cmt & in MPs; tr P as dissem blebs; tr r-b clay as blebs & subvert stgrs; tr gy clay in lower 0.2'; upper cont E/S w/ clay- & L-filled pit. Below 1380.3: H, f-m IV, w/ c-vc IV cmt, orange, local MPs & pits; some P beds & disc

AIS depth

1373-1366.5

1384.5-1373

1386.5-1384.5

1398-1386.5

1401-1398

1409-1401

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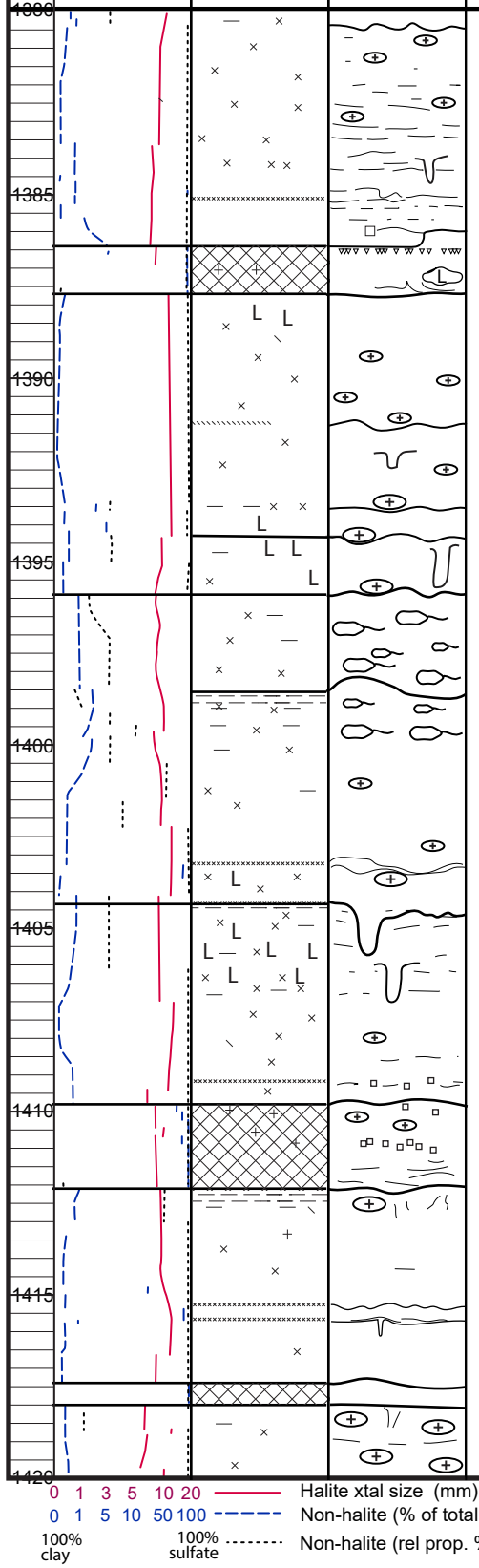
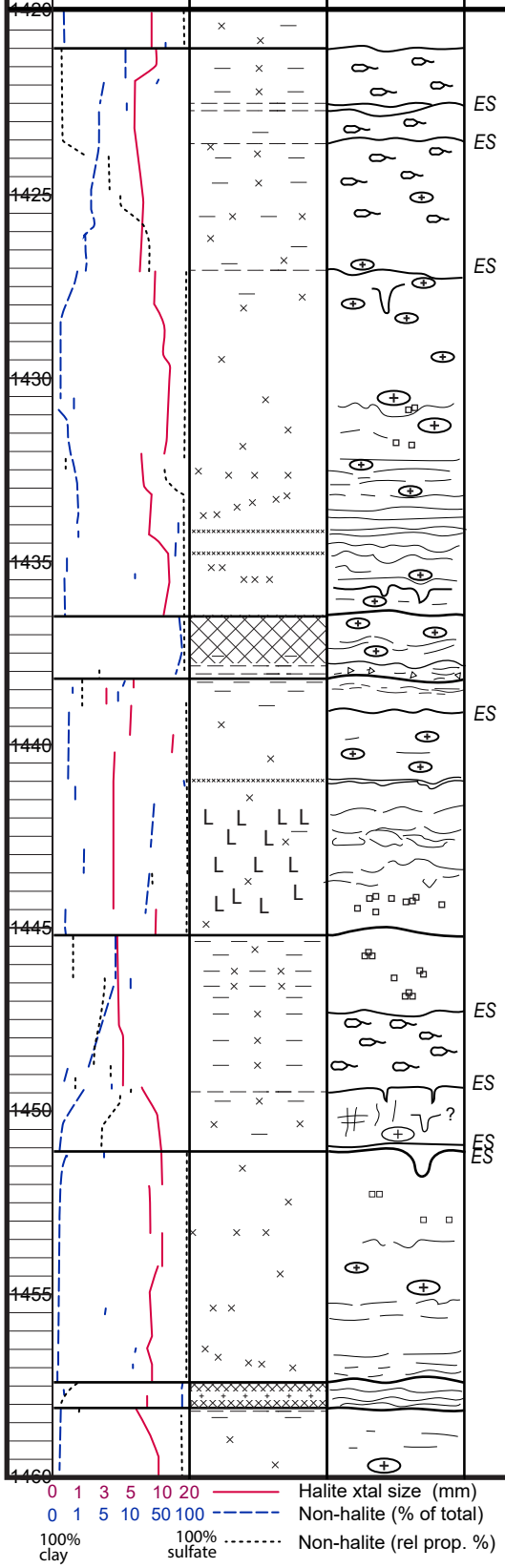


Description	AIS depth
ES blebby lam near base; P stgrs & blebby zones subhoriz below 1383.0, becomes more dispersed upward; abund P xtl lngs near base; local Ia-b in P zones near base; upper cont E/S w/ no clay or P lags.	1409-1401
1386.4-1387.7: P, microxtln, disrupted bedding near top & base, H PAGS 1/4" high near top; local zones of H; irreg zone w/ L near the middle of the unit; 1/4" thick gy clay at the base; upper cont sharp & disrupted.	1410.5 -1409
1387.7-1394.3: H, m-c IV, some vc IV in MPs & pits, some f IV locally, abund cmts, mostly orange; tr P & rare A as belbs, blebby lam, disc subhoriz stgrs; some L above 1388.5 & near lower cont, possibly in MP; minor exposure surface topped w/ A at 1391.3 & ES gy clay at 1393.5; upper cont diss'n surface.	AIS relationships undertain
1394.3-1395.9: H, m-c IV, poss vc IV in MPs & pits; orange below 1395.3 w/ tr P blebs, gy above w/ tr gy clay stgrs; some L at top, ES L content decreases downward; upper cont E/S, dilated w/ no ES accumulation of clay or sulfate.	
1395.9-1404.3: Above 1398.5: H, f-m IV in pods, m-c IV cmts near ES top & in lower 0.5'; tr to some r-b clay as stgrs, blebs, & dissem material; tr dissem P; upper cont E/S, dilated, no accumulation of clay or sulfate. 1398.5-1400.0: H, f IV in pods, subhoriz stgrs of r-b clay; dissem P as POS (?) & some blebs; upper cont E/S w/ 0.5' ES relief w/ I-IIIa-b in r-b clay, poss L in clay. 1400.0-1403.2: H, m-c IV, abund cmts above 1402.6; tr to some P & r-b clay blebs, some blebs show V-O fabric, content incs upward; disrupted P bed 0.1'-0.2' thick at the base; upper cont grad. Below 1403.2: H, m-vc IV, clear, poss MP filling.	1432.5-1419
1404.3-1409.8: Above 1407.0: H, m-c IV, local pits filled w/ c-vc IV; ES tr to some P blebs & stgrs; L & leonite abund 1405-1406 as disp xtls w/ soluble rims; upper cont E/S w/ sol pit w/ ~1' relief, no clay. Below 1407.0: H, m-c IV, abund cmt, orange; tr to some P as disrupted beds, subhoriz stgrs & lam near the base; some disp H in P near base; upper cont grad.	
1409.8-1412.1: P, microxtln, wavy thin beds show low-angle cross-cutting relationships near the base, some disrupted beds; irreg zones of H, m-c IV & II-IIIa-c, H content incs upward above 1411.7; gy clay 1/8" thick at base; upper cont very irreg.	
1412.1-1417.4: H, m-c IV; poss primary H near the base, content decreases upward; H cmts become more common upward; orange from base to 1412.8; tr P blebs & disc stgrs; disrupted P bed showing collapse into sol pit near middle of the unit; tr gy clay in MP above 1412.8, shows vert trans'n; upper cont sharp diss'n surface.	1435-1432.5
1417.4-1418.0: P, microxtln, hint of subhoriz stratification; local irreg zones of H; no clay at base; upper cont sharp, wavy.	1440-1435
1418.0-1421.0: H, m-c IV, alternating zones of orange to gy 0.5'-1' thick, some f IV in gy zones (eff crust?), poss primary H in orange zones, local MPs above 1420; tr P blebs; tr gy clay stgrs & blebs in gy zones; upper cont sharp.	1441-1440
1421.0-1436.5: Above 1427.1: H, f-m IV in pods, c-vc IV in MPs &	1444-1441

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 38 of 60



Description

cmts, pods become better defined upward, f-m IV w/ no pods in lower ~1.5'; Arg w/ tr to some clay, highest concentration 1421.3-1425.3 w/ some thick (0.25'-0.5') Arg zones, clay mostly gy above 1422.0, r-b clay occurs 1420.0-1425.8, gy clay below 1425.8; E/S at 1422.5 shows irreg surface over 0.1' & up to 0.1' of r-b clay as a sol lag; other E/S capped by r-b clay; tr to some large P blebs; upper cont E/S capped by gy clay. 1427.1-1429.0: H, m-c IV, some MPs, orange grading to gy above 1427.8; tr P blebs, local large blebs of P to 1" across show vert displacement into pit; upper cont E/S, dilated, dissem gy clay. 1429-1432.0: H, c-vc IV, orange, abund cmt; large blebs of A or P show vert displacement, isolated small blebs of P occur, disrupted bed of P or A at 1430.8; upper cont grad. Below 1432.0: H, mainly m-c IV w/ some f IV, c-vc IV in MP, abund primary H, local V-O H xtls w/ drapes of P, orange; tr to some P as stgrs, xtl drapes, & flat to disrupted lam & beds, disrupted bed of P 1434.4 & 1435.0; upper cont grad to diffuse.

1436.5- 1438.2: P, microxtln; wavy to deformed lam, some slumping at the base; strata deformed around cores of m IV H; deformed gy clay lam in lower part; lower 0.3' consist of gy clay w/ irreg breccia (?) clasts of P; upper cont sharp.

1438.2-1445.2: Above 1439.0: H, f-m IV; Arg (gy) zone 0.2' thick at 1438.5, some disc gy clay lam near top. 1439.0-1441.0: H, m-c IV, c-vc IV in MPs, orange; tr P blebs & subhoriz stgrs; 0.1' thick P bed at base, upper cont E/S, no clay. 1441.0-1441.5: H, f IV, cloudy to clear. Below 1441.5: H, f-m IV, orange below 1444.0; contains irreg masses of c-vc L & disp L xtls (some a, mostly c, boundaries); tr P blebs & stgrs; tr clay blebs 1442.5-1443.5.

1445.2-1457.4: Above 1447.1: H'tic Mudst, r-b, gy zone above 1445.6; f-m I-IIIa-b H xtls; mod'ly abund P blebs. 1447.1-1449.2: H, f-m IV in pods bounded by r-b clay stgrs & dissem blebs; some P blebs, upper cont E/S w/ r-b clay. 1449.2-1451.1: H, f-c IV, abund cmts; tr P & gy clay as dissem blebs, some w/ disp margins, some showing vert trans'n, some boxwork fabric; r-b clay & P vert trans'd in & near a desic crack at the upper cont; E/Ss near base & at upper cont w/ r-b clay. Below 1451.1: H, f-m IV at base, m-c IV at top, arrange, abund cloudy H w/ some cmts at base, cmts become more abund upward, some c-vc IV in MPs, some small V-O MPs; P as stgrs, blebby lam, & disc/disrupted lam in lower part, P xtl drapes near base, tr dissem P blebs; upper cont E/S w/ no clay.

1457.4-1458.1: P, microxtln, separated into an upper & lower bed by a 0.3' thick H bed. Upper P bed is 0.2' thick & shows hints of stratification. Middle H bed is 0.3' thick & consists of f-mIV, orange H w/ a tr of P. Lower P bed shows disrupted lam, some w/ gy clay drapes at the base, & gy clay at the base.

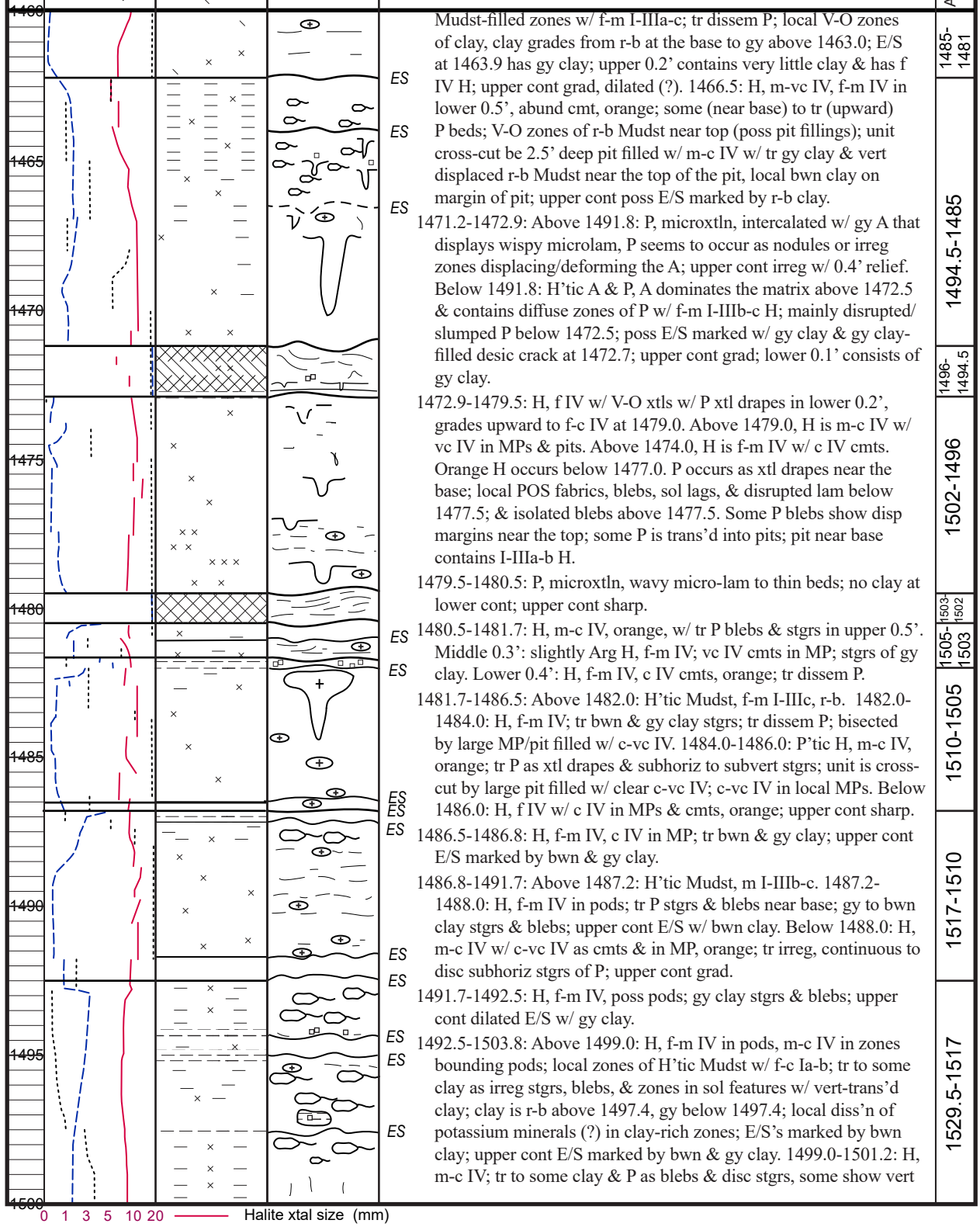
1458.1-1462.2: H, f-m IV, c IV cmts, local vc IV in MPs, m-c IV in middle of unit, f IV in upper 1/2", abund primary H near base w/ some small V-O MPs, orange, beds 0.1-0.3' thick; tr subhoriz P & A stgrs; tr gy clay in upper 0.1'; upper cont sharp diss'n surface.

1462.2-1471.2: Above 1466.5: Arg H, f-m IV in pods, m-vc IV cmts locally, some pods bounded by pits filled w/ m-vc IV, local irreg

AIS depth

1444-1441
1449-1444
1459.5-1449.5
1461.5-1459.5
1468.5-1461.5
1475.5-1468.5
1480-1475.5
1481-1480
1485-1481

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 39 of 60



Description

Mudst-filled zones w/ f-m I-IIIa-c; tr dissem P; local V-O zones of clay, clay grades from r-b at the base to gy above 1463.0; E/S at 1463.9 has gy clay; upper 0.2' contains very little clay & has f IV H; upper cont grad, dilated (?). 1466.5: H, m-vc IV, f-m IV in lower 0.5', abund cmt, orange; some (near base) to tr (upward) P beds; V-O zones of r-b Mudst near top (poss pit fillings); unit cross-cut be 2.5' deep pit filled w/ m-c IV w/ tr gy clay & vert displaced r-b Mudst near the top of the pit, local bwn clay on margin of pit; upper cont poss E/S marked by r-b clay.

1471.2-1472.9: Above 1491.8: P, microxtln, intercalated w/ gy A that displays wispy microlam, P seems to occur as nodules or irreg zones displacing/deforming the A; upper cont irreg w/ 0.4' relief. Below 1491.8: H'tic A & P, A dominates the matrix above 1472.5 & contains diffuse zones of P w/ f-m I-IIIb-c H; mainly disrupted/ slumped P below 1472.5; poss E/S marked w/ gy clay & gy clay-filled desic crack at 1472.7; upper cont grad; lower 0.1' consists of gy clay.

1472.9-1479.5: H, f IV w/ V-O xtls w/ P xtl drapes in lower 0.2', grades upward to f-c IV at 1479.0. Above 1479.0, H is m-c IV w/ vc IV in MPs & pits. Above 1474.0, H is f-m IV w/ c IV cmts. Orange H occurs below 1477.0. P occurs as xtl drapes near the base; local POS fabrics, blebs, sol lags, & disrupted lam below 1477.5; & isolated blebs above 1477.5. Some P blebs show disp margins near the top; some P is trans'd into pits; pit near base contains I-IIIa-b H.

1479.5-1480.5: P, microxtln, wavy micro-lam to thin beds; no clay at lower cont; upper cont sharp.

1480.5-1481.7: H, m-c IV, orange, w/ tr P blebs & stgrs in upper 0.5'. Middle 0.3': slightly Arg H, f-m IV; vc IV cmts in MP; stgrs of gy clay. Lower 0.4': H, f-m IV, c IV cmts, orange; tr dissem P.

1481.7-1486.5: Above 1482.0: H'tic Mudst, f-m I-IIIc, r-b. 1482.0-1484.0: H, f-m IV; tr bwn & gy clay stgrs; tr dissem P; bisected by large MP/pit filled w/ c-vc IV. 1484.0-1486.0: P'tic H, m-c IV, orange; tr P as xtl drapes & subhoriz to subvert stgrs; unit is cross-cut by large pit filled w/ clear c-vc IV; c-vc IV in local MPs. Below 1486.0: H, f IV w/ c IV in MPs & cmts, orange; upper cont sharp.

1486.5-1486.8: H, f-m IV, c IV in MP; tr bwn & gy clay; upper cont E/S marked by bwn & gy clay.

1486.8-1491.7: Above 1487.2: H'tic Mudst, m I-IIIb-c. 1487.2-1488.0: H, f-m IV in pods; tr P stgrs & blebs near base; gy to bwn clay stgrs & blebs; upper cont E/S w/ bwn clay. Below 1488.0: H, m-c IV w/ c-vc IV as cmts & in MP, orange; tr irreg, continuous to disc subhoriz stgrs of P; upper cont grad.

1491.7-1492.5: H, f-m IV, poss pods; gy clay stgrs & blebs; upper cont dilated E/S w/ gy clay.

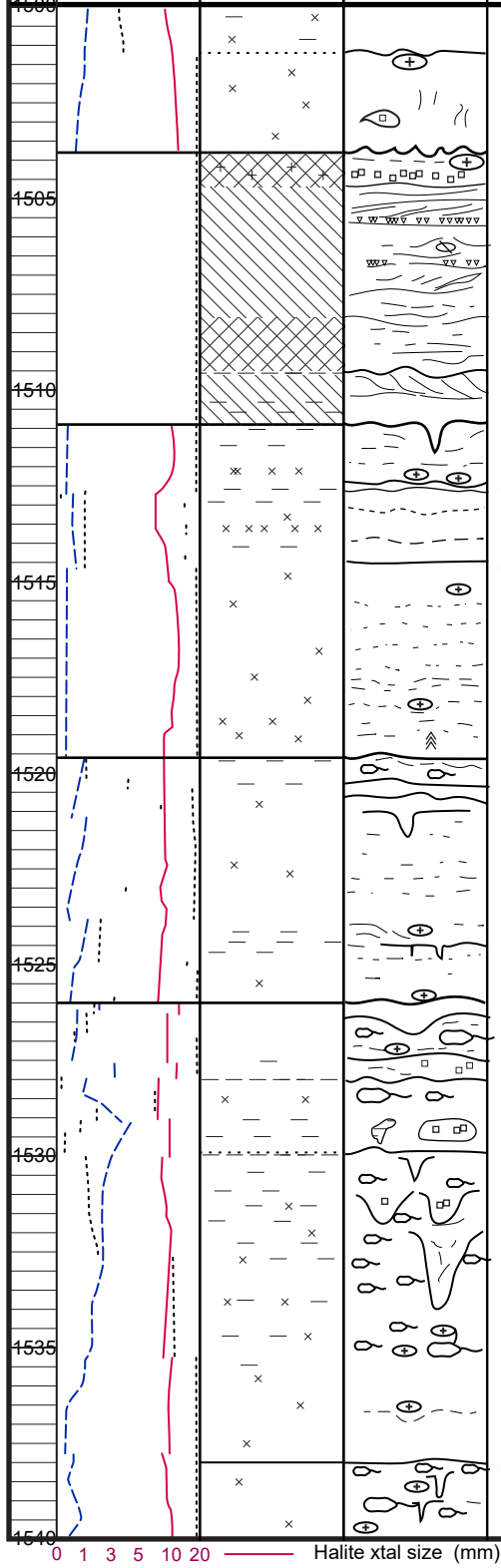
1492.5-1503.8: Above 1499.0: H, f-m IV in pods, m-c IV in zones bounding pods; local zones of H'tic Mudst w/ f-c Ia-b; tr to some clay as irreg stgrs, blebs, & zones in sol features w/ vert-trans'd clay; clay is r-b above 1497.4, gy below 1497.4; local diss'n of potassium minerals (?) in clay-rich zones; E/S's marked by bwn clay; upper cont E/S marked by bwn & gy clay. 1499.0-1501.2: H, m-c IV; tr to some clay & P as blebs & disc stgrs, some show vert

AIS depth

1485-1481
1494.5-1485
1496-1494.5
1502-1496
1503-1502
1505-1503
1510-1505
1517-1510
1529.5-1517

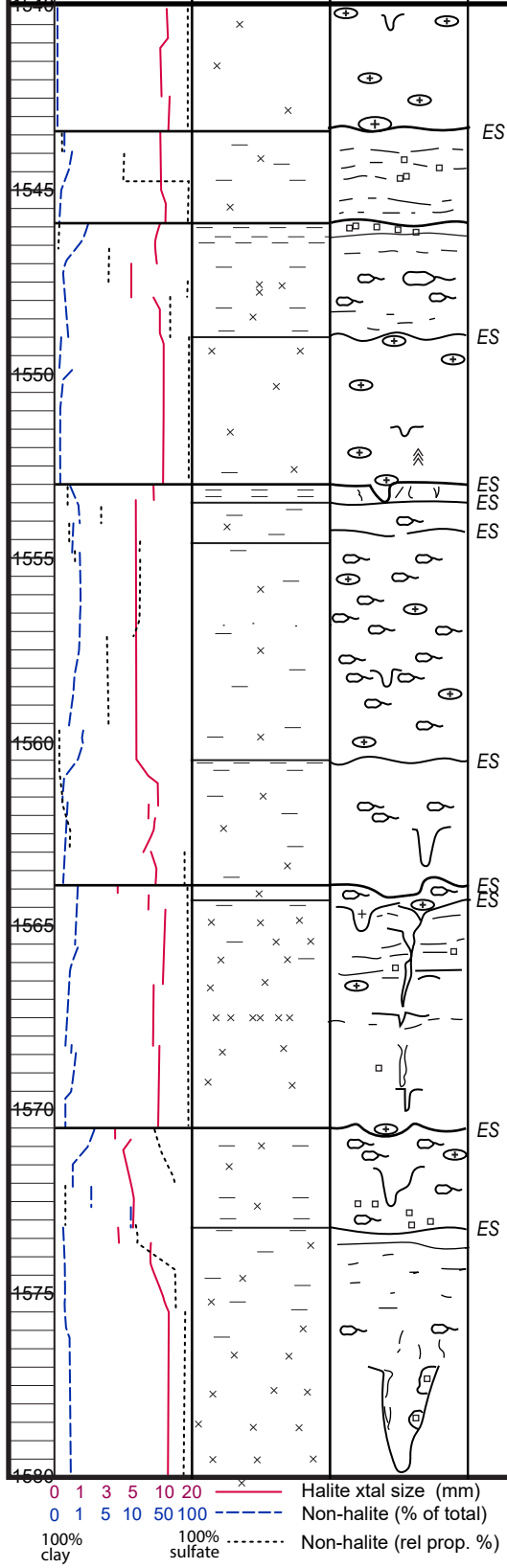
0 1 3 5 10 20 — Halite xtal size (mm)
0 1 5 10 50 100 – – – Non-halite (% of total)
100% clay 100% sulfate ····· Non-halite (rel prop. %)

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 40 of 60



Description	AIS depth
fabrics; upper cont grad. Below 1501.2: H, m-c IV, c IV cmt abund ES ; mod'ly abund P blebs, vert trans'd, dilated fabric common, rare I-IIa-c in blebs, many blebs show disp margins; tr gy clay stgrs above 1502.0; upper cont E/S w/ gy clay. 1503.8-1510.9: Above 1504.7: H'tic P, microxtln, H concentration incs downwards, becomes A'tic in lower 0.2', some f-m I-IIIb-c, upper cont sharp. 1504.7-1508.1: A, microxtln, microlam'd to lam'd, local dipping strata, some strata are slumped, gy clay is squeezed deformed strata at 1507.1', local APAGS to 1 mm high, upper cont grad. 1508.1-1509.5, P, microxtln, contorted lam. 1509.5-1510.2: P'tic A, microxtln, contorted lam; disrupted black clay beds at upper cont. Below 1510.2: A micronodules w/ gy clay (?), sol pit filled w/ gy clay(?) at lower cont. ES	1529.5-1517
1510.9-1519.6: Above 1512.0: H m-c IV, abund cmts, has bwn color, tr dissem gy clay & P. 1512.0-1514.5: alternating zones of P'tic H & Arg (gy) H. P'tic zones contain H, f-m IV w/ some m-c IV cmts; P is most abund in areas of f-m IV as xtl drapes, blebs, & rare stgrs. Arg zones contain f-m IV H w/ tr dissem gy to bwn (less common) clay. E/S w/ gy clay at 1512.4. Below 1514.5: H, orange, f-m IV at base, w/ some B-G H & cumulates, grading to m-c IV above 1519.0, local MPs; 0.1'-0.3' thick beds alternate m IV & c IV above 1519.0; tr to some P as xtl drapes, xtl lngs, blebs, & subhoriz stgrs & sol lags; upper cont E/S w/ gy clay. ES ES ES	1535.5-1529.5
1519.6-1526.0: Above 1520.7: H, f-m IV, some pods; tr to some gy clay as dissem material, blebs, & irreg lam; tr dissem P near base; E/S w/ gy clay at 1520.3' & at top. Below 1520.7: H, m-c IV, local f IV, c IV occurs mainly as cmts, cmts inc upward, some primary (?) H near base, rare MPs filled w/ c-vc IV; divided into alternating zones of orange H (tr P) & clear to gy H (tr gy clay); Arg zones tend to have more cmts, clay is dissem & occurs as rare stgrs on E/S; P occurs as isolated xtl drapes & blebs; upper cont E/S w/ gy clay. ES ES ES ES	1544.5-1535.5
1526.0-1538.0: Above 1526.3: H, f-m IV; tr dark bwn clay as stgrs; upper cont E/S w/ dark bwn clay. 1526.3-1527.8: H, f-m IV in pods local MP w/ c IV; tr dissem P; upper cont E/S w/ no clay. 1527.8-1528.0: Arg H, f-m IV w/ local zones of f II-IIIb-c; gy clay stgrs; upper cont E/S w/ gy clay. 1528.0-1529.9: H, f-m IV in pods above 1528.7, m-c IV in lower part; small to large blebs & zones of bwn Mudst are V-O & large zones contain f-m I-IIIa-c; upper cont E/S w/ gy clay. 1529.9-1535.5: H, f-m IV in pods, m-c IV as cmts & in pits, pods & pits are abund , rare MPs; tr-mod'ly abund clay, mostly r-b, some gy, occurs as large V-O blebs & stgrs, large blebs & zones of clay contain f Ia-b & m-c II-IIIb-c; tr to some P as blebs, xtl lngs, & sol lags; some pits show vert trans'd bwn clay & P; upper cont E/S w/ bwn mud & large V-O blebs of mud containing f-m I-IIIb-c H. Below 1535.5: H, m-c IV w/ some f IV, rare MP; orange, clear in lower 0.3'; tr P blebs & xtl lngs; upper cont diffuse. ES ES ES ES	1552-1544.5
1538.0-1543.4: Above 1539.5: H, f IV in pods, m-c IV cmts, c-vc IV in MPs & pits, clear in upper 1.5', orange in lower part; tr P as irreg stgrs; upper cont E/S no clay. Below 1539.5: H, f-m IV at base grading up to m-c IV, c IV in pits & MP, orange; tr P xtl lings ES	1560-1552
	1568-1560

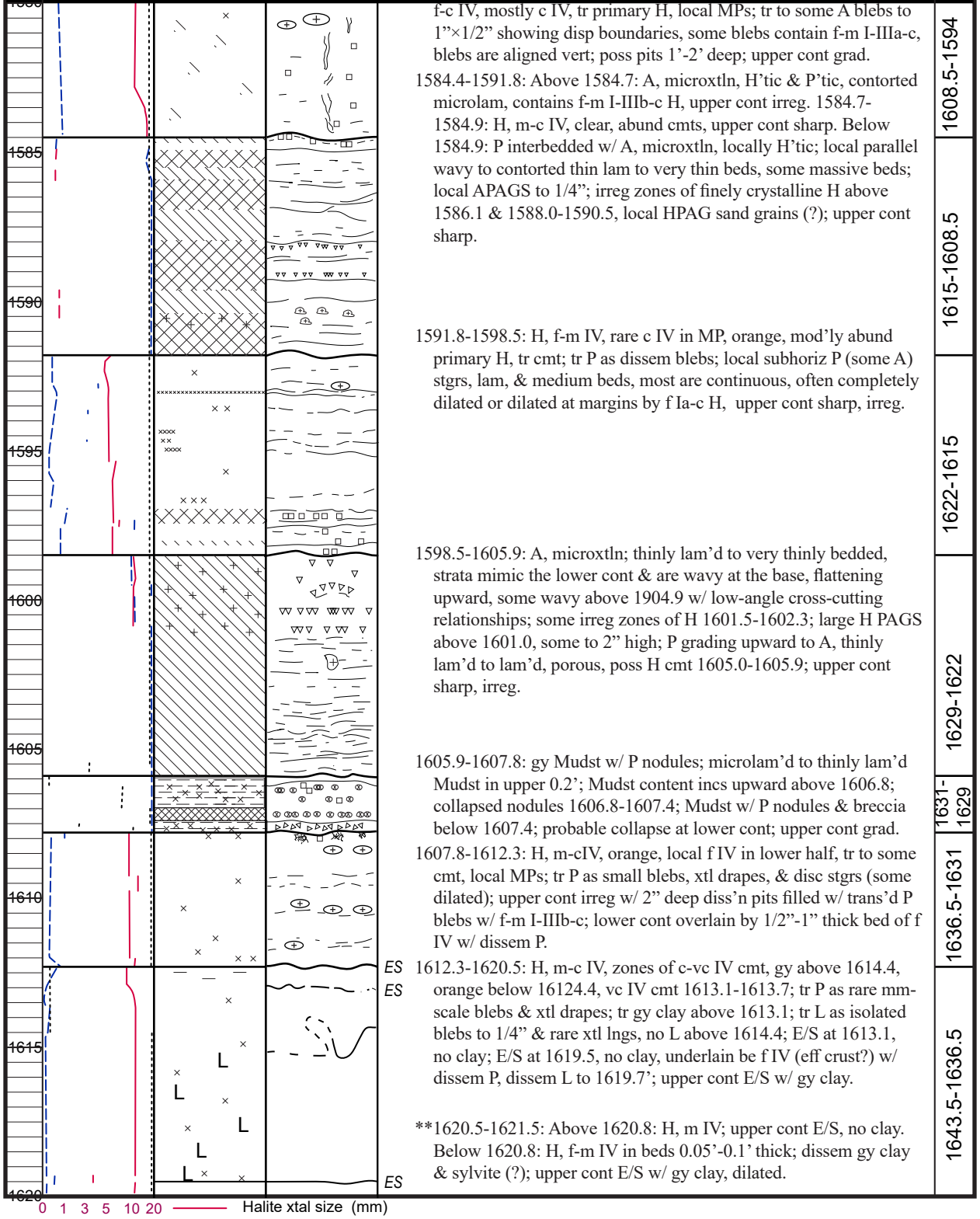
Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 41 of 60



Description	AIS depth
& small blebs; upper cont diffuse. 1543.4-1545.9: H, f-m IV, cmts are common, rare c IV cmts, local f IV eff crust (?); tr r-b & gy clay above 1545.0', mod amounts of r-b clay 1544.0'-1544.5', some f Ia H in clay stgrs & blebs; tr to some P xtl lngs & blebs; upper cont E/S w/ some bwn clay.	1568-1560
1545.9-1553.0: Above 1546.1: Arg H, gy to bwn clay w/ f I-IIIa-b. 1546.1-1547.0: H, m-c IV w/ blebs of r-b to gy mud, f IV pods w/ dissem clay & tr P. 1547.0-1549.0: H, f IV in pods w/ tr dissem P & bwn to gy clay; m-c IV cmts w/ r-b clay & P stgrs & blebs, cmts most abund below 1548.0. 1549.0-1553.0: H, f-m IV w/ c-vc IV as cmts & in MPs, some primary H near the base & middle, cmts mod'ly abund , orange w/ clear band 1549.9-1550.0; tr P as rare blebs & xtl lngs; tr at lower cont, dilated in pit; upper cont E/S w/ no clay.	1571-1568
1553.0-1563.9: Above 1553.5: H, m-c IV; mod'ly abund r-b Mudst, large blebs of Mudst show vert trans'n; upper cont E/S w/ r-b Mudst, Mudst w/in pit at upper cont is dilated. 1553.5-1554.6: H, f-m IV, some pods; some r-b clay blebs; tr P blebs; upper cont E/S w/ bwn clay. 1554.6-1559.2: H, f IV in pods w/ dissem P & r-b to gy clay; pods bounded by f-c IV cmts w/ local stgrs & sol lags of clay & P; m-c IV cmts in rare MPs; upper cont E/S w/ dilated r-b to gy clay & P sol lag. 1559.2-1560.5: H, m-c IV, tr f IV in local zones; tr to some r-b to gy clay as blebs, xtl drapes & disc stgrs; tr P xtl drapes, upper cont grad. 1560.5-1562.1: H, f-m IV w/ rare c IV cmts; tr r-b clay & P as xtl lngs; f IV eff crust (?) at top; upper cont E/S w/ r-b clay. 1561.7-1562.1: H, f IV as eff crust (?) or pods. Below 1562.1: H, f-m IV, some c IV cmt, local diss'n pipes; tr r-b to gy clay & P as stgrs & xtl drapes near the lower cont; upper cont grad.	1578-1571
1563.9-1570.5: Above 1564.3: H, f IV pods bounded by c-vc IV cmts & MP; tr dissem P; upper cont E/S w/ no clay. 1563.4-1567.5: H, m-c IV w/ vc IV in MPs & as abund cmts, vert-stacked, narrow diss'n pipes are abund ; disc subhoriz P sol lags, to 1/2" thick, are crosscut by vert-trans'd blebs of P 1/4"-1" wide forming a boxwork fabric; upper cont E/S w/ P sol lag & some gy clay. 1567.5-1570.5: H, f-m IV w/ some c IV cmts, orange, some primary H, mod'ly abund cmt, local pit near base filled w/ f IV eff crust (?) & P drapes; tr to some P as small to medium blebs, xtl drapes, & sol lags; some P is vert trans'd in pits; upper cont marked by a P sol lag.	1589-1578
1570.5-1584.4: Above 1571.3: H, f-m IV pods, local c-vc IV in MPs & cmts; tr P & clay; upper cont E/S w/ gy & bwn clay. 1571.3-1572.5: H, f-m IV, poss pods or eff crust, some pits w/ m IV; tr P stgrs & blebs; tr bwn to gy clay. 1572.5-1573.2: H'tic Mudst, bwn, w/ f-m I-IIIa-b H; pod of f IV. 1573.2-1573.5: H, f IV, poss eff crust at top; tr P & bwn clay; upper cont E/S w/ bwn clay. 1573.5-1580.0: H, m-c IV w/ abund cmts, vc IV becomes more abund upward, xtl size decreases above 1574.5, zone of f IV pods/eff crust cross-cut by pit at 1575.8; tr to some P & bwn to gy clay, xtl drapes & blebs, blebs show vert trans'n & disp boundaries; unit is cross-cut by a large diss'n pipe containing large (up to 1" diameter) P blebs, blebs are vert trans'd & contain m-c I-IIIa-c H, tr gy clay & P blebs occur above pipe; upper cont grad. Below 1580.0: H,	1594-1589
	1608.5-1594

0 1 3 5 10 20 Halite xtal size (mm)
0 1 5 10 50 100 Non-halite (% of total)
100% clay 100% sulfate Non-halite (rel prop. %)

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 42 of 60



Description

f-c IV, mostly c IV, tr primary H, local MPs; tr to some A blebs to 1"×1/2" showing disp boundaries, some blebs contain f-m I-IIIa-c, blebs are aligned vert; poss pits 1'-2' deep; upper cont grad.

1584.4-1591.8: Above 1584.7: A, microxtln, H'tic & P'tic, contorted microlam, contains f-m I-IIIb-c H, upper cont irreg. 1584.7-1584.9: H, m-c IV, clear, abund cmts, upper cont sharp. Below 1584.9: P interbedded w/ A, microxtln, locally H'tic; local parallel wavy to contorted thin lam to very thin beds, some massive beds; local APAGS to 1/4"; irreg zones of finely crystalline H above 1586.1 & 1588.0-1590.5, local HPAG sand grains (?); upper cont sharp.

1591.8-1598.5: H, f-m IV, rare c IV in MP, orange, mod'ly abund primary H, tr cmt; tr P as dissem blebs; local subhoriz P (some A) stgrs, lam, & medium beds, most are continuous, often completely dilated or dilated at margins by f Ia-c H, upper cont sharp, irreg.

1598.5-1605.9: A, microxtln; thinly lam'd to very thinly bedded, strata mimic the lower cont & are wavy at the base, flattening upward, some wavy above 1904.9 w/ low-angle cross-cutting relationships; some irreg zones of H 1601.5-1602.3; large H PAGS above 1601.0, some to 2" high; P grading upward to A, thinly lam'd to lam'd, porous, poss H cmt 1605.0-1605.9; upper cont sharp, irreg.

1605.9-1607.8: gy Mudst w/ P nodules; microlam'd to thinly lam'd Mudst in upper 0.2'; Mudst content incs upward above 1606.8; collapsed nodules 1606.8-1607.4; Mudst w/ P nodules & breccia below 1607.4; probable collapse at lower cont; upper cont grad.

1607.8-1612.3: H, m-cIV, orange, local f IV in lower half, tr to some cmt, local MPs; tr P as small blebs, xtl drapes, & disc stgrs (some dilated); upper cont irreg w/ 2" deep diss'n pits filled w/ trans'd P blebs w/ f-m I-IIIb-c; lower cont overlain by 1/2"-1" thick bed of f IV w/ dissem P.

1612.3-1620.5: H, m-c IV, zones of c-vc IV cmt, gy above 1614.4, orange below 16124.4, vc IV cmt 1613.1-1613.7; tr P as rare mm-scale blebs & xtl drapes; tr gy clay above 1613.1; tr L as isolated blebs to 1/4" & rare xtl lngs, no L above 1614.4; E/S at 1613.1, no clay; E/S at 1619.5, no clay, underlain be f IV (eff crust?) w/ dissem P, dissem L to 1619.7'; upper cont E/S w/ gy clay.

**1620.5-1621.5: Above 1620.8: H, m IV; upper cont E/S, no clay. Below 1620.8: H, f-m IV in beds 0.05'-0.1' thick; dissem gy clay & sylvite (?); upper cont E/S w/ gy clay, dilated.

AIS depth

1608.5-1594

1615-1608.5

1622-1615

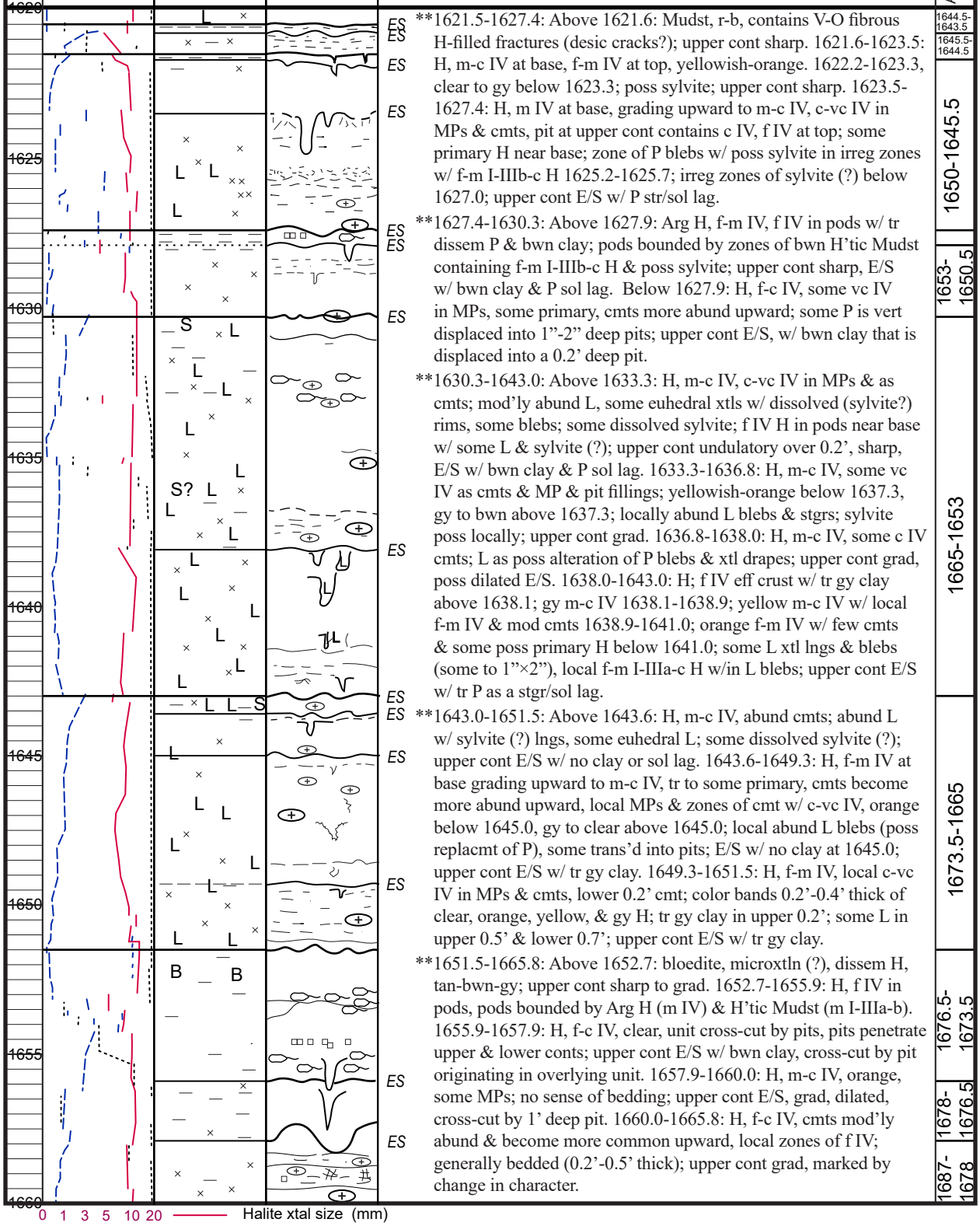
1629-1622

1631-1629

1636.5-1631

1643.5-1636.5

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 43 of 60



Description

**1621.5-1627.4: Above 1621.6: Mudst, r-b, contains V-O fibrous H-filled fractures (desic cracks?); upper cont sharp. 1621.6-1623.5: H, m-c IV at base, f-m IV at top, yellowish-orange. 1622.2-1623.3, clear to gy below 1623.3; poss sylvite; upper cont sharp. 1623.5-1627.4: H, m IV at base, grading upward to m-c IV, c-vc IV in MPs & cmts, pit at upper cont contains c IV, f IV at top; some primary H near base; zone of P blebs w/ poss sylvite in irreg zones w/ f-m I-IIIb-c H 1625.2-1625.7; irreg zones of sylvite (?) below 1627.0; upper cont E/S w/ P str/sol lag.

**1627.4-1630.3: Above 1627.9: Arg H, f-m IV, f IV in pods w/ tr dissem P & bwn clay; pods bounded by zones of bwn H'tic Mudst containing f-m I-IIIb-c H & poss sylvite; upper cont sharp, E/S w/ bwn clay & P sol lag. Below 1627.9: H, f-c IV, some vc IV in MPs, some primary, cmts more abund upward; some P is vert displaced into 1"-2" deep pits; upper cont E/S, w/ bwn clay that is displaced into a 0.2' deep pit.

**1630.3-1643.0: Above 1633.3: H, m-c IV, c-vc IV in MPs & as cmts; mod'ly abund L, some euhedral xtls w/ dissolved (sylvite?) rims, some blebs; some dissolved sylvite; f IV H in pods near base w/ some L & sylvite (?); upper cont undulatory over 0.2', sharp, E/S w/ bwn clay & P sol lag. 1633.3-1636.8: H, m-c IV, some vc IV as cmts & MP & pit fillings; yellowish-orange below 1637.3, gy to bwn above 1637.3; locally abund L blebs & stgrs; sylvite poss locally; upper cont grad. 1636.8-1638.0: H, m-c IV, some c IV cmts; L as poss alteration of P blebs & xtl drapes; upper cont grad, poss dilated E/S. 1638.0-1643.0: H; f IV eff crust w/ tr gy clay above 1638.1; gy m-c IV 1638.1-1638.9; yellow m-c IV w/ local f-m IV & mod cmts 1638.9-1641.0; orange f-m IV w/ few cmts & some poss primary H below 1641.0; some L xtl lngs & blebs (some to 1"×2"), local f-m I-IIIa-c H w/in L blebs; upper cont E/S w/ tr P as a stgr/sol lag.

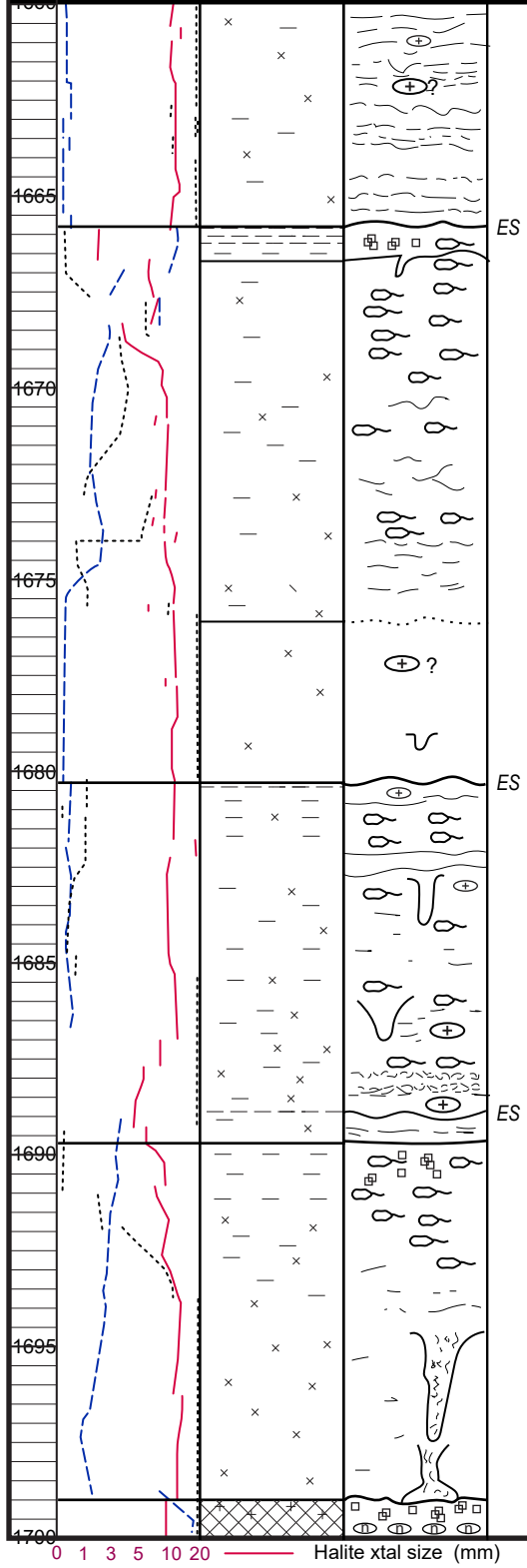
**1643.0-1651.5: Above 1643.6: H, m-c IV, abund cmts; abund L w/ sylvite (?) lngs, some euhedral L; some dissolved sylvite (?); upper cont E/S w/ no clay or sol lag. 1643.6-1649.3: H, f-m IV at base grading upward to m-c IV, tr to some primary, cmts become more abund upward, local MPs & zones of cmt w/ c-vc IV, orange below 1645.0, gy to clear above 1645.0; local abund L blebs (poss replacmt of P), some trans'd into pits; E/S w/ no clay at 1645.0; upper cont E/S w/ tr gy clay. 1649.3-1651.5: H, f-m IV, local c-vc IV in MPs & cmts, lower 0.2' cmt; color bands 0.2'-0.4' thick of clear, orange, yellow, & gy H; tr gy clay in upper 0.2'; some L in upper 0.5' & lower 0.7'; upper cont E/S w/ tr gy clay.

**1651.5-1665.8: Above 1652.7: bloedite, microxtln (?), dissem H, tan-bwn-gy; upper cont sharp to grad. 1652.7-1655.9: H, f IV in pods, pods bounded by Arg H (m IV) & H'tic Mudst (m I-IIIa-b). 1655.9-1657.9: H, f-c IV, clear, unit cross-cut by pits, pits penetrate upper & lower conts; upper cont E/S w/ bwn clay, cross-cut by pit originating in overlying unit. 1657.9-1660.0: H, m-c IV, orange, some MPs; no sense of bedding; upper cont E/S, grad, dilated, cross-cut by 1' deep pit. 1660.0-1665.8: H, f-c IV, cmts mod'ly abund & become more common upward, local zones of f IV; generally bedded (0.2'-0.5' thick); upper cont grad, marked by change in character.

AIS depth

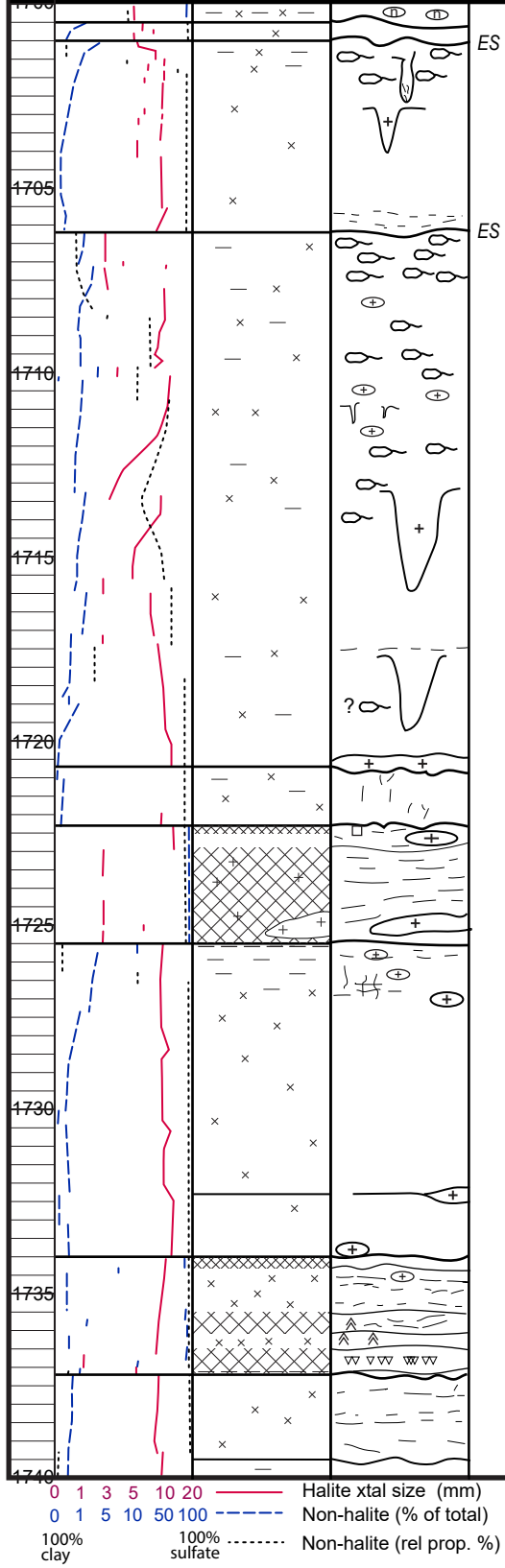
1644.5-1643.5	
1645.5-1644.5	
1650-1645.5	
1653-1650.5	
1665-1653	
1673.5-1665	
1676.5-1673.5	
1678-1676.5	
1687-1678	

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 44 of 60



Description	AIS depth
1665.8-1680.3: Above 1666.7: Mudst, r-b; no visible stratification; upper 0.3' cmted w/ H, no visible xtls; lower part contains Arg H (f IV in pods?) & zones w/ rare f-m I-IIIa H; upper cont E/S w/ tr P & gy clay as a sol lag. 1666.7-1676.2: zones of podular H (f IV w/ dissem bwn to gy clay & P) alternate w/ zones of H (m-c IV) & H cmt (vc IV); tr to some bwn Mudst as blebs, disc stgrs, & thin lam that show disp margins w/ H; tr gy clay & P as stgrs & small blebs; podular fabrics absent below ~1674; upper cont E/S w/ sol pit & abund trans'd bwn Mudst. Below 1676.2: H, m-c IV, local f IV (eff crust) in 0.1'-0.2' thick beds in the lower 0.5', abund cmt, tr primary H near base, mostly clear; tr P as stgrs, blebs, & dissem material in f IV H; upper cont grad, dilated.	1687-1678 1697-1687
1680.3-1689.7: Above 1888.0: H, f IV in rare to common pods w/ stgrs & blebs of P & gy to r-b clay; pods are bounded by pits, zones of cmt, & poss deep pipes containing m-c IV H; blebs & stgrs of clay & P occur in zones of H cmt, some show poss vert displacement; vc H w/ xtls 2-3" across occurs 1682.1-1682.5; upper cont E/S w/ r-b to gy clay. Below 1688: H, 0.1'-0.2' thick beds of m-c IV overlain by f IV; tr bwn to gy clay stgrs & xtl drapes; some MPs w/ m-c IV; tr to some P blebs & dilated sol lags; upper cont grad.	1701-1697 1710.5-1701
1689.7-1699.0: Above 1693.0: H, f-m IV in pods; pods contain dissem r-b clay & P & stgrs & blebs; pods are bounded by H'tic Mudst w/ m-c I-IIIa-c H above 1691.0; pods are bounded by clear m-c IV cmts (tr primary H) w/ irreg blebs of P & clay (r-b to gy) below 1691.0; upper cont sharp. Below 1693.0: H, m-vc IV, mostly cmt, local horiz zones of f IV near base; tr P blebs in matrix; P blebs more abund in pits, show vert trans'n; large pit widens into a MP at the base; upper cont grad. **1699.0-1700.5 Above 1699.5: P, microxtln, some nodular fabrics; dilated by f-c I-IIIb-c; upper cont irreg. 1699.5-1700.0: P, microxtln, nodular; locally H'tic; upper cont irreg. Below 1700.0: nodular P w/ gy clay, Arg nodular P bounded by irreg zones of P nodules; upper cont irreg; lower cont a sol surface w/ ~0.2' relief.	1719.5-1710.5 1720.5-1719.5

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 45 of 60



1700.5-1701.0: H, f-m IV, xtl size decreases upward, orange; tr P blebs & stgrs; upper cont sol surface w/ collapse of overlying unit.

1701.0-1706.2: Above 1702.0: H, f IV in pods; tr dissem P & r-b clay; unit cross-cut by pits filled w/ m-c IV H; upper cont E/S w/ bwn clay. Below 1702.0: H, f-c IV, vc IV locally, local pits; 0.1' thick beds in lower 0.3'; tr dissem P blebs; upper cont grad.

1706.2-1720.9: Three types of H: 1) f IV in pods w/ bwn clay & P as dissem material & local stgrs. 2) m-c IV, clear; blebs of clay & P, some showing vert trans'n over short distances, local P sol lags, some irreg P & clay stgrs. 3) c-vc IV in pits, pipes, & MPs; tr bwn clay & P blebs. Large MP at the base. Upper cont E/S w/ bwn clay.

1720.9-1722.3: H, c-vc IV, mostly cmts & MPs; tr to some (at base) P blebs, stgrs, & xtl lngs in vc IV; tr gy clay blebs & stgrs above 1721.5; upper cont overlain by large MP.

**1722.3-1725.5: Above 1722.5: irreg P bed, microxtln, w/ c IIIc H. From 1722.5-1722.8: H, m-c IV, w/ P stgrs, MP filled w/ vc IV H. Below 1722.8: P, microxtln, H'tic, some microxtln H appears disp; strata appear to follow the upper surface of an irreg zone of m-vc IV H; ~1" gy clay at base; upper cont grad/partially dilated.

**1725.5-1734.0: Above 1726.0: H, f-c IV, f at base, c at top; dissem gy clay stgrs, blebs, & material infiltrated downward from upper cont; upper cont sol boundary, marked by gy clay. Below 1726.0: H, f-m IV, m-c IV locally, local MPs, orange, xtl size incs upward, beds 0.1'-0.2' thick below 1728.4; some vert-trans'd P blebs form a boxwork fabric locally; upper cont grad.

**1734.0-1737.2: Above 1734.2: P, H'tic, irreg upper cont. 1734.2-1735.5: H, f-m IV, c IV at the top, orange, local MP, poss B-G H; upper cont sharp, undulatory. 1735.5-1736.2: H'tic P, microxtln, lam to thin beds; local beds of B-G H w/ P xtl drapes; upper cont sharp, slightly undulatory. 1736.2-1736.5: H, f-m IV, orange; upper cont sharp, irreg. Below 1736.5: P, microxtln; hints of subhoriz strata; local P PAGS to 1/8" high near top; poss H PAGS to 1" high at 1737.0; lower cont sol surface, marked by gy clay.

**1737.2-1741.7: Above 1739.5: H, f-m IV, in beds 0.1'-0.5' thick, orange; local P sol lag; upper cont sharp, marked by P blebs & infiltrated gy clay. 1739.5-1740.1: H, m-c IV, eq, gy; tr gy clay; upper cont sharp, E/S w/ no clay. Below: 1740.1: H, f-m IV, some c-vc IV, orange, some cmt; upper cont sharp.

AIS depth

1722-1720.5

1727.5-1722

1740-1727.5

1745.5-1740

1748-1745.5

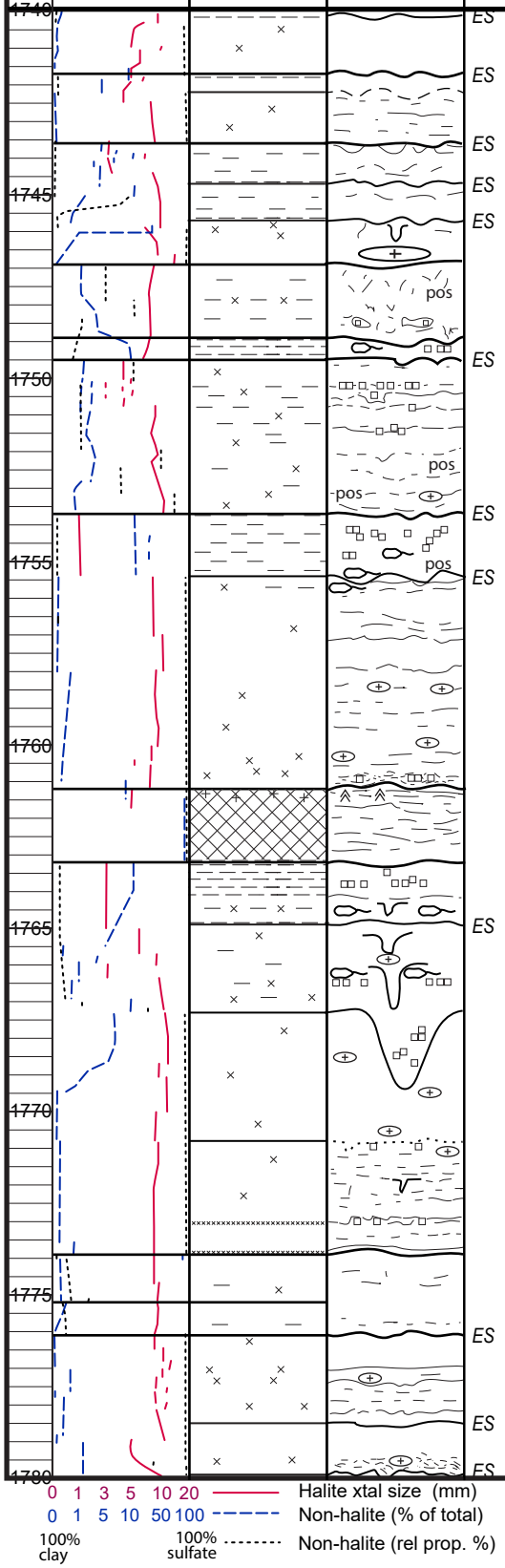
1754-1748

1756-1754

1759.5-1756

1770-1759.5

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 46 of 60



Description

**1741.7-1743.6: Above 1742.2: H, f IV, gy, possibly hygroscopically altered; dissem gy clay; upper cont E/S w/ gy clay & sol pits filled w/ gy clay. Below 1742.2: H, f-m IV; orange except near top; beds 0.1-0.2' thick; grad upper cont, no clay.

**1743.6-1746.9: Above 1744.9: H, m-c IV at base, f IV at top, hygroscopically altered; upper cont E/S w/ gy clay stgrs. 1744.9-1745.7: H, f IV at top, c IV at base; upper cont E/S w/ bwn/black clay. Below 1745.7: H, m-c IV, f IV at top, vc IV in MP, abund cmts, orange to clear; upper cont E/S w/ gy clay.

1746.9-1748.9: H, m-c IV, abund cmts; dissem gy & bwn clay as blebs & stgrs; bwn clay as pipe fillings & large blebs w/ f-m I-IIIa-b; local P blebs & POS; stgrs; upper cont sharp, irreg.

**1748.9-1753.7: Above 1749.5: H'tic Mudst, f-m I-IIIab, local pod of f IV; upper cont undulatory. 1749.5-1751.6: H, f-m IV, beds 0.1'-0.2' thick; beds locally separated by irreg lam to very thin beds of r-b Mudst; upper cont E/S w/ bwn Mudst. Below 1751.6: H, f-c IV, average xtl size decreases upward, abund cmts, local MPs; dissem P in zones of f IV; local bwn clay blebs & stgrs, some vert trans'n; upper cont marked by bwn clay separation.

**1753.7-1761.2: Above 1755.4: H, f IV in pods, abund dissem r-b clay; pods bounded by bwn H'tic Mudst w/ f I-IIIa-c; upper cont E/S w/ bwn clay. 1755.4-1757.1: H, f-m IV, orange, rare c IV cmts, weak beds 0.1'-0.3' thick; upper cont E/S, undulatory over 0.1'. 1757.1-1754.9: H, c-vc IV, clear, poss large pit/MP filling. Below 1754.9: H, f-m IV, orange, some c IV cmt, grades to m-c IV at top where cmts are more abund , local MPs, beds 0.1'-0.2' thick; abund P blebs near base w/ f I-II a-b H.

**1761.2-1763.2: P, microxtln; B-G H separated by thin lam to lam of P in upper 0.3', H shows P xtl drapes & lngs; rest of unit is lam'd to m bedded, strata are wavy to locally contorted, some poss nodules, some strata separated by gy clay; 1/2" gy clay at base.

**1763.2-1773.9: Above 1764.2: Arg H & H'tic Mudst, r-b; dilated thin beds of f-m IIIc H bounded by H'tic Mudst; upper cont sharp, marked by gy clay. 1764.2-1764.9: H, f-m IV in pods; local sol pits; upper cont irreg. 1764.9-1765.9: H m-c IV at base, f IV in upper 0.3', local pits & MPs; upper cont E/S w/ bwn clay. 1765.9-1766.4: H, f-m IV in pods w/ dissem bwn clay (some) & P (tr); pods bounded by pit containing clear m-vc IV H; upper cont E/S w/ no clay. 1766.4-1767.3: H, m-c IV w/ vc IV cmts in MPs & pits. 1767.3-1770.8: H, f-c IV, vc IV in MP, abund cmts, orange; upper cont sol pipe 2.1' deep. Below 1770.8: H, f-m IV, some c-vc IV in cmts & MPs, orange, in beds 0.1'-0.3' thick; irreg bed of P w/ f-m I-IIIa-c H occurs 1773.1-1773.2; a 0.1' thick P bed at lower cont, overlies a gy clay lam; upper cont grad, marked by dilated sol lag.

1773.9-1775.2: H, f-m IV at top, m-c IV at base, orange; tr P stgrs & xtl lngs; tr gy clay; upper cont sharp, sol surface.

1775.2-1776.1: H, f-m IV at base, m-c IV at top, abund cmts; tr gy clay blebs & stgrs; upper cont missing.

**1776.1-1782.9: Above 1778.5: H, f-m IV w/ clear c IV cmts 1776.5-1777.0; local irreg, blebby thin lam of P; f IV in upper 0.2', w/ dissem P; upper cont E/S, w/ ~1" relief, no clay. 1778.5-1779.9: H, f-m IV; clear, c IV cmts occur 1778.6-1779.0; orange below

AIS depth

1770-1759.5
1772-1770
1775-1772
1777-1775
1783-1777
1784.5-1783
1790-1784.5
1793-1790
1795-1793
1799-1795
1806-1799

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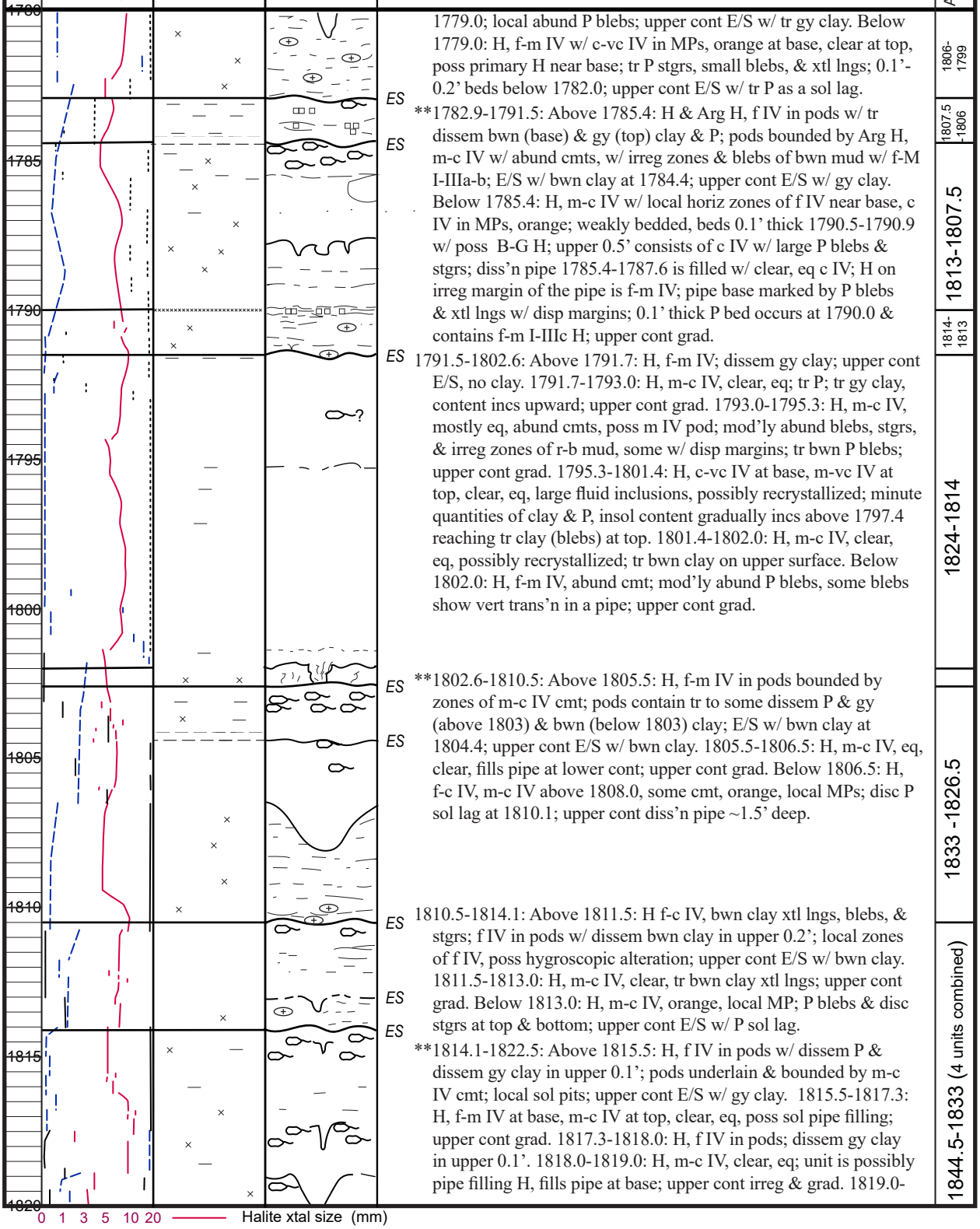

Description

1779.0; local abund P blebs; upper cont E/S w/ tr gy clay. Below 1779.0: H, f-m IV w/ c-vc IV in MPs, orange at base, clear at top, poss primary H near base; tr P stgrs, small blebs, & xtl lngs; 0.1'-0.2' beds below 1782.0; upper cont E/S w/ tr P as a sol lag.

**1782.9-1791.5: Above 1785.4: H & Arg H, f IV in pods w/ tr dissem bwn (base) & gy (top) clay & P; pods bounded by Arg H, m-c IV w/ abund cmts, w/ irreg zones & blebs of bwn mud w/ f-M I-IIIa-b; E/S w/ bwn clay at 1784.4; upper cont E/S w/ gy clay. Below 1785.4: H, m-c IV w/ local horiz zones of f IV near base, c IV in MPs, orange; weakly bedded, beds 0.1' thick 1790.5-1790.9 w/ poss B-G H; upper 0.5' consists of c IV w/ large P blebs & stgrs; diss'n pipe 1785.4-1787.6 is filled w/ clear, eq c IV; H on irreg margin of the pipe is f-m IV; pipe base marked by P blebs & xtl lngs w/ disp margins; 0.1' thick P bed occurs at 1790.0 & contains f-m I-IIIc H; upper cont grad.

1791.5-1802.6: Above 1791.7: H, f-m IV; dissem gy clay; upper cont E/S, no clay. 1791.7-1793.0: H, m-c IV, clear, eq; tr P; tr gy clay, content incs upward; upper cont grad. 1793.0-1795.3: H, m-c IV, mostly eq, abund cmts, poss m IV pod; mod'ly abund blebs, stgrs, & irreg zones of r-b mud, some w/ disp margins; tr bwn P blebs; upper cont grad. 1795.3-1801.4: H, c-vc IV at base, m-vc IV at top, clear, eq, large fluid inclusions, possibly recrystallized; minute quantities of clay & P, insol content gradually incs above 1797.4 reaching tr clay (blebs) at top. 1801.4-1802.0: H, m-c IV, clear, eq, possibly recrystallized; tr bwn clay on upper surface. Below 1802.0: H, f-m IV, abund cmt; mod'ly abund P blebs, some blebs show vert trans'n in a pipe; upper cont grad.

**1802.6-1810.5: Above 1805.5: H, f-m IV in pods bounded by zones of m-c IV cmt; pods contain tr to some dissem P & gy (above 1803) & bwn (below 1803) clay; E/S w/ bwn clay at 1804.4; upper cont E/S w/ bwn clay. 1805.5-1806.5: H, m-c IV, eq, clear, fills pipe at lower cont; upper cont grad. Below 1806.5: H, f-c IV, m-c IV above 1808.0, some cmt, orange, local MPs; disc P sol lag at 1810.1; upper cont diss'n pipe ~1.5' deep.

1810.5-1814.1: Above 1811.5: H f-c IV, bwn clay xtl lngs, blebs, & stgrs; f IV in pods w/ dissem bwn clay in upper 0.2'; local zones of f IV, poss hygroscopic alteration; upper cont E/S w/ bwn clay. 1811.5-1813.0: H, m-c IV, clear, tr bwn clay xtl lngs; upper cont grad. Below 1813.0: H, m-c IV, orange, local MP; P blebs & disc stgrs at top & bottom; upper cont E/S w/ P sol lag.

**1814.1-1822.5: Above 1815.5: H, f IV in pods w/ dissem P & dissem gy clay in upper 0.1'; pods underlain & bounded by m-c IV cmt; local sol pits; upper cont E/S w/ gy clay. 1815.5-1817.3: H, f-m IV at base, m-c IV at top, clear, eq, poss sol pipe filling; upper cont grad. 1817.3-1818.0: H, f IV in pods; dissem gy clay in upper 0.1'. 1818.0-1819.0: H, m-c IV, clear, eq; unit is possibly pipe filling H, fills pipe at base; upper cont irreg & grad. 1819.0-

AIS depth

1806-1799

1807.5-1806

1813-1807.5

1814-1813

1824-1814

1833 -1826.5

1844.5-1833 (4 units combined)

0 1 3 5 10 20 Halite xtl size (mm)
0 1 5 10 50 100 Non-halite (% of total)
100% clay 100% sulfate Non-halite (rel prop. %)

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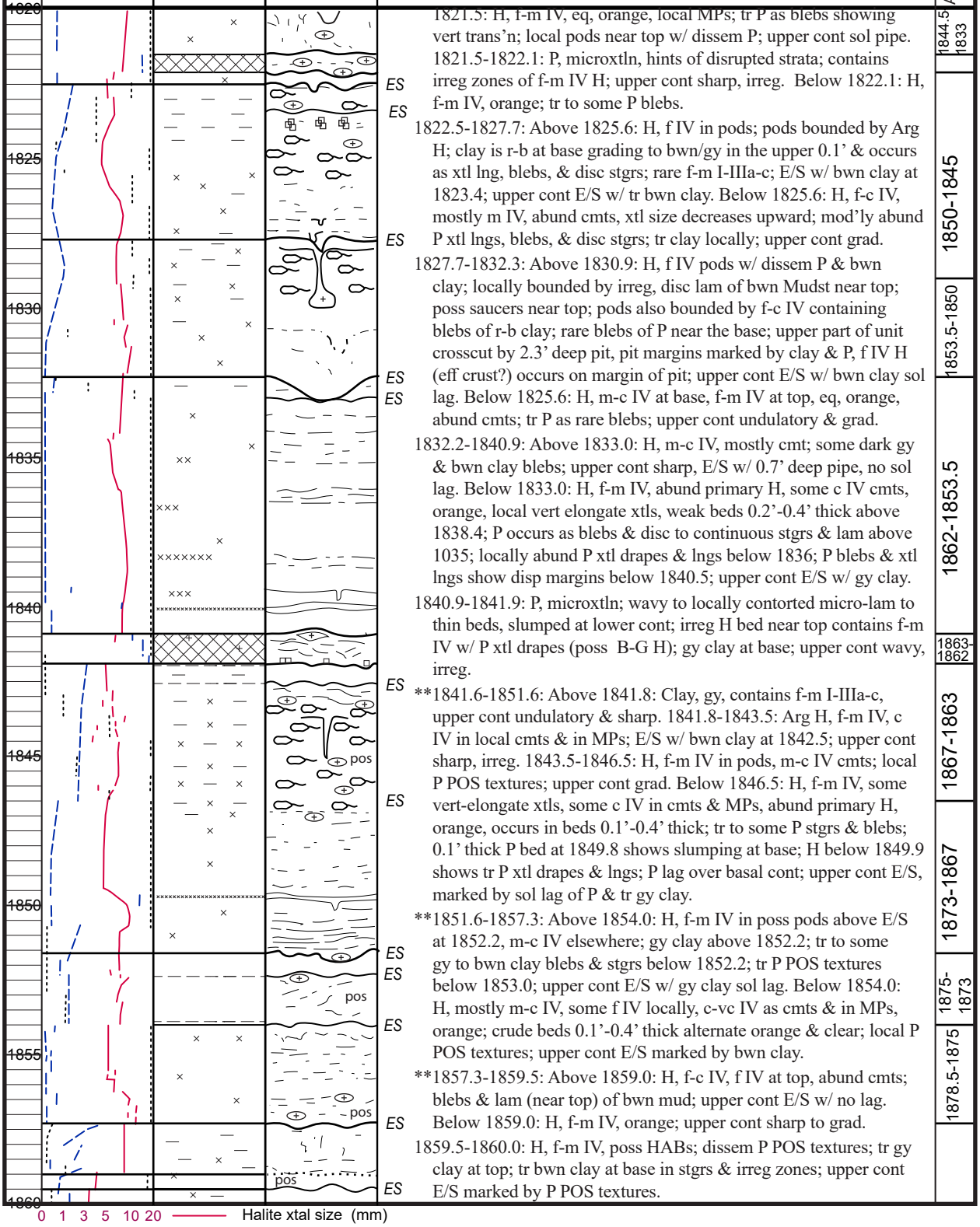
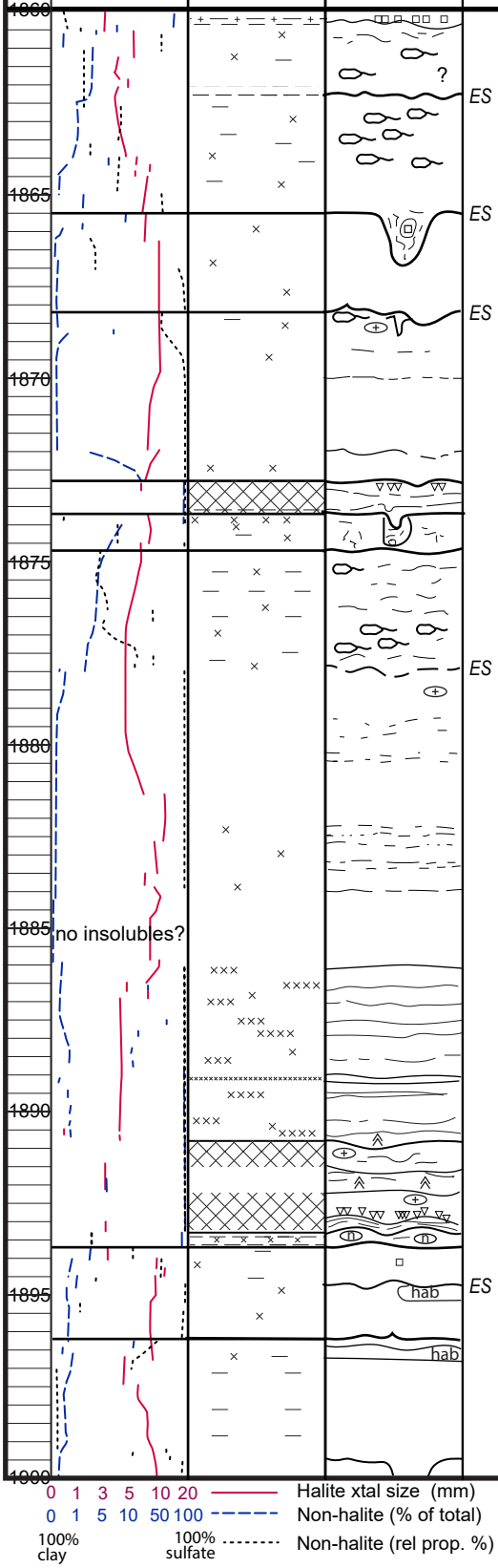


Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 49 of 60



Description

1860.0-1868.2: Above 1865.5: H, local pods of f-m IV w/ dissem P & r-b clay; some horiz to subhoriz zones of f IV may be large pods or HABs; pods are bounded by f-m IV w/ abund cmts, tr bwn clay & P xtl lngs; upper 0.1' consists of bwn H'tic Mudst w/ f-m I-IIb-c; E/S w/ r-b clay occurs at 1862.3; P blebs become abund toward the base & in the sol pipe at the lower cont; upper cont E/S w/ bwn clay. Diss'n pipe originating at 1865.5 contains: H, c-vc IV at base, m-c IV at top; trans'd r-b (top) to gy (bottom) clay; irreg masses of P; large (2"×2") irreg zone of r-b mud containing f-m Ia-b H. Below 1865.5: H, m-c IV, some primary H, abund cmts; tr P blebs, some w/ vert orientation; upper cont marked by sol pit.

1868.2-1872.8: Above 1870.0: H; f IV in pod near upper cont w/ some r-b clay & small diss'n pits; remainder consists of f-m IV w/ c IV cmts, gy to bwn above 1869.0, orange below 1869.0, tr P blebs; upper cont E/S w/ r-b clay & P sol lag. 1870.0-1872.0: H, f-vc IV, eq; rare P blebs; upper cont grad to diffuse. Below 1872.0: H, f-m IV, some vert-elongate xtls, some c IV cmts; abund P xtl drapes, xtl lngs, & stgrs; upper cont sharp to grad.

1872.8-1873.7: P, microxtln; hints of slumped strata at the base; local zones w/ PPAG growing into H-filled voids; H PAGS to 1/8" high near top; lower cont shows slumping/collapse w/ gy clay & nodular P; upper cont sharp, slightly irreg.

1873.7-1874.7: H, m IV, some f IV, orange; some P xtl lngs & blebs near base, content decreases upward; gy H w/ gy clay in pit originating at upper cont; upper cont diss'n surface w/ ~0.3' relief.

1874.7-1893.7: Above 1877.9: H, f-m IV in pods bounded by f-m IV cmts; tr to some P as dissem material & blebs; tr to some gy clay as disc stgrs & lam; upper cont irreg w/ ~1" relief. 1877.9-1882.2: H, f-m IV, some c IV cmts, hints of beds 0.2'-0.3' thick; tr P as dissem blebs; upper cont E/S, no clay, dilated. 1882.2-1884.0: H, f-m IV, some c-vc IV cmt, clear w/ orange interbeds 0.1'-0.2' thick; P as dissem xtl lngs; upper cont grad. 1884.0-1886.1: H, f-m IV, some B-G H, some primary H, orange; tr dissem P xtl lngs; some P xtl drapes near base, concentration decreases upward; beds 0.2'-0.5' thick separated by wavy & slightly slumped lam to very thin beds of P; P bed w/ irreg zones of H 1889.0-1889.2; upper cont sharp, marked by irreg & disc P lam. 1890.8-1891.6: P, microxtln, H'tic; contains irreg stgrs & zones of A; poss HPAG sand; upper cont sharp, slightly undulatory. 1891.6-1892.2: H, f-m IV, orange, P'tic; tr to some P xtl drapes & lngs; upper cont irreg, possibly dilated. 1892.2-1893.3: P, microxtln; thinly lam'd w/ gy clay in lower part w/ P PAGS 2 mm-1.5 cm high; hints of disrupted strata in upper part; upper cont sharp, slightly irreg. Below 1893.3: clay, dark gy, w/ P nodules 1 mm to 5 mm in diameter; upper cont grad.

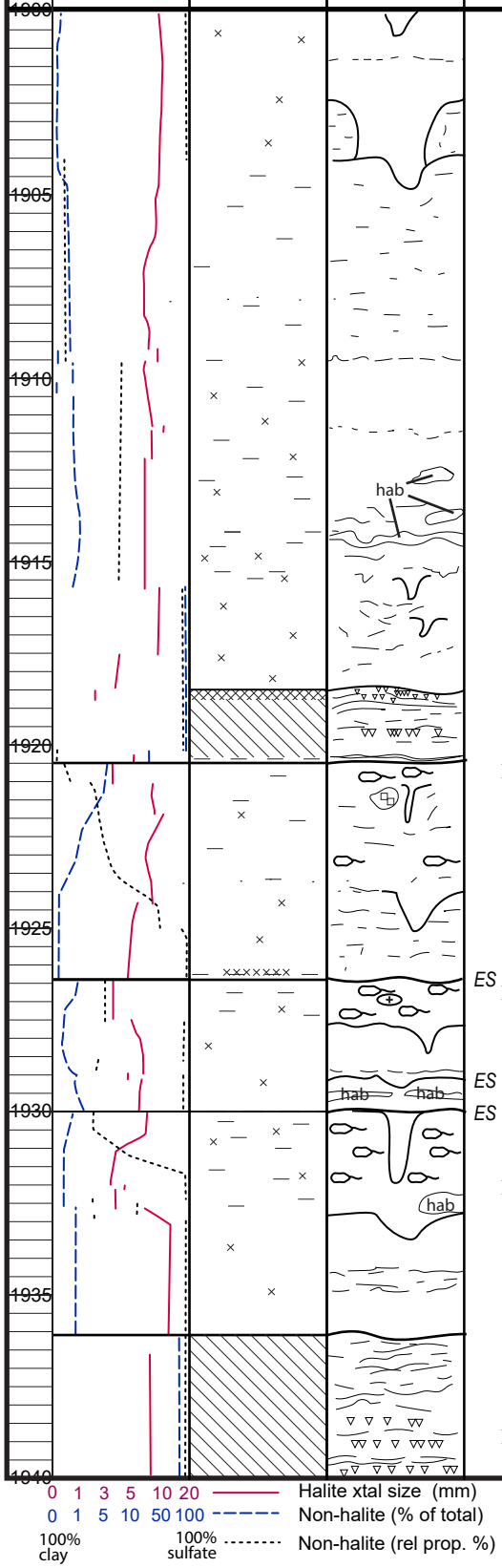
1893.7-1896.2: H, f-m IV; alternating gy & orange, gy zones have gy clay stgrs & blebs, orange zones have tr P blebs; clear m-c IV in lower 0.3'; P accumulation at E/S at 1894.7, E/S underlain by disc bed of f IV (HAB); upper cont sharp, irreg, diss'n surface.

1896.2-1920.5: Above 1899.5: H, f-m IV at base, f IV at above 1897.7, local HAB near top, gy; tr dark gy clay blebs & local disc & irreg stgrs; tr dissem P in upper 0.5'; upper cont E/S w/ some gy & bwn clay. 1899.5-1901.3: H, f-c IV, abund cmt, P'tic, orange; tr P; upper cont E/S w/ diss'n pit, no sol lag. 1901.3-1904.0: H, f-c

AIS depth

1887-1878.5
1889.5-1887
1894-1889.5
1895-1894
1896.5-1895
1908-1898.5
1913-1908
1914.5-1913
1918-1915
1922-1918

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 50 of 60



Description

IV, clear, abund cmt, fills pit below 1902.5; pit cross-cuts P'tic H, f-m IV, orange w/ tr P blebs; upper cont grad, dilated (?). 1904.0-1909.5: H, m-vc IV above 1906.5, f-m IV 1906.5-1909.2, c IV below 1909.2, mostly eq, abund cmts; tr to some gy clay as blebs & disc & irreg stgrs; upper cont marked by diss'n pipe. 1909.5-1918.5: H, m-c IV, some vc IV cmts, local zones of f IV as HABs beneath local E/S, local diss'n pits, orange from 1915.5-1918.5, alternating zones of gy (tr gy clay) & orange above 1915.5, no apparent primary H; mod'ly abund , irreg & disc P stgrs & lam, many showing vert displacement; tr to some thick P xtl lngs; P content decreases upward; unit show apparent slumping of insol materials; upper cont undulatory, grad, no sol lag, poss E/S. Below 1918.5: A, microxtln, gy; upper 0.1' consists of P; H PAGS to 1" tall in upper part; microlam'd to thinly lam'd, wavy, some low angle cross-cutting relationships, 0.1' gy clay at base; upper cont sharp, undulatory, mod'ly irreg.

1920.5-1926.4: Above 1924.0: H, f IV in local pods, pods bounded by gy m-c IV w/ some vc IV cmt, pit at lower cont filled w/ clear m-c IV; tr to some gy clay as stgrs & dissem material; local blebs of gy clay w/ f I-IIIa-b H; tr P blebs; tr P as lag along the lower diss'n pipe boundary; upper cont sharp, diss'n surface. Below 1924.0: H, f-m IV, rare c IV cmt, some primary H, orange, hints of beds 0.2'-0.4' thick; tr P as blebs & intercrystalline material; upper cont marked by diss'n pipe.

1926.4-1930.0: Above 1927.4: H, f IV in pods bounded by f-m IV cmt, local c IV in MPs & diss'n pits; tr gy clay; tr dissem P & gy clay in pods; upper cont irreg E/S w/ gy clay, overlain by deformed P lam (sol lag?). Below 1927.8: H, f-m IV, abund cmts, orange; tr P blebs; tr gy clay near middle of unit; undulatory E/S at 1928.9 is dilated & marked by gy clay; poss disc HABs in lower 1'; upper cont E/S no clay, marked by diss'n pipe.

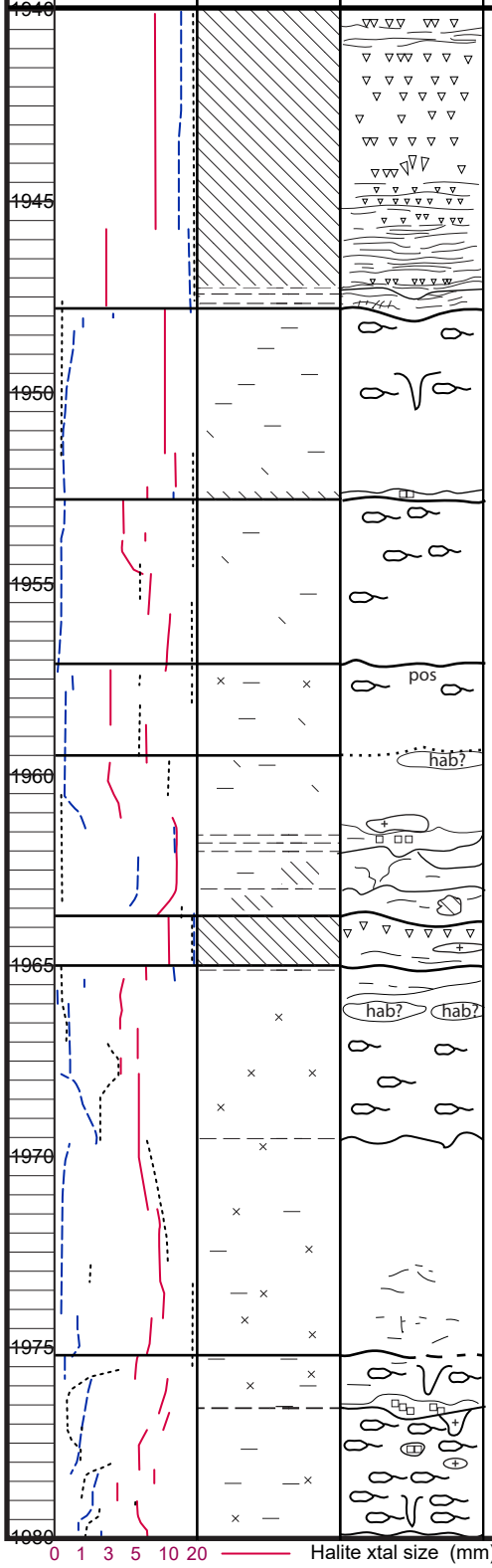
1930.0-1936.1: Above 1932.8: H, f IV in pods & poss HABs (above 1932.8), pods bounded by clear m-c IV as cmt & diss'n pipe filling; pods contain tr dissem gy clay & P; local P blebs, local gy clay stgrs & blebs; pipes & cmts contain rare gy clay & P blebs; upper cont E/S w/ gy clay, E/S cross-cuts pit in upper part of unit. Below 1932.8: H, c-vc IV in lower part w/ abund cmts, m-c IV above 1933.5 (may fine upward), hints of beds near middle part of unit 0.1'-0.2' thick; tr P as blebs, some w/ disp margins; upper cont marked by diss'n pipe.

1936.1-1947.8: Above 1946.9: A, microxtln, gy; strata in zones bounding H PAGS, thin lam to lam flat to wavy, locally contorted

AIS depth

1925-1922
1933-1925
1939-1933
1942-1939
1944-1942
1947.5-1944
1950-1947.5
1952.5-1950
1956-1952.5
1968-1956

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 51 of 60



Description

& disrupted, some cross-cutting relationships; H PAGS range from 1/4"- 4" tall, local H PAGS mounds; upper cont sharp. 1946.9-1947.3: A, microxtln, gy; microlam'd at base grading to thin lam at top, strata parallel & follow lower cont. Below 1947.3: gy clay, hints of microlam parallel undulatory lower cont, contains subhoriz fibrous H-filled fracture to 1/2" thick.

**1947.8-1952.6: Above 1950.5: H, m-c IV w/ some pods of f IV, abund cmt, gy; upper cont sharp, irreg, diss'n surface. Below 1950.5: H, m-c IV, eq, abund cmt, gy; tr A xtl lngs; tr gy clay at top.

1952.6-1952.8: A, microxtln, gy; microlam'd to thinly lam'd, wavy to contorted, mimic lower boundary; unit contains relict zones of H; upper cont sharp, irreg.

1952.8-1957.1: Above 1955.5: H, f IV in upper ~1.5', some f IV in pods, some m-c IV in zones bounding pods & as cmts; tr dissem A & gy clay; upper cont sharp, irreg. 1955.5-1957.1: H, m-c IV at base, f-m IV at top, clear, abund cmt; tr A; upper cont grad.

ES 1957.1-1959.5: Above 1958.0: H, f IV, in pods or HABs; tr to some dissem P & P POS textures; tr dissem gy clay; upper cont grad, possibly dilated. Below 1958.0: H, f-m IV, gy; tr A xtl lngs & dissem gy clay; upper cont diffuse.

**1959.5-1963.7: Above 1961.5: H, f-m IV at base, f IV at top; upper cont grad. 1961.5-1962.0: clay, gy; contains m-c I-IIa-b H, poss cave filling; unit thins dramatically across diameter of core; upper cont sharp, irreg. Below 1962.0: H, c-vc IV; eq, gy, large MP filled w/ clear H near top; disc A lam show vert trans'n; irreg mass of A near base shows vert trans'n; upper cont sharp, irreg.

1963.7-1965.0: A, microxtln; microlam'd to thinly lam'd, strata are wavy to contorted; local irreg zones of H; H PAGS to 2" high; gy clay at lower cont; upper cont sharp, slightly irreg & undulatory.

**1965.0-1975.2: Above 1971.2: H, f IV in pods & HABs, pods & HABs are bounded by f-m IV; E/S (?) w/ gy clay at 1964.4; upper cont sharp, diss'n surface marked by gy clay. 1971.2-1974.0: H, f-c IV, mostly m IV, eq, bwn to gy; tr P blebs; upper cont grad. Below 1974.0: H, f-c IV, abund cmts, orange, bwn in upper 0.2'; P blebs concentrated in upper 0.3'; upper cont grad.

1975.2-1984.5: Above 1981.9: H; abund f IV pods; m-vc IV in MPs, diss'n pipes, & zones of cmt; pods contain irreg stgrs & blebs of P & bwn clay; zones of cmt contain abund blebs & stgrs of r-b clay at top; tr bwn clay & P at base; E/S at 1976.6 marked by bwn clay containing f-m I-IIIa H, clay shows disp "a" boundaries w/ IV H; E/S w/ bwn clay at 1979.9; upper cont grad, dilated E/S. Below 1981.9: H, f-m IV, beds ~0.3' thick, MP at base; orange;

Lithofacies | Cycle Limit | AIS depth

1968-1956
1973-1968
1984-1973
1985-1984
1990-1985
1995.5-1990
2004-1995.5

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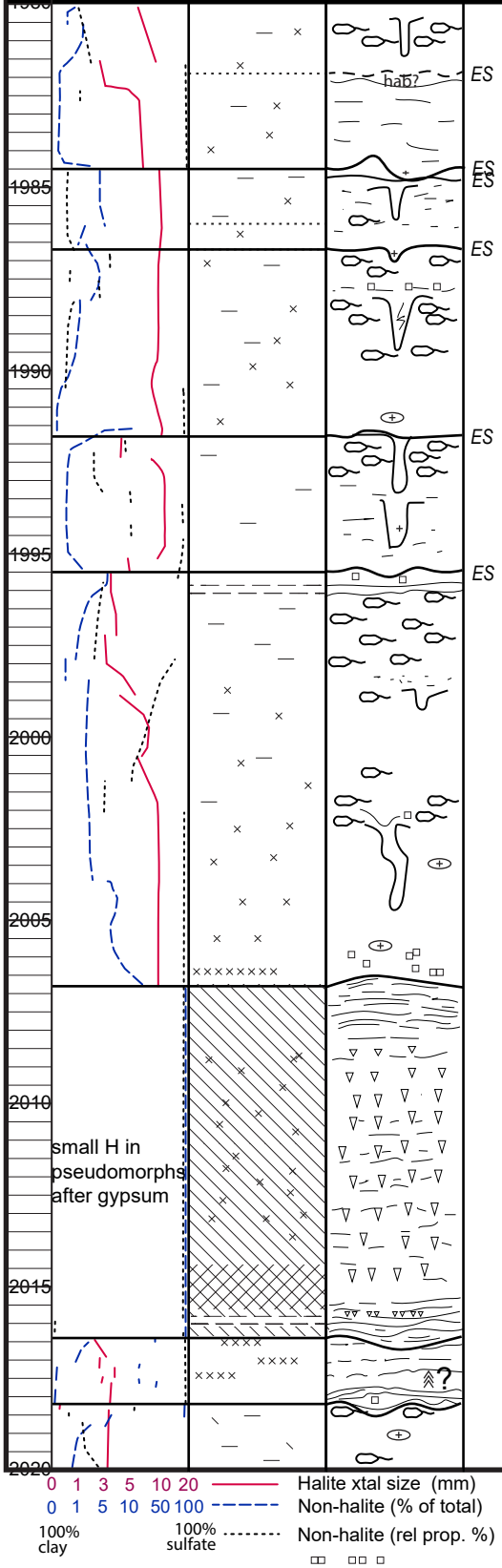

Description

bwn 1982.5-1983.0, zone contains bwn clay stgrs & blebs; tr P xtl lngs, blebs, & stgrs; upper cont grad.

1984.5-1986.7: Above 1986.0: Arg H, f-m IV w/ c IV in MPs & cmts; r-b clay stgrs & blebs show disp boundaries w/ IV H & contains f IIa H; tr P blebs & stgrs; E/S w/ bwn clay at 1984.7; upper cont undulatory E/S w/ no sol lag. Below 1986.0: H, m-c IV, clear, abund cmts; tr P; upper cont grad.

1986.7-1991.8: Above 1990.4: Arg H; f IV in pods w/ dissem r-b clay & P, some gy clay, irreg disc lam & zones of r-b clay w/ some Ia H & disp boundaries w/ IV H; zones bounding pods, cmts, MPs, & diss'n pits contain m-c IV H w/ dissem r-b clay blebs & disc stgrs & lam; tr P blebs; upper cont E/S w/ r-b clay & P sol lag. Below 1990.4: H, f-m IV, w/ c IV cmt & MP filling, orange, tr P as dissem xtl drapes, blebs, & disc subhoriz stgrs; upper cont grad.

1991.8-1995.5: Above 1993.0: H, f IV in pods w/ dissem P & bwn clay, some stgrs of bwn clay; unit cross-cut by diss'n pipe filled w/ eq m-vc IV H; pipe contains trans'd P & r-b clay blebs w/ disp boundaries (IIIa); upper cont E/S w/ r-b clay & P sol lag. Below 1993.0: H, m-vc, orange, cross-cut be diss'n pipe filled w/ clear m-vc IV; tr P blebs w/ disp boundaries; tr r-b clay in pit; upper cont grad.

1995.5-2006.8: Above 1998.1: H, f IV in pods, m-c IV as cmts & in small MP; bwn clay as dissem material, as stgrs & in irreg zones; irreg zone of bwn Mudst near upper cont contains f Ib-c H; upper cont E/S w/ r-b sol lag. 1998.1-2002.1: H, f-c IV, c IV occurs mainly as cmts, some pods of f IV w/ dissem P, color alternates orange & gy (clay); some P xtl lngs & blebs; upper cont grad. Below 2002.1: H, f-c IV, f IV in pods above 2002.5; mod'ly abund P xtl lngs & sol lags of xtl lngs above 2005.5; abund P xtl lngs to 1 mm thick below 2005.5, many w/ disp "a" boundaries, local sol lags of lngs w/ m-c I-IIa-b H; P blebs mod'ly abund above 2004.0, some w/ disp boundaries; sol lag of P xtl lngs in lower 0.3', some f-m I-IIa-c H; 2.7' deep sol pipe originates near upper cont, filled w/ mostly clear H; upper cont grad.

2006.8-2016.4: A, P'tic below 2008.2, microxtln, gy to gyish orange; thinly lam'd to lam'd above 2008.2, wavy, dips following upper cont, some low angle cross-cutting relationships; mix of A & P 2008.2-2015.5, H PAGS w/ some P PAGS to 4" high, P content ranges from 10% at top to 60% at base; A below 2015.5, microlam'd to thinly lam'd, APAGS to 2 mm high; H'tic gy clay 2016.0-2016.2; A in lower 0.2'; no clay at lower cont; upper cont sharp, undulatory.

2016.4-2018.2: H, f-m IV, clear, some primary H (?); beds to 0.5' thick delineated by dilated, flat P lam; A bed 0.1' thick at base, microxtln, gy, wavy to disrupted thin lam to lam, overlies diss'n surface w/ 0.1' relief, gy clay mixed w/ H underlies A bed; upper cont sharp, diss'n surface marked by dilated P sol lag.

2018.2-2032.8: Above 2028.0: H, gy f-m IV above 2024.9, gy f IV 2024.9-2027.0, clear m-c IV below 2027, local f IV in pods near the top & in zones of HABs; dissem gy clay, bwn clay, & A,

AIS depth

2004-1995.5

2012.5-2004

2016-2012.5

2023-2016

2037-2023

2040-2037

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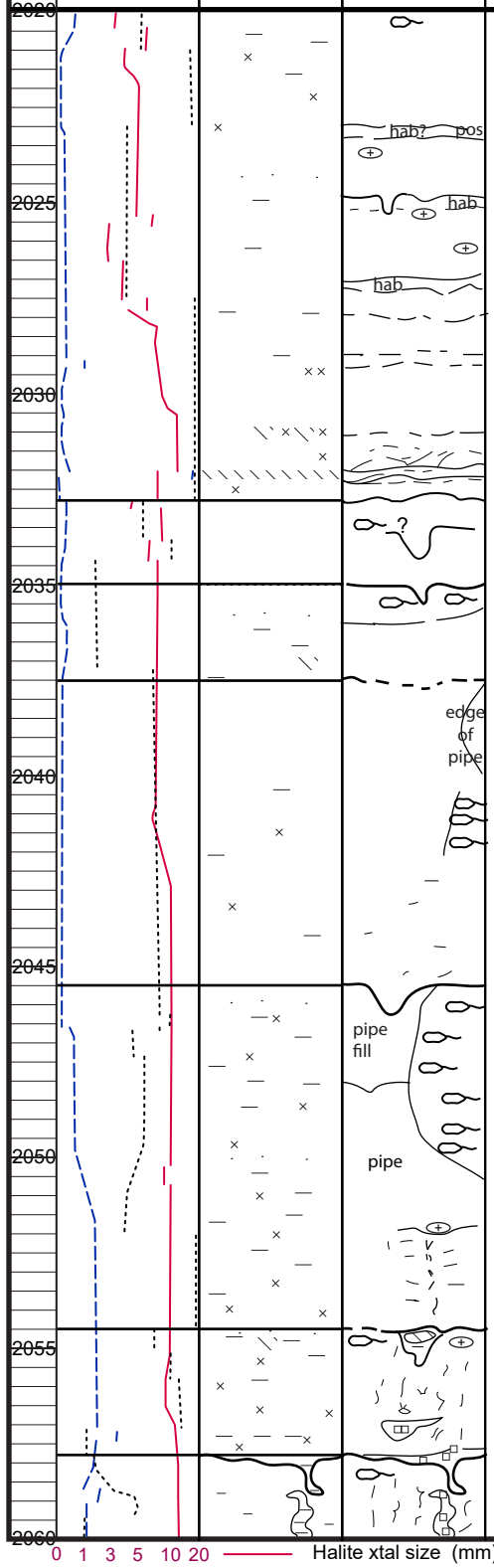
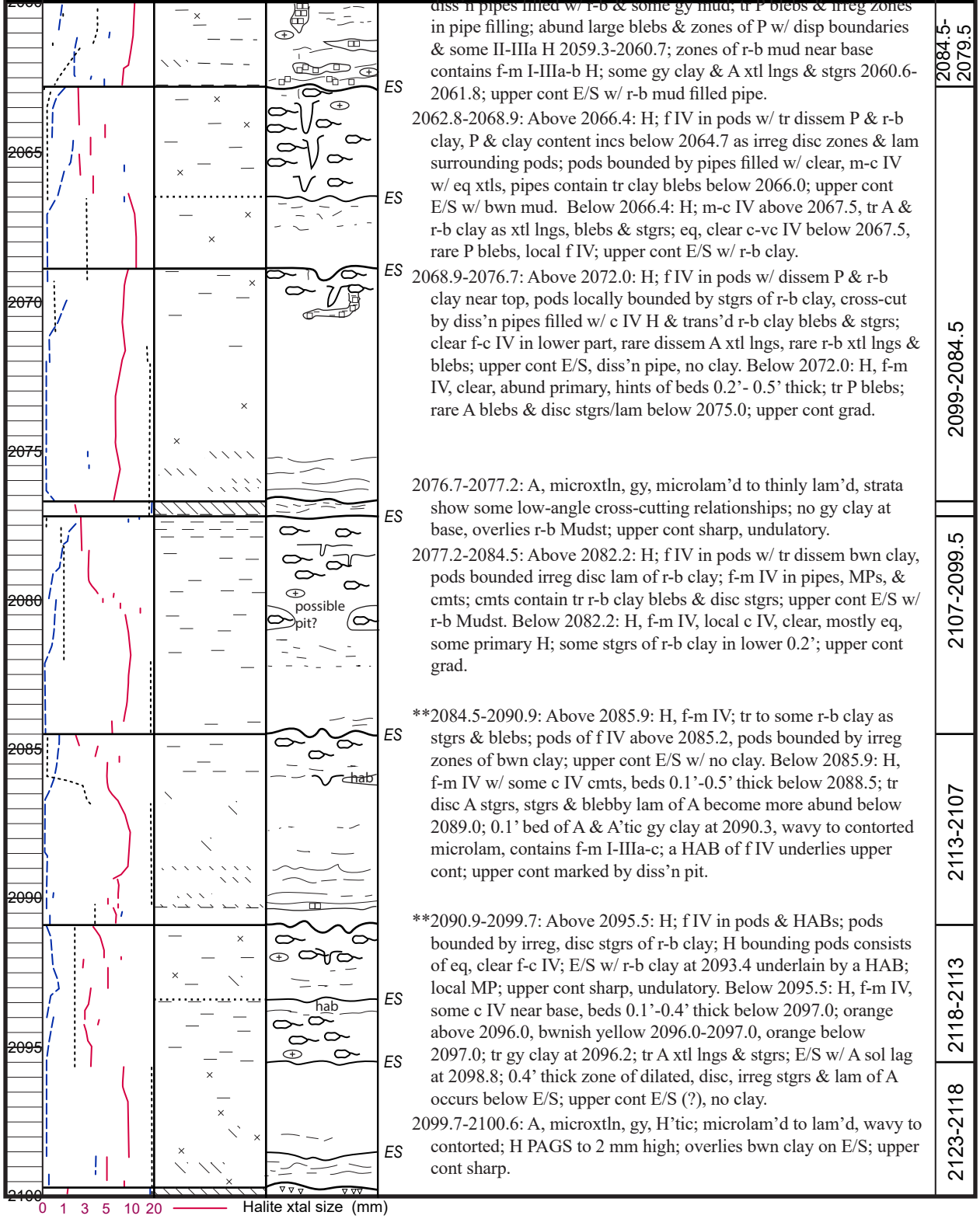


Description	AIS depth
locally concentrated in pods & HABs; P POS textures in some HABs near base; upper cont E/S w/ tr to some gy clay. Below 2028.0: H, f-m IV above 2031.0, m-c IV below 2031.0; 0.1' thick A bed w/ irreg, deformed, thin lam at 2022.0; orange w/ tr P blebs & irreg lam below 2032.0; disc, irreg, 0.5' thick zone of dipping (~45°) P lam above 2032.0; clear transitioning to yellow at top; disc P & A stgrs & lam above 2031.0, crude beds 0.3'-0.5' thick; upper cont marked by bwn clay str.	2055-2040
2032.8-2035.0: H; gy f-m IV w/ tr dissem P & gy clay above 2034.0, poss pods; clear to orange, eq m-c IV w/ tr P blebs; gy H in pit; upper cont irreg, possibly dilated.	
ES 2035.0-2037.5: Above 2036.0: H; f IV in pods w/ tr P & gy clay at top; clear, eq f-m IV w/ tr bwn clay blebs & stgrs at base; upper cont E/S. Below 2036.0: H, f-m IV, gy; dissem gy & bwn clay; tr P; upper cont E/S w/ tr gy clay.	
2037.5-2045.5: Above 2040.5: H, m-c IV, mostly diss'n pipe filling, clear; local f IV on margin of pipe; tr P blebs on margin of pipe; upper cont E/S w/ tr bwn clay. 2040.5-2042.0: H, f IV in pods or HABs cross-cut by a diss'n pipe filled w/ clear, eq m-c IV; tr dissem gy clay & P in pods or HABs; rare P & bwn clay blebs in pipe; upper cont grad. Below 2042.0: H, m-c IV, clear, eq; tr P, A, & bwn clay blebs; upper cont diffuse.	2069.5-2055
ES 2045.5-2054.5: Above 2050.5: H, f IV in pods, pods contain tr dissem P & r-b to gy (at top) clay; pods bounded by eq f-m IV cmt w/ tr r-b clay blebs; entire unit cross-cut by diss'n pipe. Pipe is filled w/ eq m-c IV; tr to some P blebs, some show disp boundaries; tr r-b clay blebs; local r-b clay lam crosses pipe but doesn't enter adjacent pods at 2047.0; pipe is likely continuous w/ overlying unit. Below 2050.5: H, m-c IV w/ some f IV & vc IV, clear to bwn above 2052.0, orange below 2052.0; mod'ly abund P as large blebs, some w/ disp "a" boundaries, many appear vert trans'd, P content decreases upward; some gy & bwn clay blebs & stgrs above 2053; tr bwn clay stgrs & blebs above 2052.0; most of unit likely pipe filling; upper cont diffuse.	2076.5-2069.5
ES **2054.5-2057.8: H; c-vc IV in lower 1'; m-c IV in most of unit, fines upward; f IV in a pod near upper cont; cobble size A clasts near upper cont; irreg zone of r-b Mudst near top contains f-m Ia H; irreg zones of vert trans'd Mudst in lower 1', contains c-vc I-IIIa-b H; abund vert trans'd P blebs; upper cont E/S, no clay, poss diss'n pipe.	2079.5-2076.5
2057.8-2062.8: H, m-c IV, pod of f IV w/ dissem P in upper 0.5', vc IV in MPs near base, orange 2059.3-2060.7; unit cross-cut by	2084.5-2079.5

0 1 3 5 10 20 Halite xtal size (mm)
0 1 5 10 50 100 Non-halite (% of total)
100% clay 100% sulfate Non-halite (rel prop. %)

Hole ID: C3977 (PSC) SALADO CORE LOG (cont. sheet, rev) Sheet 54 of 60



Description

diss'n pipes filled w/ r-b & some gy mud; tr P blebs & irreg zones in pipe filling; abund large blebs & zones of P w/ disp boundaries & some II-IIIa H 2059.3-2060.7; zones of r-b mud near base contains f-m I-IIIa-b H; some gy clay & A xtl lngs & stgrs 2060.6-2061.8; upper cont E/S w/ r-b mud filled pipe.

2062.8-2068.9: Above 2066.4: H; f IV in pods w/ tr dissem P & r-b clay, P & clay content incs below 2064.7 as irreg disc zones & lam surrounding pods; pods bounded by pipes filled w/ clear, m-c IV w/ eq xtls, pipes contain tr clay blebs below 2066.0; upper cont E/S w/ bwn mud. Below 2066.4: H; m-c IV above 2067.5, tr A & r-b clay as xtl lngs, blebs & stgrs; eq, clear c-vc IV below 2067.5, rare P blebs, local f IV; upper cont E/S w/ r-b clay.

2068.9-2076.7: Above 2072.0: H; f IV in pods w/ dissem P & r-b clay near top, pods locally bounded by stgrs of r-b clay, cross-cut by diss'n pipes filled w/ c IV H & trans'd r-b clay blebs & stgrs; clear f-c IV in lower part, rare dissem A xtl lngs, rare r-b xtl lngs & blebs; upper cont E/S, diss'n pipe, no clay. Below 2072.0: H, f-m IV, clear, abund primary, hints of beds 0.2'- 0.5' thick; tr P blebs; rare A blebs & disc stgrs/lam below 2075.0; upper cont grad.

2076.7-2077.2: A, microxtln, gy, microlam'd to thinly lam'd, strata show some low-angle cross-cutting relationships; no gy clay at base, overlies r-b Mudst; upper cont sharp, undulatory.

2077.2-2084.5: Above 2082.2: H; f IV in pods w/ tr dissem bwn clay, pods bounded irreg disc lam of r-b clay; f-m IV in pipes, MPs, & cmts; cmts contain tr r-b clay blebs & disc stgrs; upper cont E/S w/ r-b Mudst. Below 2082.2: H, f-m IV, local c IV, clear, mostly eq, some primary H; some stgrs of r-b clay in lower 0.2'; upper cont grad.

**2084.5-2090.9: Above 2085.9: H, f-m IV; tr to some r-b clay as stgrs & blebs; pods of f IV above 2085.2, pods bounded by irreg zones of bwn clay; upper cont E/S w/ no clay. Below 2085.9: H, f-m IV w/ some c IV cmts, beds 0.1'-0.5' thick below 2088.5; tr disc A stgrs, stgrs & blebby lam of A become more abund below 2089.0; 0.1' bed of A & A'tic gy clay at 2090.3, wavy to contorted microlam, contains f-m I-IIIa-c; a HAB of f IV underlies upper cont; upper cont marked by diss'n pit.

**2090.9-2099.7: Above 2095.5: H; f IV in pods & HABs; pods bounded by irreg, disc stgrs of r-b clay; H bounding pods consists of eq, clear f-c IV; E/S w/ r-b clay at 2093.4 underlain by a HAB; local MP; upper cont sharp, undulatory. Below 2095.5: H, f-m IV, some c IV near base, beds 0.1'-0.4' thick below 2097.0; orange above 2096.0, bwnish yellow 2096.0-2097.0, orange below 2097.0; tr gy clay at 2096.2; tr A xtl lngs & stgrs; E/S w/ A sol lag at 2098.8; 0.4' thick zone of dilated, disc, irreg stgrs & lam of A occurs below E/S; upper cont E/S (?), no clay.

2099.7-2100.6: A, microxtln, gy, H'tic; microlam'd to lam'd, wavy to contorted; H PAGS to 2 mm high; overlies bwn clay on E/S; upper cont sharp.

AIS depth

2084.5-2079.5

2099-2084.5

2107-2099.5

2113-2107

2118-2113

2123-2118

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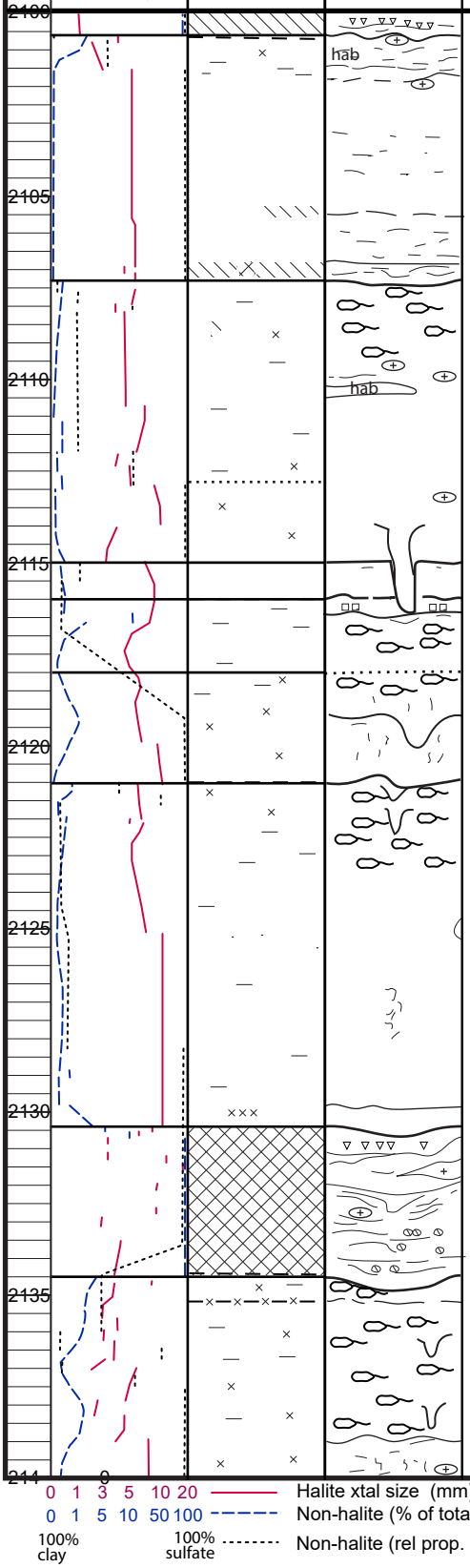

Description

AIS depth

ES 2100.6-2107.3: Above 2101.8: H; f IV in HABs w/ tr dissem clay & rare P; beds bounded by irreg, disc, subhoriz stgrs of bwn clay; remaining H consists of eq, clear, f-m IV w/ tr amounts of A; upper cont E/S w/ bwn clay. 2101.8-2107.0: H, f-m IV, clear w/ a yellow hue, poss primary H, hints of beds 0.2'-0/5' thick; local disc A lam; upper cont grad. Below 2107.0: A, microxtln, gy; disc, disrupted microlam to lam; disc zones of f-m IV H w/ P POS textures; underlain by gy clay; upper cont sharp, slightly irreg.

**2107.3-2115.0: Above 2110.5: H; f IV in pods; pods bounded by f-m IV w/ bwn to gy clay stgrs & blebs, rare A blebs; eq, f IV w/ tr dissem bwn clay in lower 1.5'; poss HAB at base; upper cont diss'n surface w/ gy clay. 2110.5-2112.8: H, f-m IV, eq, local c IV, abund cmt; upper cont grad. Below 2112.8: H, f-c IV, c-vc IV in pipes & MPs; diss'n pipe filled w/ clear m-c IV penetrates lower cont; upper cont grad.

**2115.0-2116.0: H, m-c IV, eq; bwn clay blebs near top; unit cut by pit from overlying unit; upper cont sharp to grad.

ES **2116.0-2118.0: H; m-c IV, mostly cmt; f IV in pods w/ dissem bwn clay 2116.5-2117.3, pods bounded by irreg & disc stgrs of bwn clay; eq f-m IV below 2117.3; E/S w/ bwn clay containing I-IIIa-b H at 2116.5; upper cont grad.

**2118.0-2121.0: Above 2018.5: H, f IV in pods; upper cont grad. 2018.5-2019.2: H, m-c IV, eq; upper cont grad. Below 2019.2: H,

ES m-c IV at base, grading to f-m IV at top; upper part of unit cross-cut by diss'n pipe; upper cont grad.

**2121.0-2130.4: Above 2123.5: H; f IV in pods, edges of pods show irreg & disc stgrs (sol lags) of bwn clay; pods bounded by diss'n pipes & cmts consisting of eq f-m IV; upper cont E/S, marked by sol lag of P & gy & bwn clay. 2123.5-2129.9: H, m-c IV, clear, eq, locally contains zones of f-m IV & c-vc IV; rare blebs of bwn clay above 2128.7, some showing vert trans'n in a diss'n pit (?); gy clay xtl lngs below 2128.7; rare P blebs below 2129.0; unit may be mostly diss'n pipe filling; upper cont grad. Below 2129.9: P'tic H, m-c IV, eq; abund P as 1 mm thick xtl lngs & large blebs (to 2"), some blebs show disp "a" margins; upper cont sharp to grad.

2130.4-2134.5: P, microxtln, orange; tipped, collapsed, & dissolved H PAGS & irreg zones (relicts of H beds?) of vc IV H above 2132.0; P contains nodules (?) of A below 2132.0, some w/ dissem P, A content incs downward; A nodules coalesced into beds (?) below 2133.5; consists of microxtln, gy, A below 2134.2, A exhibits wavy to contorted, slumped & disrupted lam to very thin beds; bedded nodular A overlies microlam'd to thinly lam'd A at base; 1/2" thick bed of gy clay at base; upper cont sharp, irreg & undulatory.

**2134.5-2142.4: Above 2139.0: H; f IV in pods w/ tr dissem gy clay & P, local disc stgrs & lam of gy clay on edges of pods; H bounding pods consists of eq, clear to gy, f-m IV w/ disc stgrs & lam of gy clay, rare blebs of gy clay & P; upper cont diss'n surface marked by gy clay. Below 2139.0: H, m-c IV below 2141.0, f-m

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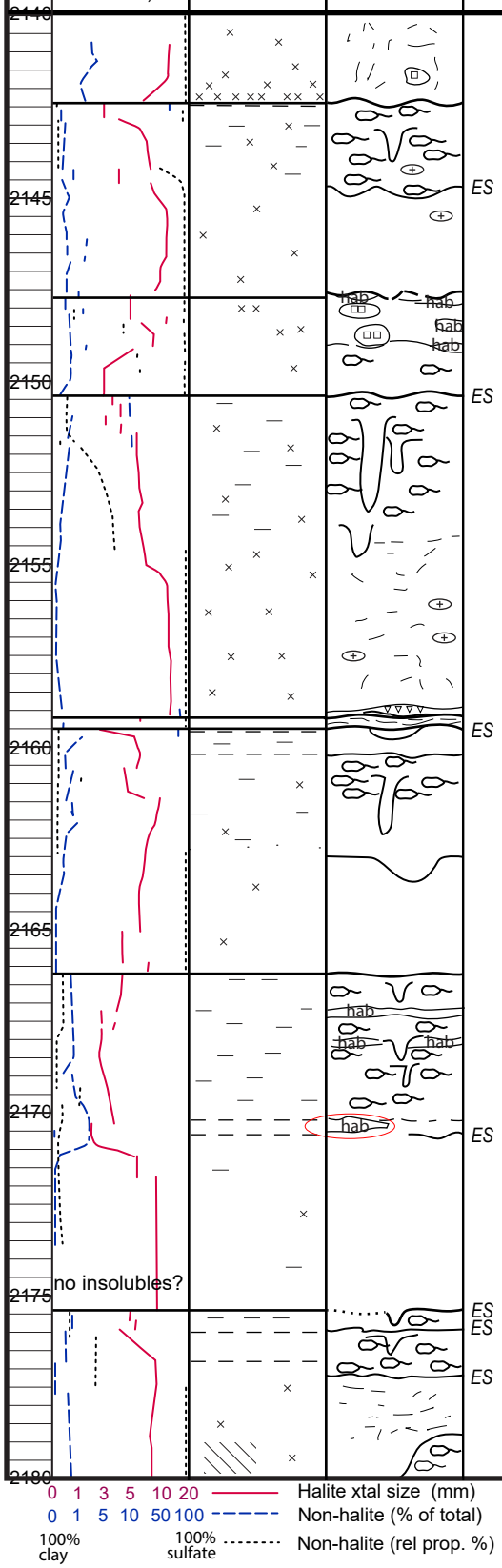

Description

IV above 2141.0, P'tic, orange; local P xtl lngs & subhoriz stgrs; unit has sense of vert trans'n; blebby sol lag of P in lower 0.1', partly dilated, underlain by gy clay; upper cont grad.

**2142.4-2147.7: Above 2144.7: H; f IV pods w/ tr dissem P & r-b & gy clay; bounded by diss'n pipe & MPs w/ clear m IV; local zones of f-m IV cmts; upper cont diss'n surface, marked by gy clay. Below 2144.7: H, f-m IV, rare c IV in MPs, coarsens upward; P as xtl lngs, vert-displaced blebs, & 2" thick zones of sol lags; P sol lags contain f-m I-IIIa-c H; upper cont E/S, no lag.

2147.7-2150.4: Zones of f IV in pods & HABs alternate w/ gy to orange, eq, m-c IV cmts; pods contain dissem P & gy clay; cmts contain large zones of P sol lags w/ f I-IIb-c, tr subhoriz stgrs of gy clay; upper cont marked by HABs, grad.

2150.4-2159.2: Above 2154.2: H, f IV in pods, m-c IV cmts, m-vc IV in diss'n pipes; pods contain tr dissem P & r-b clay, dissem bwn & gy clay in upper 0.7'; cmts contain rare, dissem P blebs; diss'n pipes contain vert-displaced small to large blebs of P & bwn mud (some w/ disp "a" boundaries); diss'n pipe in lower 0.5' contains infiltrated bwn mud w/ m I-IIa-b H; upper cont E/S w/ dilated P & gy clay sol lag. Below 2154.2: H, f-c IV, c-vc IV in MP, f-m IV in upper 1' & lower 0.7', orange; tr to some P as xtl lngs, disc & irreg lam, & vert displaced blebs; 0.1' thick irreg bed of P at 2159.0; upper cont grad.

2159.2-2159.5: A, microxtln, gy; H PAGS to 3 mm high near top; local zones of H bounded by collapsed (?) A; wavy microlam to thin lam near at top; gy clay at base; upper cont sharp.

**2159.5-2166.2: Above 2163.0: H; f-m IV above 2060.2, E/S marked by gy clay is cross-cut by sol surface at upper cont; middle of unit contains f IV in pods w/ tr dissem P & bwn clay; pods are cross-cut by a diss'n pipe containing clear, eq f-c IV; the lower part of the unit is clear f-m IV; E/S marked by gy clay at 2060.2; upper cont diss'n surface, sharp. Below 2163.0: H, m IV at base grading to f IV at top, eq, orange, in beds 0.2'-0.5'; upper cont marked by sol pit, grad, dilated.

2166.2-2175.4: Above 2170.2: H, f IV in pods & HABs w/ tr dissem bwn clay & P (rare); HABs contain subhorizontal, irreg, disc bwn clay lam; pods & HABs bounded by zones of cmt & diss'n pipes w/ clear, f-m IV w/ r-b clay blebs. Below 2170.2: H, f-m IV below 2174.0, m-c IV 2172.0-2174.0, f-m IV above 2172.0, clear; tr gy clay 2170.6-2171.0 & at upper cont; f IV remnant of a HAB near top; H contains rare intracrystalline blebs of P & gy clay; upper cont E/S marked by gy clay sol lag.

2175.4-2178.8: Above 2177.2: H; f IV in pods w/ dissem gy clay; pods locally cross-cut by diss'n pits; pods bounded by f-m IV w/ tr to some vert displaced blebby lam & blebs (some contain I-IIIa-c H); diss'n pits filled w/ eq f-m IV; upper cont E/S w/ pit & local gy clay sol lag (above a f IV pod). Below 2177.2: H, m-f IV, orange; tr P as dissem xtl lngs & disc stgrs; upper cont E/S, no lag.

2178.8-2186.9: Above 2180.0: H; f-m IV w/ some c IV, gy to orange, cross-cuts pods or HABs of f IV w/ dissem P; mod'ly abund A blebs, disc stgrs, & xtl drapes; upper cont sharp to grad. Below

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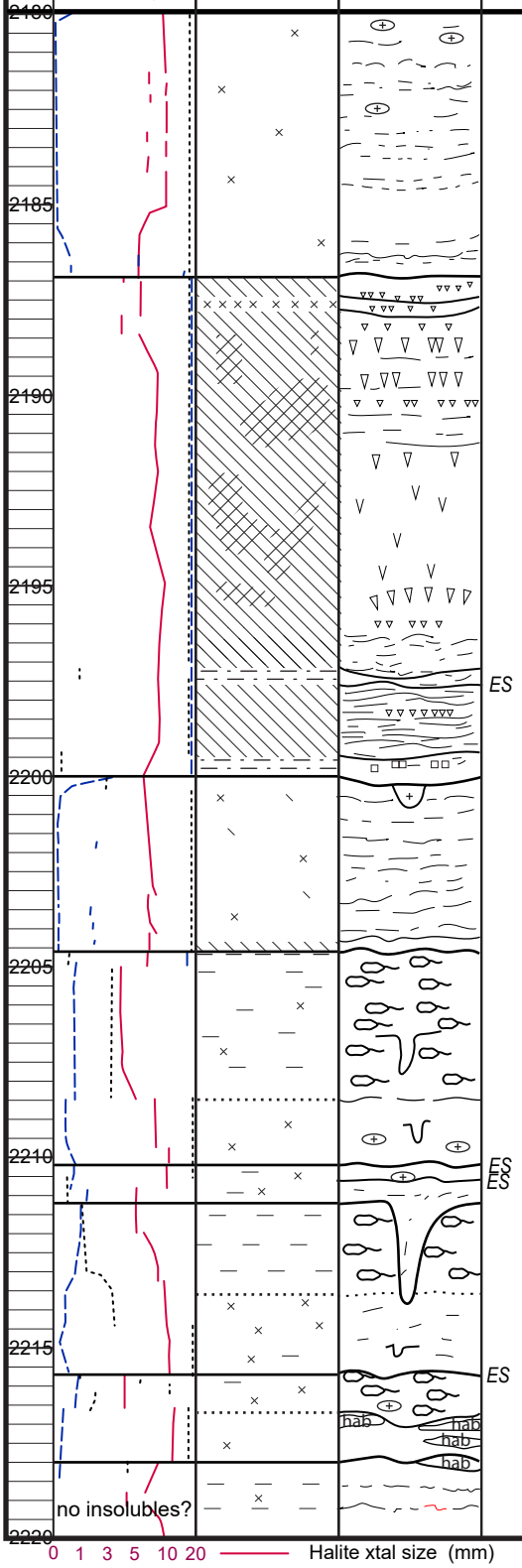

Description

2180.0: H, f-m IV, poss primary H, some c IV in MPs, orange, occurs in beds 0.1'-0.5' thick, beds become less distinct upwards; tr P as disc to continuous, subhoriz stgrs & lam; some P xtl lngs & drapes; dilated A bed at 2186.5; upper cont grad.

2186.9-2200.0: Above 2197.2: A, microxtln, gy, locally P'tic 2191.5-2096.5; H'tic A & P above 2188.0 w/ H PAGS to 5 mm tall & local f-m I-IIIa-b; upper 0.3' shows dilated lam separated by H; locally lam'd to thinly bedded, mostly wavy to contorted w/ H PAGS to 4" high; poss crushed-prism texture 2192-2095; upper cont sharp, marked by A lam. 2197.2-2197.6: A'tic Sltst, gy; hints of flat strata; poss A nodules (?) near top; thin lam of A near base; upper cont sharp. 2197.6-2199.5: A, microxtln, gy; microlam'd to thinly lam'd, flat w/ some low-angle cross-cutting relationships; upper cont sharp, erosional. Below 2199.5: Sandy Sltst, H'tic, gy; local f I-IIIa-b H; upper cont sharp.

2200.2-2204.6: H, f-m IV, orange, occurs in beds 0.1'-0.5' thick; tr subhoriz P & rare A stgrs; some dissem, intracrystalline P; diss'n pit at top filled w/ m-c IV & tr gy clay; ~0.1' thick dilated bed of A occurs at base of unit, bed contains f-m IV & some IIIa H & overlies 1/2" thick gy clay bed; upper cont sharp, diss'n surface.

2204.6-2210.2: Above 2208.5: H; f IV in pods w/ dissem P & gy (near top) & r-b (near base) clay; pods bounded by irreg zones of f-m IV cmt containing tr bwn clay blebs; large blebs occur in diss'n pipe w/ m-c IV, pipe contains some vert trans'd P blebs; upper cont sharp, diss'n surface marked by gy clay. Below 2208.5: H, f-m IV, c IV in MPs, orange; tr to some P blebs & xtl lngs; upper cont grad.

**2210.2-2211.2: H, f-m IV, c IV in MP & diss'n pipe at base, clear, f IV in pod at top; E/S at 2210.6 marked by bwn clay & P sol lag; upper cont E/S, marked by bwn mud sol lag w/ f Ia H.

**2211.2-2215.7: Above 2013.6: H; f IV in pods; margins of pods marked by stgrs & irreg zones of bwn clay; unit cross-cut by diss'n pipe; pipe filling & cmts bounding pods consist of eq m-c IV; upper cont marked by diss'n pipe. Below 2013.6: H, f-m IV, some c IV, orange; pit penetrates grad upper cont.

2215.7-2218.0: Above 2216.7: H; f IV in pods w/ dissem P, bwn clay lam & zones on edges of pods; pods bounded by eq m IV cmt w/ tr bwn clay; upper cont E/S marked by a bwn clay & P sol lag. Below 2216.7: H, f-m IV, mostly clear, tr P; some disc HABs of f IV containing tr dissem P, beds 0.2'-0.5' thick; upper cont grad.

**2218.0-2224.2: Above 2221.7: H; m-c IV at base, eq, clear; grades

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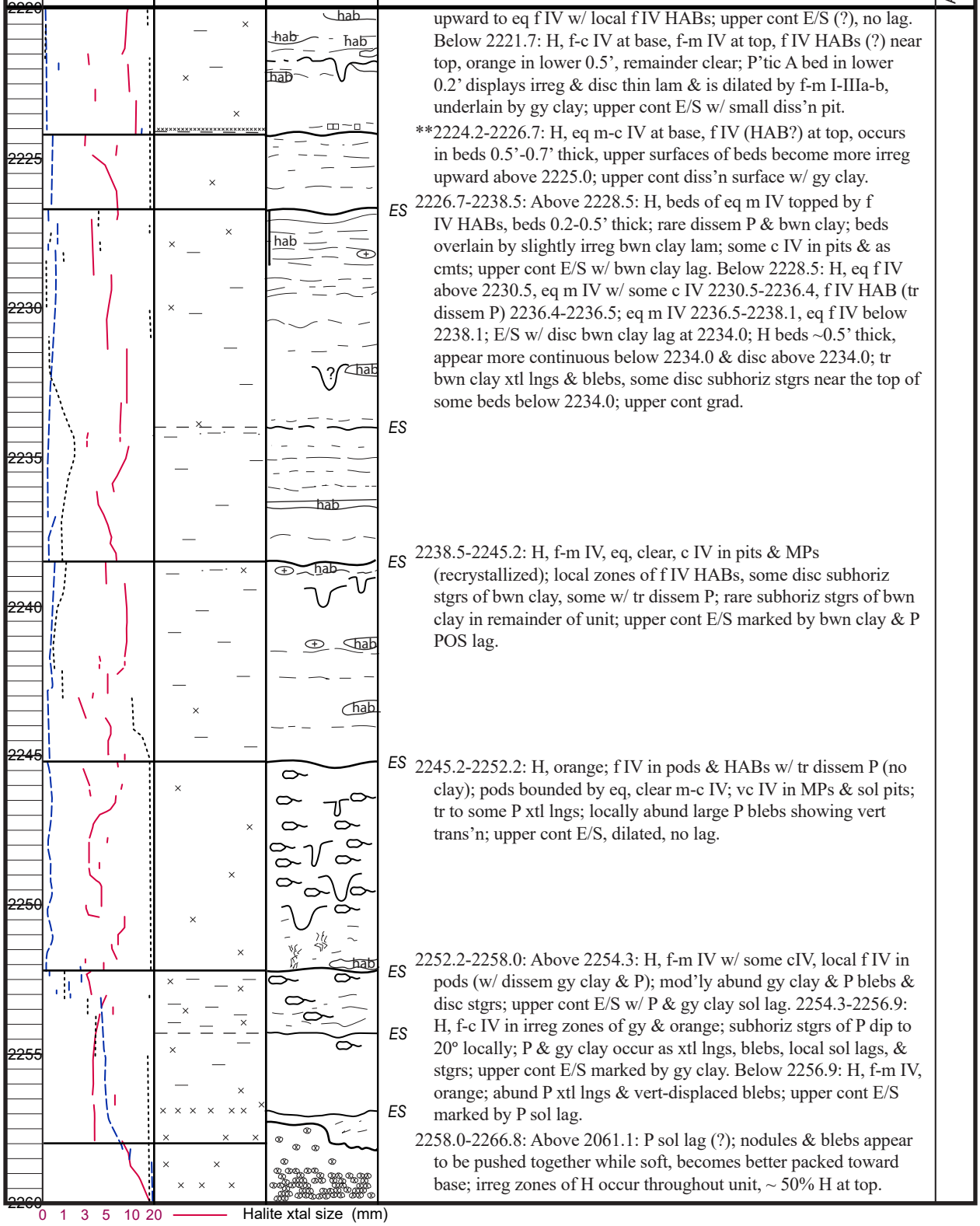

upward to eq f IV w/ local f IV HABs; upper cont E/S (?), no lag. Below 2221.7: H, f-c IV at base, f-m IV at top, f IV HABs (?) near top, orange in lower 0.5', remainder clear; P'tic A bed in lower 0.2' displays irreg & disc thin lam & is dilated by f-m I-IIIa-b, underlain by gy clay; upper cont E/S w/ small diss'n pit.

**2224.2-2226.7: H, eq m-c IV at base, f IV (HAB?) at top, occurs in beds 0.5'-0.7' thick, upper surfaces of beds become more irreg upward above 2225.0; upper cont diss'n surface w/ gy clay.

2226.7-2238.5: Above 2228.5: H, beds of eq m IV topped by f IV HABs, beds 0.2-0.5' thick; rare dissem P & bwn clay; beds overlain by slightly irreg bwn clay lam; some c IV in pits & as cmts; upper cont E/S w/ bwn clay lag. Below 2228.5: H, eq f IV above 2230.5, eq m IV w/ some c IV 2230.5-2236.4, f IV HAB (tr dissem P) 2236.4-2236.5; eq m IV 2236.5-2238.1, eq f IV below 2238.1; E/S w/ disc bwn clay lag at 2234.0; H beds ~0.5' thick, appear more continuous below 2234.0 & disc above 2234.0; tr bwn clay xtl lngs & blebs, some disc subhoriz stgrs near the top of some beds below 2234.0; upper cont grad.

2238.5-2245.2: H, f-m IV, eq, clear, c IV in pits & MPs (recrystallized); local zones of f IV HABs, some disc subhoriz stgrs of bwn clay, some w/ tr dissem P; rare subhoriz stgrs of bwn clay in remainder of unit; upper cont E/S marked by bwn clay & P POS lag.

2245.2-2252.2: H, orange; f IV in pods & HABs w/ tr dissem P (no clay); pods bounded by eq, clear m-c IV; vc IV in MPs & sol pits; tr to some P xtl lngs; locally abund large P blebs showing vert trans'n; upper cont E/S, dilated, no lag.

2252.2-2258.0: Above 2254.3: H, f-m IV w/ some cIV, local f IV in pods (w/ dissem gy clay & P); mod'ly abund gy clay & P blebs & disc stgrs; upper cont E/S w/ P & gy clay sol lag. 2254.3-2256.9: H, f-c IV in irreg zones of gy & orange; subhoriz stgrs of P dip to 20° locally; P & gy clay occur as xtl lngs, blebs, local sol lags, & stgrs; upper cont E/S marked by gy clay. Below 2256.9: H, f-m IV, orange; abund P xtl lngs & vert-displaced blebs; upper cont E/S marked by P sol lag.

2258.0-2266.8: Above 2061.1: P sol lag (?); nodules & blebs appear to be pushed together while soft, becomes better packed toward base; irreg zones of H occur throughout unit, ~ 50% H at top.

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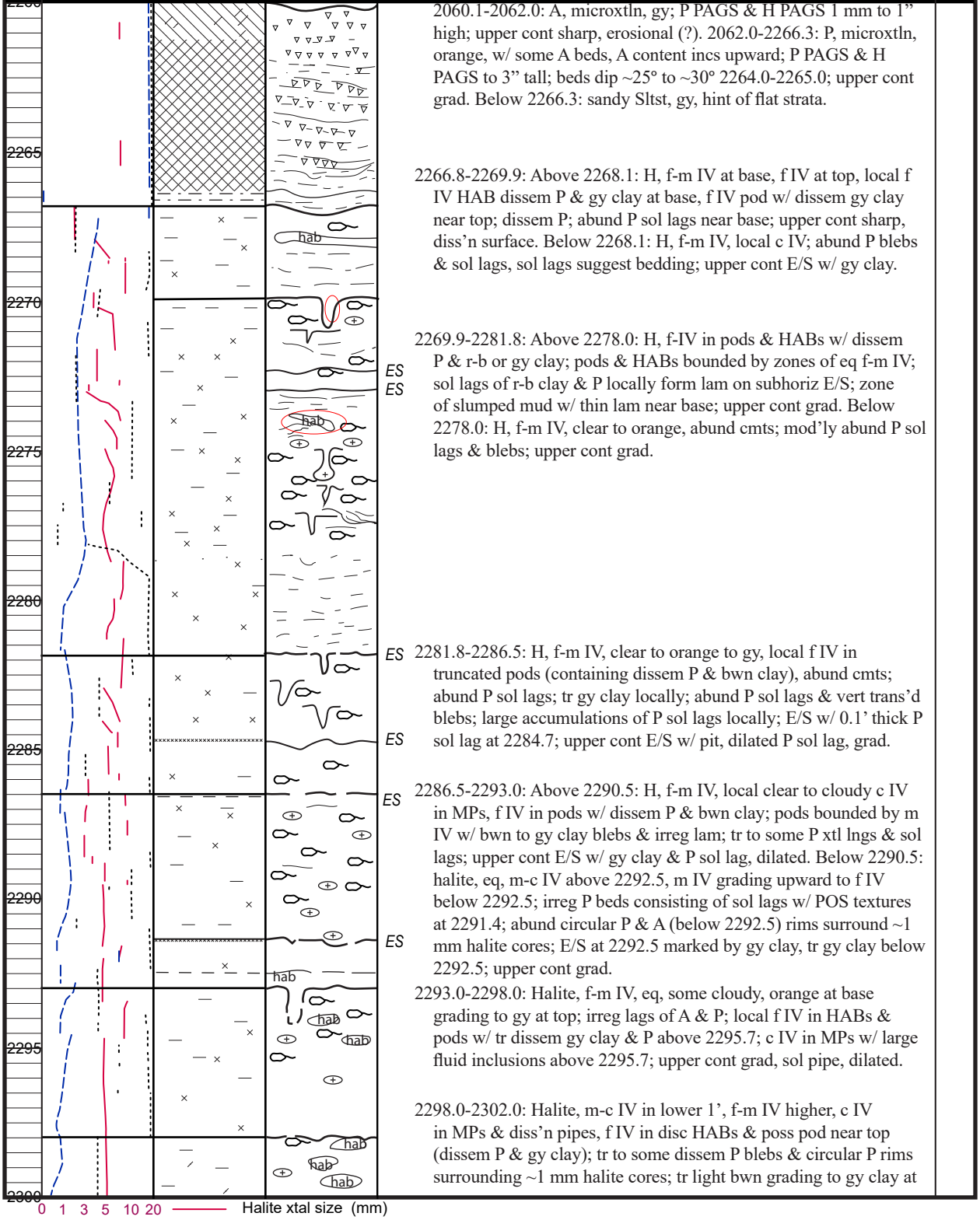

Description

2060.1-2062.0: A, microxtln, gy; P PAGS & H PAGS 1 mm to 1" high; upper cont sharp, erosional (?). 2062.0-2266.3: P, microxtln, orange, w/ some A beds, A content incs upward; P PAGS & H PAGS to 3" tall; beds dip ~25° to ~30° 2264.0-2265.0; upper cont grad. Below 2266.3: sandy Sltst, gy, hint of flat strata.

2266.8-2269.9: Above 2268.1: H, f-m IV at base, f IV at top, local f IV HAB dissem P & gy clay at base, f IV pod w/ dissem gy clay near top; dissem P; abund P sol lags near base; upper cont sharp, diss'n surface. Below 2268.1: H, f-m IV, local c IV; abund P blebs & sol lags, sol lags suggest bedding; upper cont E/S w/ gy clay.

2269.9-2281.8: Above 2278.0: H, f-IV in pods & HABs w/ dissem P & r-b or gy clay; pods & HABs bounded by zones of eq f-m IV; sol lags of r-b clay & P locally form lam on subhoriz E/S; zone of slumped mud w/ thin lam near base; upper cont grad. Below 2278.0: H, f-m IV, clear to orange, abund cmts; mod'ly abund P sol lags & blebs; upper cont grad.

2281.8-2286.5: H, f-m IV, clear to orange to gy, local f IV in truncated pods (containing dissem P & bwn clay), abund cmts; abund P sol lags; tr gy clay locally; abund P sol lags & vert trans'd blebs; large accumulations of P sol lags locally; E/S w/ 0.1' thick P sol lag at 2284.7; upper cont E/S w/ pit, dilated P sol lag, grad.

2286.5-2293.0: Above 2290.5: H, f-m IV, local clear to cloudy c IV in MPs, f IV in pods w/ dissem P & bwn clay; pods bounded by m IV w/ bwn to gy clay blebs & irreg lam; tr to some P xtl lngs & sol lags; upper cont E/S w/ gy clay & P sol lag, dilated. Below 2290.5: halite, eq, m-c IV above 2292.5, m IV grading upward to f IV below 2292.5; irreg P beds consisting of sol lags w/ POS textures at 2291.4; abund circular P & A (below 2292.5) rims surround ~1 mm halite cores; E/S at 2292.5 marked by gy clay, tr gy clay below 2292.5; upper cont grad.

2293.0-2298.0: Halite, f-m IV, eq, some cloudy, orange at base grading to gy at top; irreg lags of A & P; local f IV in HABs & pods w/ tr dissem gy clay & P above 2295.7; c IV in MPs w/ large fluid inclusions above 2295.7; upper cont grad, sol pipe, dilated.

2298.0-2302.0: Halite, m-c IV in lower 1', f-m IV higher, c IV in MPs & diss'n pipes, f IV in disc HABs & poss pod near top (dissem P & gy clay); tr to some dissem P blebs & circular P rims surrounding ~1 mm halite cores; tr light bwn grading to gy clay at

AIS depth

0 1 3 5 10 20 Halite xtal size (mm)
0 1 5 10 50 100 Non-halite (% of total)
100% clay 100% sulfate Non-halite (rel prop. %)

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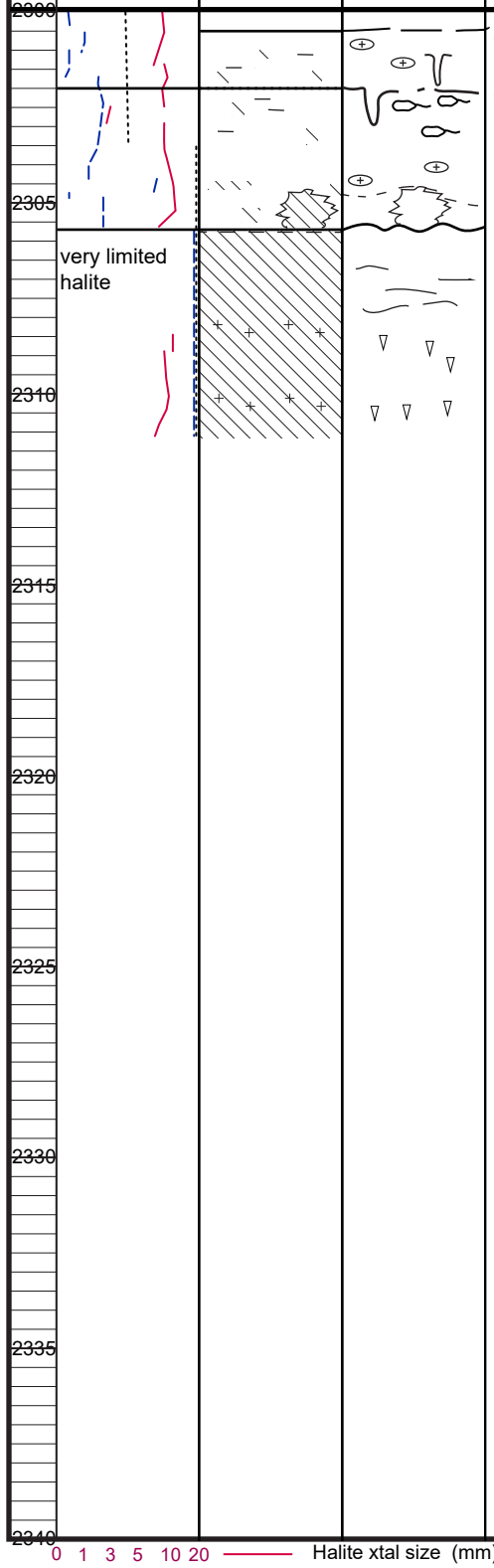


Description

top; blebby sol lag of P (?) & gy accumulated in base of pipe above lower cont; upper cont sharp to grad.

2302.0-2305.0: Halite, f-c IV, gy to light orange; local pods of f IV w/ dissem gy clay & P; tr to some A blebs suggesting vert trans'n; local irreg masses of f IV w/ gy clay & A also suggest vert movement; 0.2' thick irreg sol lag of A at 2304.5, displays granular (?) fabric & local POS textures, some APAG xtls appear to have grown into open voids; irreg microlam of A & A POS textures below 2304.6, locally dilated; upper cont E/S w/ diss'n pipe.

2305.0-2305.7: Halite bounding irreg mass of A; upper cont sharp, marked by A stgrs. Halite, m-c IV, light orange to light gy, some V-O xtls near base & top, eq xtls near middle of unit; P xtl lngs & POS textures common; subhorizontal stgrs of A near top bound V-O xtls; has irregular to ragged cont w/ A mass. A mass is 0.7' high & appears to consist of amalgamated soft clasts of A surrounding a core of m-c IV halite; some clasts display crushed-prism textures & H PAGS, these features are often rotated more than 90□ from vertical; separated from underlying unit by lamr gy A.

2307.5-2311.2: A, microcrystalline, white to light gy to light bwn; above 2307.4: wavy microlam to thin lam showing some cross-cutting relationships, local bedded nodular textures, some nodules near top & 2307.0; below 2307.4: no apparent bedding, H PAGS to 4" at 2308.5, remnants of H PAGS occur above & below 2308.5; upper sharp, slightly undulatory.

AIS depth

0 1 3 5 10 20 ——— Halite xtal size (mm)
0 1 5 10 50 100 – – – – Non-halite (% of total)
100% clay 100% sulfate ..... Non-halite (rel prop. %)

APPENDIX D

CORE RUN, RQD, AND RECOVERY DATA

RQD and Recovery Data for C-3977

Core Run #	Depth top (ft)	Depth Base (ft)	Sum of Recovered length (ft)	Sum of Length (ft) of segments > 4 inches	Recovery (%)	RQD	Notes
	0.0	12.0					drilled for temporary diverter and casing
1	12.0	27.0	5.7	0.7	38.0%		Drilled, not cored
2	27.0	47.0	19.0	7.4	95.0%	38.9	
3	47.0	49.5	3.3	1.0	132.0%	30.3	RQD from core photographs; nrif; most of core disked along bedding planes
4	49.5	70.0	19.7	16.6	96.1%	84.3	
5	70.0	90.0	20.4	7.0	102.0%	34.3	
6	90.0	110.0	20.0	7.5	100.0%	37.5	
7	110.0	130.0	20.0	10.0	100.0%	50.0	
8	130.0	150.0	20.5	13.4	102.5%	65.4	
9	150.0	170.0	19.7	10.5	98.5%	53.3	recovery & RQD from photos
10	170.0	190.0	20.2	17.0	100.8%	84.4	
11	190.0	202.0	11.0	5.0	91.7%	45.5	
	202.0	205.0					reamed for surface casing
12	205.0	210.0	2.4	2.4	48.0%	100.0	
13	210.0	230.0	18.8	15.4	94.0%	81.9	
14	230.0	250.0	20.1	16.1	100.5%	80.1	
15	250.0	270.0	20.8	17.3	104.0%	83.2	
16	270.0	290.0	19.2	13.1	96.0%	68.2	
17	290.0	310.0	20.9	13.9	104.5%	66.5	
18	310.0	330.0	20.2	19.2	101.0%	95.0	
19	330.0	350.0	4.3	2.9	21.5%	67.4	
20	350.0	355.0	21.5	6.2	430.0%	28.8	
	355.0	357.0					hole deeper after fishing for core bit
21	357.0	390.0	31.3	31.3	94.8%	100.0	
22	390.0	427.0	34.9	33.4	94.3%	95.7	
23	427.0	467.0	39.0	34.2	97.5%	87.7	
24	467.0	507.0	39.9	36.8	99.8%	92.2	top of Rustler at 503.7 ft as marked in core
25	507.0	547.0	37.2	37.2	93.0%	100.0	

Core Run #	Depth top (ft)	Depth Base (ft)	Sum of Recovered length (ft)	Sum of Length (ft) of segments > 4 inches	Recovery (%)	RQD	Notes
26	547.0	587.0	40.6	40.0	101.5%	98.5	core log repeats #s used in core runs (#27 labeled "25"
27	587.0	627.0	36.7	36.7	91.8%	100.0	probably left ~3 ft in hole
28	627.0	664.0	40.3	38.3	108.9%	95.0	
29	664.0	694.5	30.5	25.6	100.0%	83.9	switched from air/mist to circulating brine at 694.5; ~6.5 ft above base of Culebra
30	694.5	716.0	21.0	17.4	97.7%	82.9	
31	716.0	756.0	40.8	40.0	102.0%	98.0	
32	756.0	796.0	40.6	39.4	101.5%	97.0	
33	796.0	836.0	37.8	37.8	94.5%	100.0	includes top Salado at 821.9 ft
34	836.0	874.9	35.5	33.9	91.3%	95.5	
35	874.9	909.0	40.0	38.4	117.3%	96.0	
36	909.0	939.0	30.7	30.7	102.3%	100.0	
37	939.0	979.0	39.7	39.4	99.3%	99.2	
38	979.0	1018.0	39.5	37.0	101.3%	93.7	
39	1018.0	1057.0	40.8	39.4	104.6%	96.6	
40	1057.0	1098.0	35.7	35.0	87.1%	98.0	estimated from core photos
41	1098.0	1134.0	40.3	40.0	111.9%	99.3	
42	1134.0	1174.0	40.3	29.3	100.8%	72.7	
43	1174.0	1211.0	37.2	35.8	100.5%	96.2	RQD from core photographs
44	1211.0	1251.0	39.5	39.2	98.8%	99.2	
45	1251.0	1291.0	40.1	39.7	100.3%	99.0	
46	1291.0	1331.5	40.5	39.4	100.0%	97.3	
47	1331.5	1371.5	39.9	39.9	99.8%	100.0	
48	1371.5	1411.5	40.2	40.2	100.5%	100.0	
49	1411.5	1451.5	40.1	39.6	100.3%	98.8	
50	1451.5	1491.5	40.1	40.1	100.3%	100.0	
51	1491.5	1531.5	39.7	39.2	99.3%	98.7	
52	1531.5	1571.5	40.4	40.4	101.0%	100.0	
53	1571.5	1611.5	40.0	39.2	100.0%	98.0	
54	1611.5	1651.5	40.4	40.0	101.0%	99.0	

Core Run #	Depth top (ft)	Depth Base (ft)	Sum of Recovered length (ft)	Sum of Length (ft) of segments > 4 inches	Recovery (%)	RQD	Notes
55	1651.5	1691.5	40.4	39.0	101.0%	96.5	
56	1691.5	1731.5	40.4	39.6	101.0%	98.0	
57	1731.5	1770.0	40.4	39.1	104.9%	96.8	depth correction for geolograph/pipetally
58	1770.0	1773.0	0.7	0.7	23.3%	100.0	
59	1773.0	1813.0	40.3	40.3	100.8%	100.0	
60	1813.0	1853.0	40.4	40.0	101.0%	99.0	
61	1853.0	1893.0	40.4	39.4	101.0%	97.5	
62	1893.0	1933.0	39.5	39.1	98.8%	99.0	
63	1933.0	1949.0	15.9	15.2	99.1%	95.6	
64	1949.0	1989.0	40.0	39.1	100.0%	97.8	
65	1989.0	2029.0	39.1	39.1	97.8%	100.0	RQD from core photographs; nrif
66	2029.0	2069.0	40.3	39.6	100.8%	98.3	
67	2069.0	2109.0	40.0	40.0	100.0%	100.0	
68	2109.0	2149.0	39.9	39.6	99.8%	99.2	
69	2149.0	2189.0	40.2	40.2	100.5%	100.0	
70	2189.0	2229.0	40.3	39.4	100.8%	97.8	
71	2229.0	2269.0	40.2	39.6	100.5%	98.5	
72	2269.0	2308.8	40.0	40.0	100.5%	100.0	pipe tally at TD 2308.8; core marking 2311.1

APPENDIX E

SAMPLES TO VERIFY ROCK MECHANICS PROPERTIES

(see Appendix F for Report of Results)

Dennis W. Powers, Ph. D.
Consulting Geologist

May 26, 2017

John Tinucci, President
SRK Consulting (US), Inc.
1125 17th Street, Suite 600
Denver, CO 80202

Samples Selected from C3977 for Rock Property Verification

On May 18, 2017, I selected samples from C3977 to represent various intervals of the formations that will be encountered in the proposed new shaft for the Waste Isolation Pilot Plant at, or near, the location of C3977. The samples were photographed, wrapped in bubble wrap for protection, packed in coolers for shipping, and sent to Agapito Associates, Inc. location in Grand Junction, CO, via a hot shot service.

Based on conversations with you and Bob Holt, the following general template for sampling was constructed:

1) Dewey Lake: four samples spaced out from ~30 ft below natural cement change to ~30 ft above contact with Rustler; this was modified to include samples above and below the natural cement change;

2) Rustler: three samples of anhydrite (1 each from A-3, A-4, and A-5); A-1 and A-2 are thin but should locally be similar to the upper three anhydrite beds;

3) Rustler clastic units: samples from each of the three upper mudstones (M-2, M-3, and M-4) as well as two samples from the lower part of the Los Medaños Member;

4) Salado: samples from two or three anhydrite members and two samples of halite; this was modified to include two samples from upper Salado (above 900 ft depth).

Table 1 correlates depth with unit/rock type.

A few notes about the selection process are appropriate.

In general, these samples will represent the more competent intervals of the clastic units, in particular. Per your instructions, I surveyed intervals to obtain samples that were long enough to trim down to a length of eight inches for compressive tests. Above the sulfate-cemented zone of the Dewey Lake (below ~167 ft), the core was significantly lower in RQD and recovery rates, and it was more difficult to find suitable samples. The mudstones of the Rustler also had fewer samples exceeding eight inches, although recovery through these intervals was generally good.

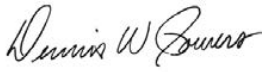
Below the sulfate cement change, the Dewey Lake displays many separations filled with fibrous gypsum. These separations are most commonly either ~horizontal or dipping between ~45-90° from vertical. I tried to avoid incorporating either in Dewey Lake samples. Photographs included here illustrate some of these separations.

The sulfate beds of the Rustler show fairly common features of halite pseudomorphs after original gypsum, and some of the samples will show these features. I refer you to Teufel (1981) for further definition of Salado sulfate mechanical properties. Because I have not found a direct online source and have misplaced my copy, I will try to obtain a copy for you next week while I am in Carlsbad.

170 Hemley Road, Anthony, TX 79821
Telephone: (915) 877-3929 E-mail: dwpowers@evaporites.com *CELL: (915) 588-7901*

Dennis W. Powers, Ph. D.
Consulting Geologist

Sincerely,



Dennis W. Powers

copies via email to:
Ashleigh Pope, NWP
R. M. Holt, University of Mississippi
Tyler Mertlich, Cementation

Reference Cited

Teufel, L.W., 1981, Mechanical properties of anhydrite and polyhalite in quasi-static triaxial compression: SAND81-0858, Sandia National Laboratories, Albuquerque, NM

Table 1
C3977 Samples for Rock Mechanics Verification Tests

Top (ft)	Base (ft)	Formation	Rock Type	Comment
163.9	165.5	Dewey Lake	Siltstone	variable carbonate cement; bedded
181.7	183.5	Dewey Lake	Sandstone	fine to very fine sand; sulfate cement
259.3	260.5	Dewey Lake	Sandstone, silty	fine to very fine sand; sulfate cement
328.95	330.3	Dewey Lake	Sandstone, silty	fine to med sand; sulfate cement
398	399.3	Dewey Lake	Sandstone, silty	fine to med sand; sulfate cement
472.45	473.75	Dewey Lake	Siltstone	argillaceous, well indurated
521.3	522.4	Rustler	Sulfate (A-5)	appears bedded
537.5	538.5	Rustler	Mudstone (M-4)	upper part of mudstone, soft sed deformation?
554.2	555.7	Rustler	Sulfate (A-4)	bedded; anhydrite and some gypsum(?)
609.5	610.8	Rustler	Sulfate (A-3)	bedded; anhydrite and some gypsum(?)
654.3	655.9	Rustler	Mudstone (M-3)	lower part of mudstone; few long samples in M-3
674.4	675.6	Rustler	Sulfate (A-2)	bedded anhydrite and gypsum (?)
706.5	708	Rustler	Mudstone (M-2)	silty claystone, dusky red
767.1	768.45	Rustler	Siltstone	upper Los Medaños; reddish-brown, laminar
781.95	783.3	Rustler	Siltstone, dark gray	upper Los Medaños; laminated, may be bioturbated
843.4	844.7	Salado	Halite	medium coarse; above possible key
898.4	898.7	Salado	Halite	coarse, near possible key
1507.7	1509.5	Salado	Anhydrite, polyhalite	Union Anhydrite; bedded
1937.5	1938.8	Salado	Anhydrite	MB134, with halite pseudomorphs after gypsum
1949.1	1950.8	Salado	Halite	medium coarse; slight content of clay/silt
2139.2	2140.8	Salado	Halite	medium coarse; slightly polyhalitic

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Photos Illustrating Sample Intervals



163.9-165.5 ft



181.7-183.5 ft



259.3-260.5 ft



328.95-330.3 ft (from on-site photography)

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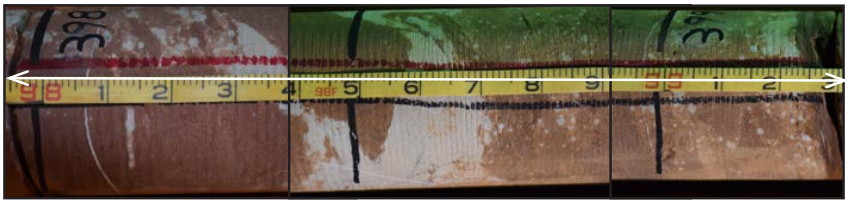
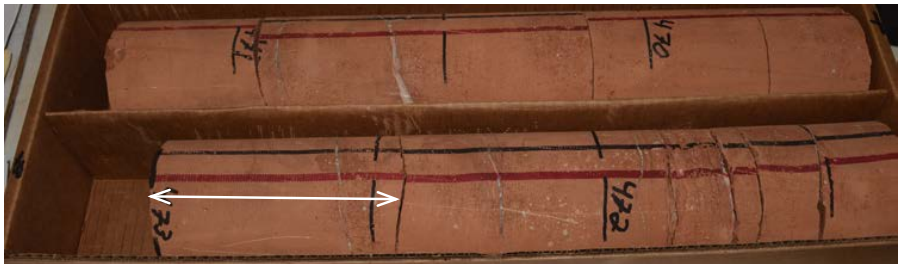


398.0-399.3 ft
photo montage
from on-site pix

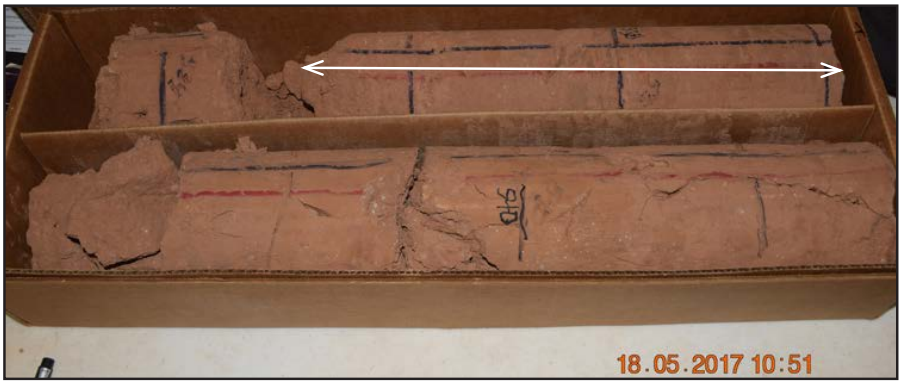


472.45-473.75 ft





521.3-522.4 ft



537.5-538.5
(538.8) ft

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554.2-555.7 ft



609.5-610.8 ft



654.3-655.9ft



706.5-708.0 ft

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767.1-768.45 ft



781.95-783.3 ft



843.4-844.7 ft



898.4-898.7 ft

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1507.7-1509.5 ft



1937.5-1938.8 ft



1949.1-1950.8 ft



2139.2-2140.8 ft

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APPENDIX F

TESTING TO VERIFY ROCK MECHANICS PROPERTIES

(pages reduced to 90% of original)

333-27

Rock Mechanics Testing Results for Core Hole C3977



Prepared for

srk consulting

June 2017

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ROCK MECHANICS TESTING FOR CORE HOLES 3977

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APPENDIX C— STRESS-STRAIN PLOTS FOR UNIAXIAL COMPRESSIVE STRENGTH WITH PROPERTIES TESTS C-1
APPENDIX D—SPLITTING TENSILE STRENGTH (BRAZILIAN) TEST DATA SHEET D-1
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DISCLAIMER OF LIABILITY: *This work was prepared based on the core samples received and by carefully following the standards and procedures listed in this report. Neither Agapito Associates, Inc. (AAI) nor any of its employees make any warranty, expressed or implied, or assumes **any** legal liability or responsibility for its application or usage. The user hereby acknowledges that the provisions of this disclaimer shall apply to all contents of this report.*

1.0 INTRODUCTION

SRK Consulting (U.S.) Inc. (SRK) commissioned Agapito Associates, Inc. (AAI) to complete a rock mechanics laboratory study to determine the mechanical properties of rock samples from core hole C3977 from the Waste Isolation Pilot Plant (WIPP) project in Eddy County, New Mexico. A single shipment of core was delivered to AAI's Grand Junction, Colorado, laboratory on May 19, 2017. This laboratory report provides results of the rock mechanics core testing performed by AAI on behalf of SRK.

2.0 LABORATORY PROCEDURES

Prior to testing, specimens were prepared according to ASTM International (ASTM) standard D4543-08.[1] The following test types were performed by AAI according to ASTM standards where applicable:

- Uniaxial (unconfined) compressive strength (UCS) test: D7012-13[2]
- Splitting tensile strength test (Brazilian): D3967-08[3]
- Water content (moisture) test: D2216-10[4]. Following UCS and TCS testing, select samples were retained for moisture testing.

3.0 TEST RESULTS

The laboratory results for the UCS tests are summarized in Table 1. Table 1 contains elastic properties calculated using both the tangent (45%–55% of UCS) and secant (0%–50% of UCS) methods as outlined in ASTM D7012. One loading cycle (unload/reload) was performed on all salt specimens. For the salt samples, elastic properties were calculated based on the data from the initial cycle for each test at (45%–55% tangent) and (0%–50% secant) of the dilation strength. Indirect splitting tensile (Brazilian) test results are presented in Table 2. Water content (moisture) test results are presented in Table 3.

Data sheets for the UCS tests with failure mode descriptions are presented in Appendix A. Before and after photos of the UCS test specimens are in Appendix B. Stress-strain plots for UCS tests are in Appendix C. Data sheets for the Brazilian tests are presented in Appendix D. Before and after photos of the Brazilian test specimens are in Appendix E.

[1]American Society for Testing and Materials (ASTM), "Standard Practice for Preparing Rock Core as Cylindrical Test Specimens and Verifying Conformance to Dimensional Shape Tolerances," Designation D4543-08.

[2]American Society for Testing and Materials (ASTM), "Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperature," Designation D7012-13 (Methods C and D).

[3]American Society for Testing and Materials (ASTM), "Standard Test Method for Splitting Tensile Strength of Intact Rock Core Specimens," Designation D3967-08.

[4] American Society for Testing and Materials (ASTM), "Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass," Designation D2216-10.

Table 1. Uniaxial Compressive Strength Test Results

Specimen No.	Hole ID	Depth From (ft)	Depth To (ft)	Weight (oz)	Average Diameter (inch)	Axial Length (inch)	Density (pcf)	Failure Load (lb)	Ultimate Strength (psi)	Dilation Strength* (psi)	Young's Modulus† ($\times 10^6$ psi)	Poisson's Ratio†	Young's Modulus‡ ($\times 10^6$ psi)	Poisson's Ratio‡
C3977-1-UCS	C3977	164.30	165.00	124.19	3.96	8.06	135	9,445	769		0.07	0.20	0.06	0.08
C3977-2-UCS	C3977	182.80	183.50	148.63	3.97	8.34	156	201,045	16,270		2.92	0.31	3.21	0.18
C3977-4-UCS	C3977	329.00	329.70	152.93	3.98	8.37	158	70,020	5,615		2.09	0.10	1.50	0.03
C3977-5-UCS	C3977	398.00	398.70	143.61	3.98	8.05	155	39,285	3,163		1.38	0.08	1.05	0.00
C3977-6-UCS	C3977	473.00	473.70	142.25	3.97	8.27	150	47,930	3,877		1.20	0.17	1.11	0.07
C3977-7-UCS	C3977	521.30	522.00	174.38	3.96	8.33	184	191,895	15,573		10.34	0.35	11.18	0.21
C3977-8-UCS	C3977	537.50	538.20	121.85	3.94	8.22	132	12,680	1,042		0.20	0.36	0.16	0.09
C3977-9-UCS	C3977	554.20	554.90	161.92	3.95	8.52	168	86,175	7,048		5.80	0.44	6.47	0.30
C3977-10-UCS	C3977	609.65	610.35	172.46	3.95	8.36	182	189,198	15,455		7.91	0.42	10.13	0.27
C3977-11-UCS	C3977	654.70	655.45	138.96	4.20	7.98	136	2,000	145		Elastic Properties not tested due to irregular diameter			
C3977-13-UCS	C3977	706.70	707.40	124.62	3.96	8.50	128	365	30					
C3977-14-UCS	C3977	767.20	767.90	142.34	3.98	8.26	150	110,280	8,887		1.52	0.29	2.92	0.19
C3977-16-UCS	C3977	843.40	844.10	127.16	3.98	8.22	134	45,205	3,635	1,300	0.62	0.15	1.12	0.08
C3977-17-UCS	C3977	898.75	899.45	123.64	3.99	8.03	133	36,910	2,955	1,735	0.87	0.14	1.53	0.10
C3977-18-UCS	C3977	1,508.55	1,509.25	162.68	3.98	8.32	170	214,380	17,249		6.13	0.34	6.95	0.24
C3977-19-UCS	C3977	1,937.60	1,938.30	161.67	3.97	8.39	168	99,735	8,053		3.96	0.40	4.77	0.25
C3977-20-UCS	C3977	1,949.45	1,950.15	127.10	3.96	8.37	133	29,185	2,369	1,261	1.13	0.16	2.40	0.12
C3977-21-UCS	C3977	2,139.55	2,140.25	125.17	3.98	8.08	135	41,423	3,332	1,491	1.75	0.23	3.41	0.06

*Salt Specimens
†Tangent calculation method.
‡Secant calculation method.

Table 2. Indirect Tensile Strength (Brazilian) Test Results

Specimen No.	Hole ID	Depth From (ft)	Depth To (ft)	Weight (oz)	Average Diameter (inch)	Axial Length (inch)	Density (pcf)	Failure Load (lb)	Splitting Tensile Strength (psi)
C3977-1-B	C3977	163.90	164.10	33.74	3.95	2.26	131	1,555	111
C3977-2-B	C3977	182.60	182.80	35.21	3.98	1.99	153	16,645	1,336
C3977-4-B	C3977	329.70	329.90	43.37	3.97	2.35	161	10,870	741
C3977-5-B	C3977	398.70	398.90	37.71	3.96	2.18	152	7,265	537
C3977-6-B	C3977	472.80	473.00	37.80	3.97	2.19	151	5,810	426
C3977-7-B	C3977	522.00	522.20	48.77	3.96	2.33	184	10,800	747
C3977-8-B	C3977	538.20	538.40	36.16	3.92	2.34	138	2,945	205
C3977-9-B	C3977	554.90	555.10	43.69	3.95	2.19	176	18,650	1,371
C3977-10-B	C3977	610.40	610.60	48.72	3.95	2.35	183	14,005	961
C3977-13-B	C3977	707.75	707.95	37.03	3.99	2.50	128	1,510	97
C3977-14-B	C3977	768.05	768.25	37.65	3.95	2.19	151	14,390	1,059
C3977-16-B	C3977	844.35	844.55	37.78	3.97	2.46	134	4,470	292
C3977-17-B	C3977	898.40	898.60	41.97	3.97	2.29	160	8,175	573
C3977-18-B	C3977	1,507.80	1,508.00	44.10	3.96	2.30	168	8,430	590
C3977-19-B	C3977	1,838.30	1,838.50	39.01	3.96	2.04	168	5,685	448
C3977-20-B	C3977	1,949.25	1,949.45	33.13	3.95	2.20	133	2,635	193
C3977-21-B	C3977	2,140.25	2,140.45	35.35	3.97	2.32	133	2,820	195

Table 3. Water (Moisture) Content Test Results

Specimen No.	Hole ID	Depth From (ft)	Depth To (ft)	Length of Interval (ft)	Water Content* (%)
C3977-1-M	C3977	164.30	165.00	0.70	2.3%
C3977-2-M	C3977	182.80	183.50	0.70	3.6%
C3977-4-M	C3977	329.00	329.70	0.70	1.1%
C3977-5-M	C3977	398.00	398.70	0.70	1.7%
C3977-6-M	C3977	473.00	473.70	0.70	3.6%
C3977-7-M	C3977	521.30	522.00	0.70	0.0%
C3977-8-M	C3977	537.50	538.20	0.70	2.7%
C3977-9-M	C3977	554.20	554.90	0.70	4.3%
C3977-10-M	C3977	609.65	610.35	0.70	0.1%
C3977-11-M	C3977	654.70	655.45	0.70	4.5%
C3977-13-M	C3977	706.70	707.40	0.70	7.3%
C3977-14-M	C3977	767.20	767.90	0.70	1.0%
C3977-16-M	C3977	843.40	844.10	0.70	0.1%
C3977-17-M	C3977	898.75	899.45	0.70	0.1%
C3977-18-M	C3977	1,508.55	1,509.25	0.70	0.2%
C3977-19-M	C3977	1,957.60	1,958.30	0.70	0.1%
C3977-20-M	C3977	1,949.45	1,950.15	0.70	0.4%
C3977-21-M	C3977	2,139.55	2,140.25	0.70	0.1%

*Water content = (mass of water/mass of solids) × 100.

APPENDIX A

UNIAXIAL COMPRESSION STRENGTH TEST DATA SHEET

Agapito Associates, Inc.

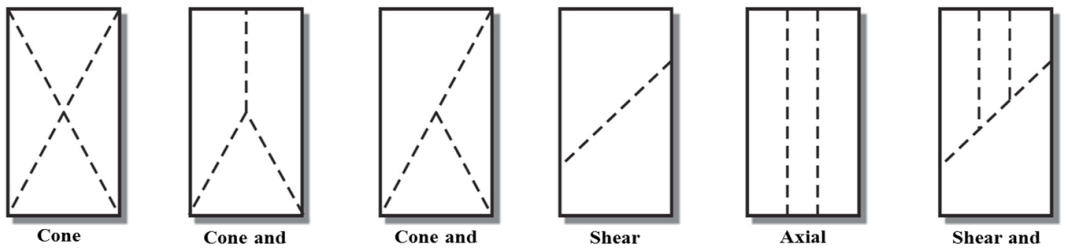
UNIAXIAL COMPRESSION TESTS

CLIENT:	SRK	**HOLE NO:**	C3977
JOB NO:	333-27	**MOISTURE CONDITION:**	As Received
DATE:	May 23, 2017	**TEMPERATURE:**	70°C

Specimen No.	Hole No.	Depth From (ft)	Depth To (ft)	Length of Interval (ft)	Weight (oz)	Diameter D_1 (in)	Diameter D_2 (in)	Axial Length (inch)	Length-to-Diameter Ratio	Area ($inch^2$)	Density (pcf)	Specific Gravity
C3977-1-UCS	C3977	164.3	165.0	0.70	124.19	3.95	3.96	8.06	2.0	12.29	135	2.17
C3977-2-UCS	C3977	182.8	183.5	0.70	148.63	3.97	3.97	8.34	2.1	12.36	156	2.50
C3977-3-UCS	C3977	*Spare*										
C3977-4-UCS	C3977	329.0	329.7	0.70	152.93	3.99	3.98	8.37	2.1	12.47	158	2.54
C3977-5-UCS	C3977	398.0	398.7	0.70	143.61	3.98	3.98	8.05	2.0	12.42	155	2.49
C3977-6-UCS	C3977	473.0	473.7	0.70	142.25	3.96	3.97	8.27	2.1	12.36	150	2.41
C3977-7-UCS	C3977	521.3	522.0	0.70	174.38	3.96	3.96	8.33	2.1	12.32	184	2.94
C3977-8-UCS	C3977	537.5	538.2	0.70	121.85	3.94	3.94	8.22	2.1	12.17	132	2.11
C3977-9-UCS	C3977	554.2	554.9	0.70	161.92	3.95	3.95	8.52	2.2	12.23	168	2.69
C3977-10-UCS	C3977	609.7	610.4	0.70	172.46	3.95	3.95	8.36	2.1	12.24	182	2.92
C3977-11-UCS	C3977	654.7	655.5	0.75	138.96	4.22	4.17	7.98	1.9	13.82	136	2.18
C3977-12-UCS	C3977	*Spare*										
C3977-13-UCS	C3977	706.7	707.4	0.70	124.62	3.93	4.00	8.50	2.1	12.34	128	2.06
C3977-14-UCS	C3977	767.2	767.9	0.70	142.34	3.98	3.97	8.26	2.1	12.41	150	2.40
C3977-15-UCS	C3977	*Spare*										
C3977-16-UCS	C3977	843.4	844.1	0.70	127.16	3.98	3.98	8.22	2.1	12.43	134	2.15
C3977-17-UCS	C3977	898.8	899.5	0.70	123.64	3.99	3.99	8.03	2.0	12.49	133	2.13
C3977-18-UCS	C3977	1,508.6	1,509.3	0.70	162.68	3.98	3.98	8.32	2.1	12.43	170	2.72
C3977-19-UCS	C3977	1,937.6	1,938.3	0.70	161.67	3.97	3.97	8.39	2.1	12.38	168	2.69
C3977-20-UCS	C3977	1,949.5	1,950.2	0.70	127.10	3.96	3.96	8.37	2.1	12.32	133	2.13
C3977-21-UCS	C3977	2,139.6	2,140.3	0.70	125.17	3.98	3.98	8.08	2.0	12.43	135	2.16

Specimen No.	Lithological Description	Failure Load (lb)	UCS (psi)	Failure Mode Notes	Comments
C3977-1-UCS	-	9,445	769	Shear	
C3977-2-UCS	-	201,045	16,270	Cone	Violent Failure
C3977-3-UCS	*Spare*				
C3977-4-UCS	-	70,020	5,615	Shear	
C3977-5-UCS	-	39,285	3,163	Axial	Failed on joints
C3977-6-UCS	-	47,930	3,877	Axial & Shear	Failed on joints
C3977-7-UCS	-	191,895	15,573	Shear & Cone	Violent Failure
C3977-8-UCS	-	12,680	1,042	Shear	
C3977-9-UCS	-	86,175	7,048	Shear	
C3977-10-UCS	-	189,198	15,455	Shear & Axial	
C3977-11-UCS	-	2,000	145	Shear & Crush	Unconsolidated, Very Weak, larger diameter >4"
C3977-12-UCS	*Spare*				
C3977-13-UCS	-	365	30	Shear & Crush	Unconsolidated, Very Weak, irregular diameter
C3977-14-UCS	-	110,280	8,887	Shear & Axial	
C3977-15-UCS	*Spare*				
C3977-16-UCS	-	45,205	3,635	Crush	
C3977-17-UCS	-	36,910	2,955	Crush	
C3977-18-UCS	-	214,380	17,249	Axial	Violent Failure
C3977-19-UCS	-	99,735	8,053	Shear	
C3977-20-UCS	-	29,185	2,369	Crush	
C3977-21-UCS	-	41,423	3,332	Crush	

Failure Mode Sketches



APPENDIX B

BEFORE AND AFTER PHOTOGRAPHS OF UNIAXIAL COMPRESSION STRENGTH TEST SPECIMENS



C3977-1-UCS (164.3-165.0 ft)—Before



C3977-1-UCS (164.3-165.0 ft)—After



C3977-2-UCS (182.8-183.5 ft)—Before



C3977-2-UCS (182.8-183.5 ft)—After



C3977-4-UCS (329.0-329.7 ft)—Before



C3977-4-UCS (329.0-329.7 ft)—After

Figure B-1. Before and After Photographs of Uniaxial Compressive Strength Test Specimens



C3977-5-UCS (398.0-398.7 ft)—Before



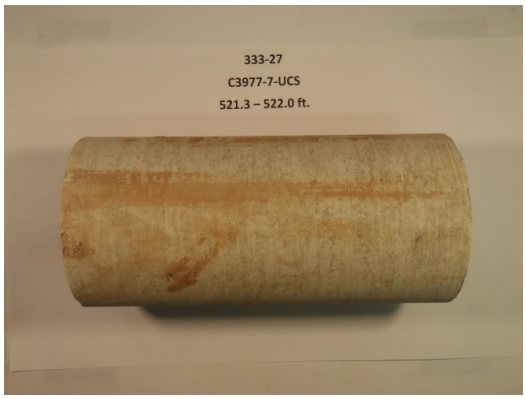
C3977-5-UCS (398.0-398.7 ft)—After



C3977-6-UCS (473.0-473.7 ft)—Before



C3977-6-UCS (473.0-473.7 ft)—After



C3977-7-UCS (521.3-522.0 ft)—Before



C3977-7-UCS (521.3-522.0 ft)—After

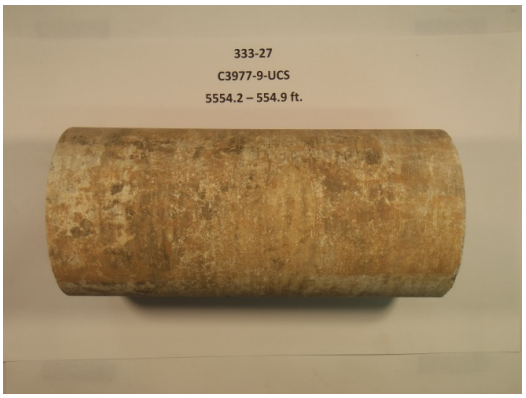
Figure B-1. Before and After Photographs of Uniaxial Compressive Strength Test Specimens *(continued)*



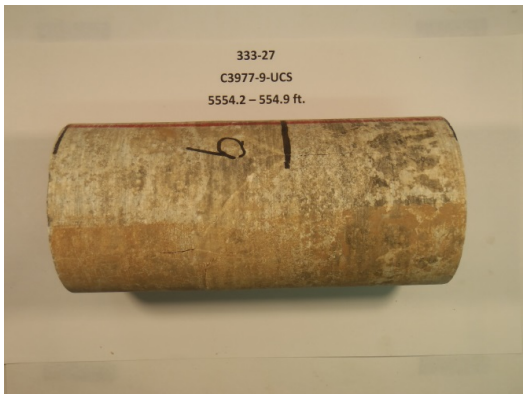
C3977-8-UCS (537.5-538.2 ft)—Before



C3977-8-UCS (537.5-538.2 ft)—After



C3977-9-UCS (554.2-554.9 ft)—Before



C3977-9-UCS (554.2-554.9 ft)—After



C3977-10-UCS (609.65-610.35 ft)—Before



C3977-10-UCS (609.65-610.35 ft)—After

Figure B-1. Before and After Photographs of Uniaxial Compressive Strength Test Specimens *(continued)*



C3977-11-UCS (654.7-655.45 ft)—Before



C3977-11-UCS (654.7-655.45 ft)—After



C3977-13-UCS (706.7-707.4 ft)—Before



C3977-13-UCS (706.7-707.4 ft)—After



C3977-14-UCS (767.2-767.9 ft)—Before



C3977-14-UCS (767.2-767.9 ft)—After

Figure B-1. Before and After Photographs of Uniaxial Compressive Strength Test Specimens *(continued)*



C3977-16-UCS (843.4-844.1 ft)—Before



C3977-16-UCS (843.4-844.1 ft)—After



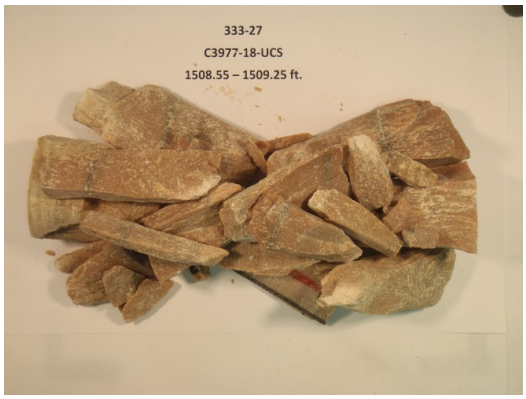
C3977-17-UCS (898.75-899.45 ft)—Before



C3977-17-UCS (898.75-899.45 ft)—After



C3977-18-UCS (1508.55-1509.25 ft)—Before



C3977-18-UCS (1508.55-1509.25 ft)—After

Figure B-1. Before and After Photographs of Uniaxial Compressive Strength Test Specimens *(continued)*



C3977-19-UCS (1937.6-1938.3 ft)—Before



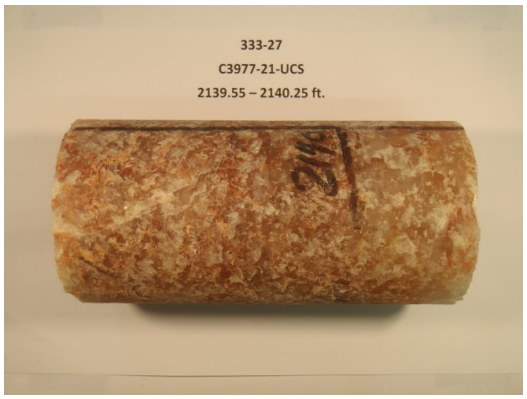
C3977-19-UCS (1937.6-1938.3 ft)—After



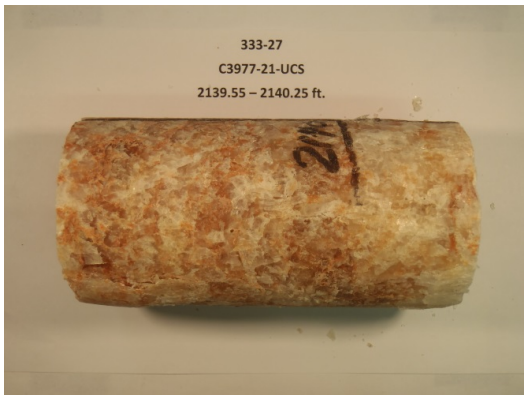
C3977-20-UCS (1949.45-1950.15 ft)—Before



C3977-20-UCS (1949.45-1950.15 ft)—After



C3977-21-UCS (2139.55-2140.25 ft)—Before

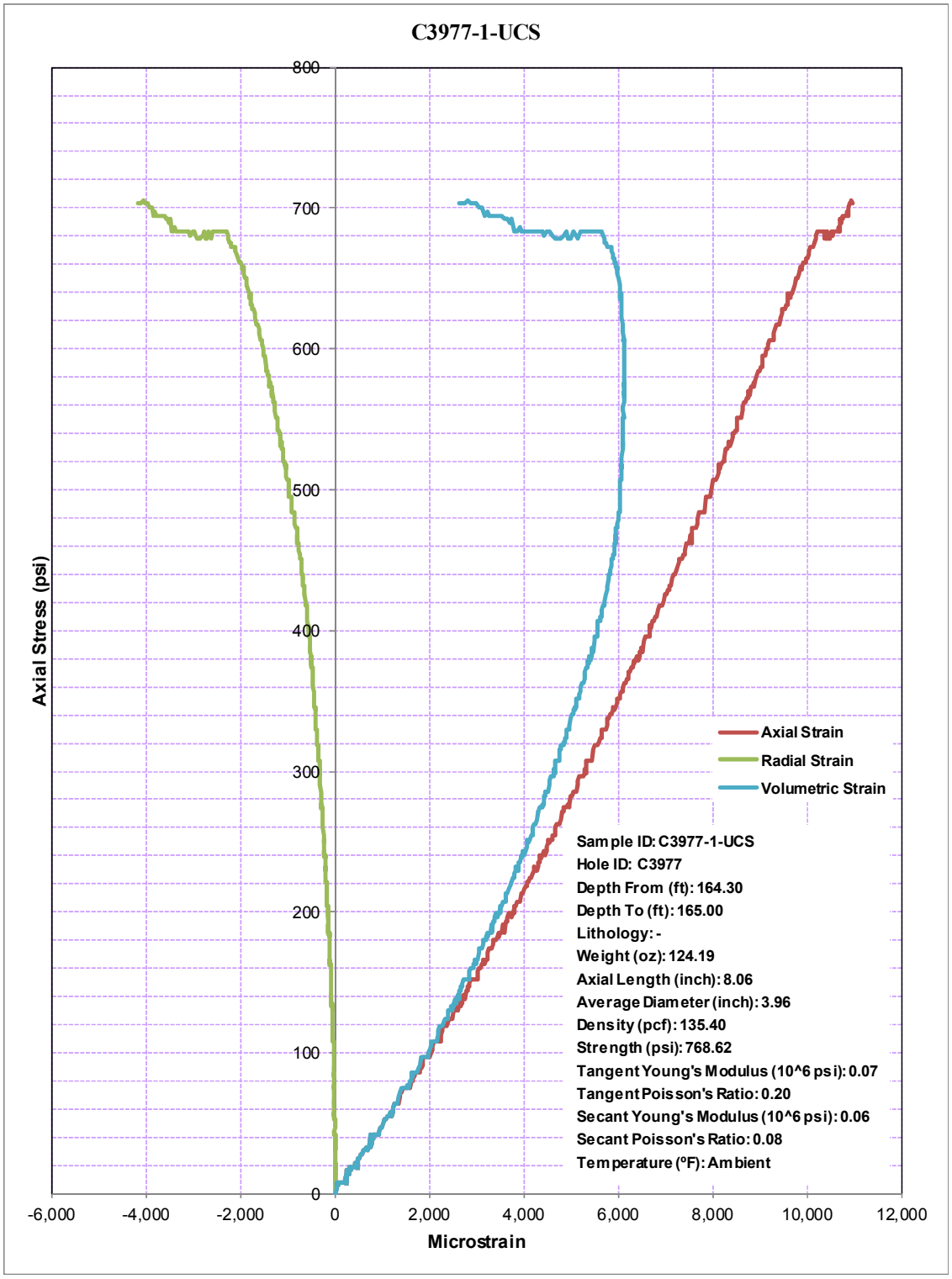


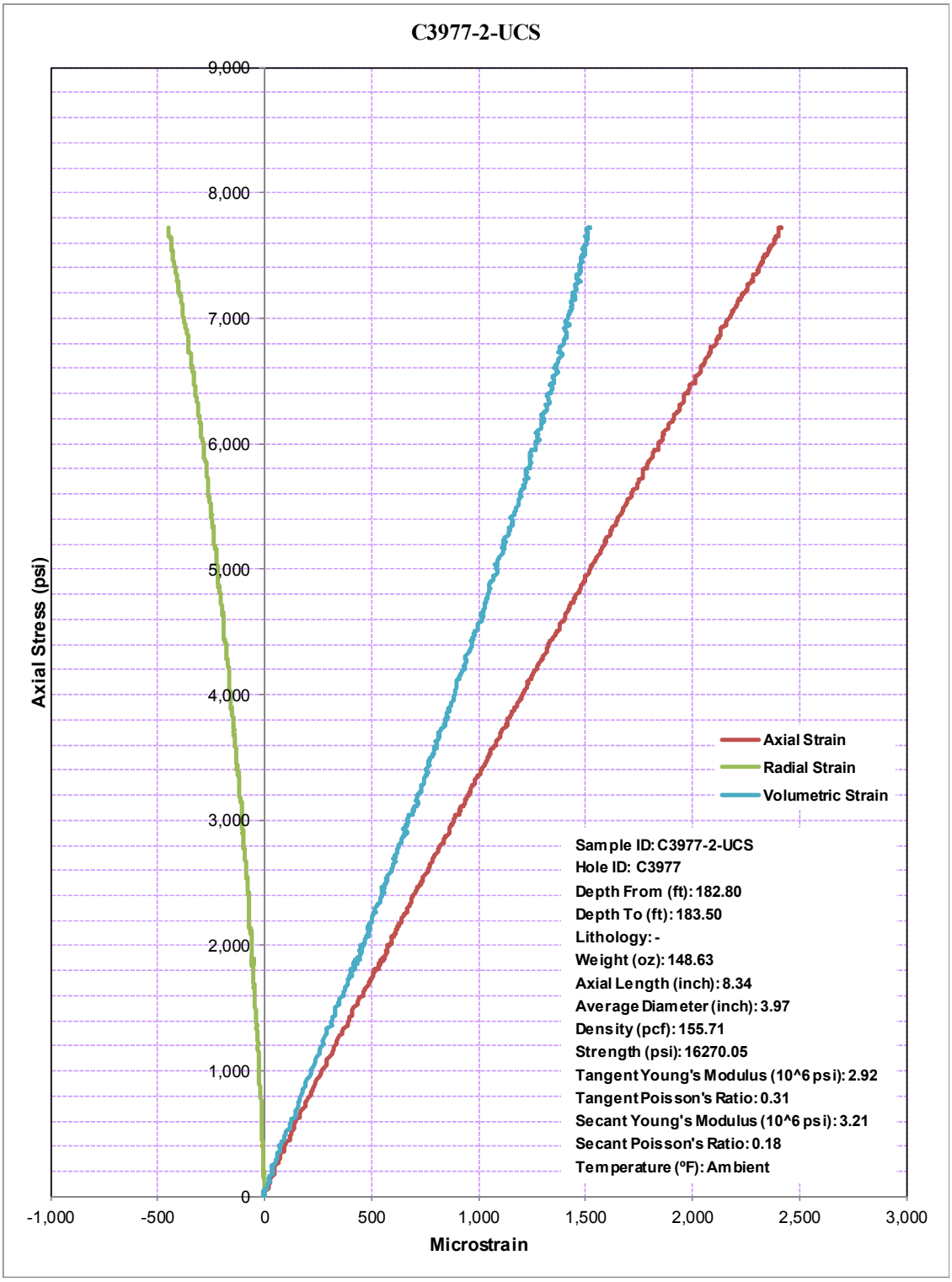
C3977-21-UCS (2139.55-2140.25 ft)—After

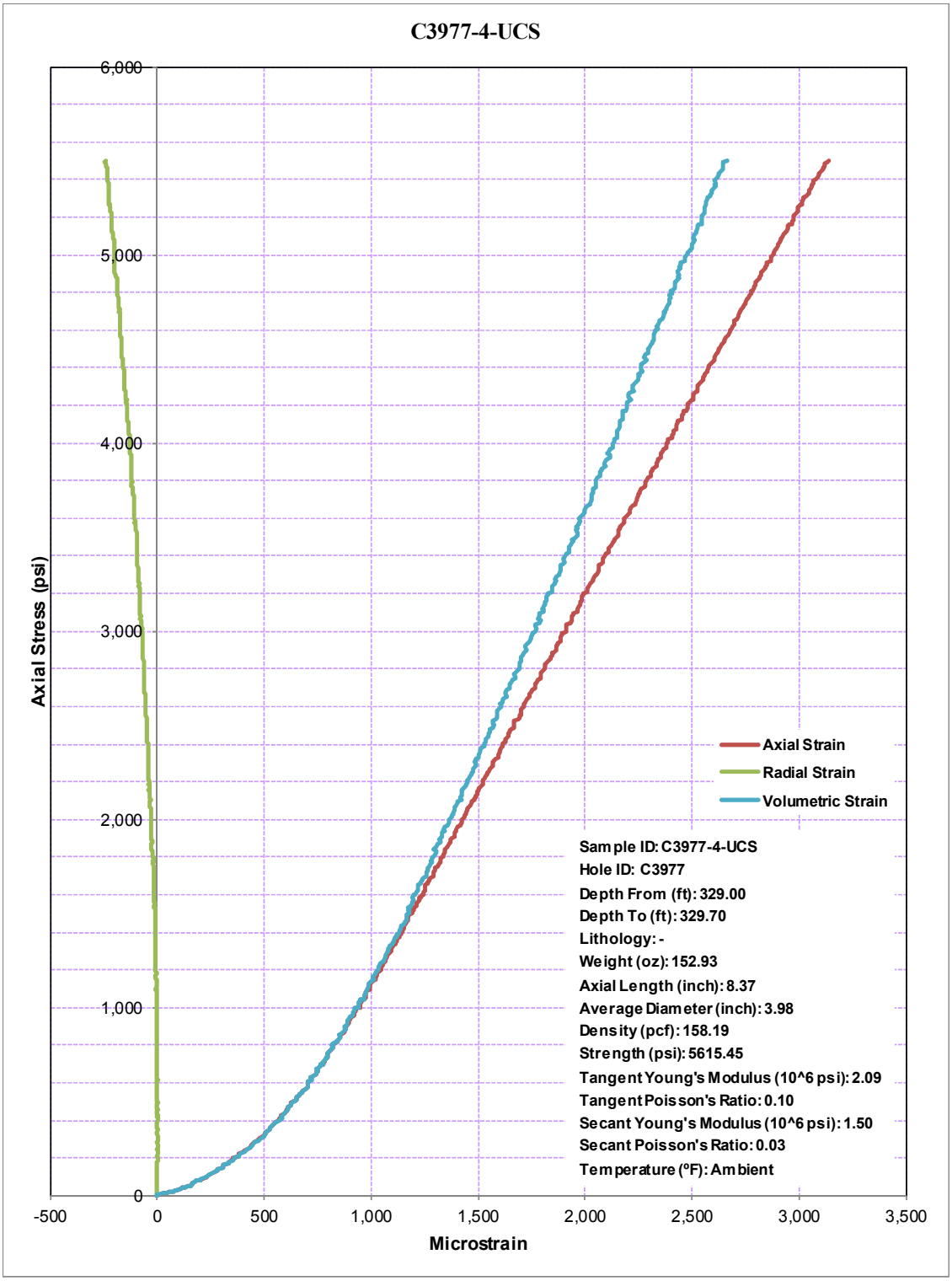
Figure B-1. Before and After Photographs of Uniaxial Compressive Strength Test Specimens *(concluded)*

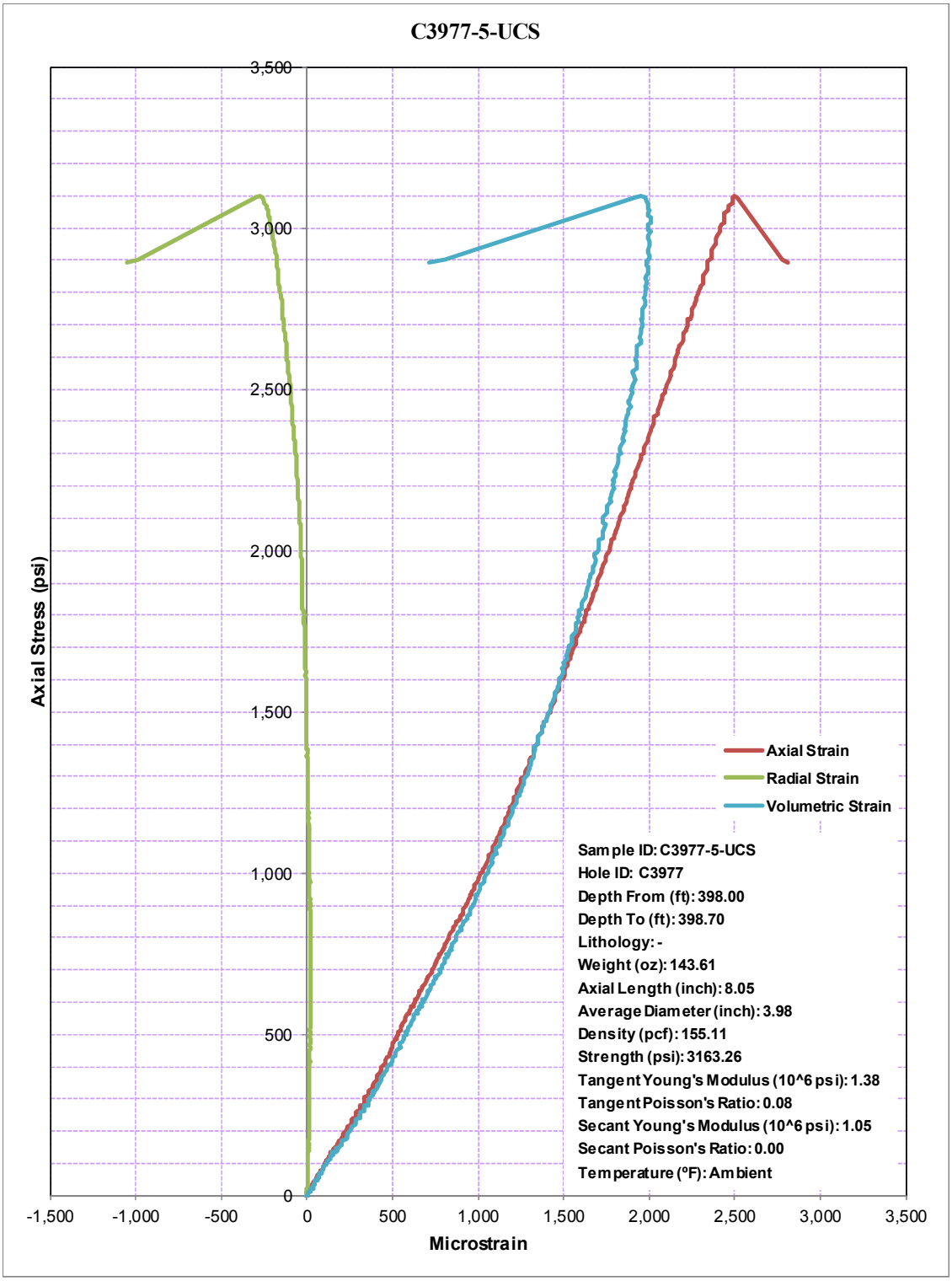
APPENDIX C

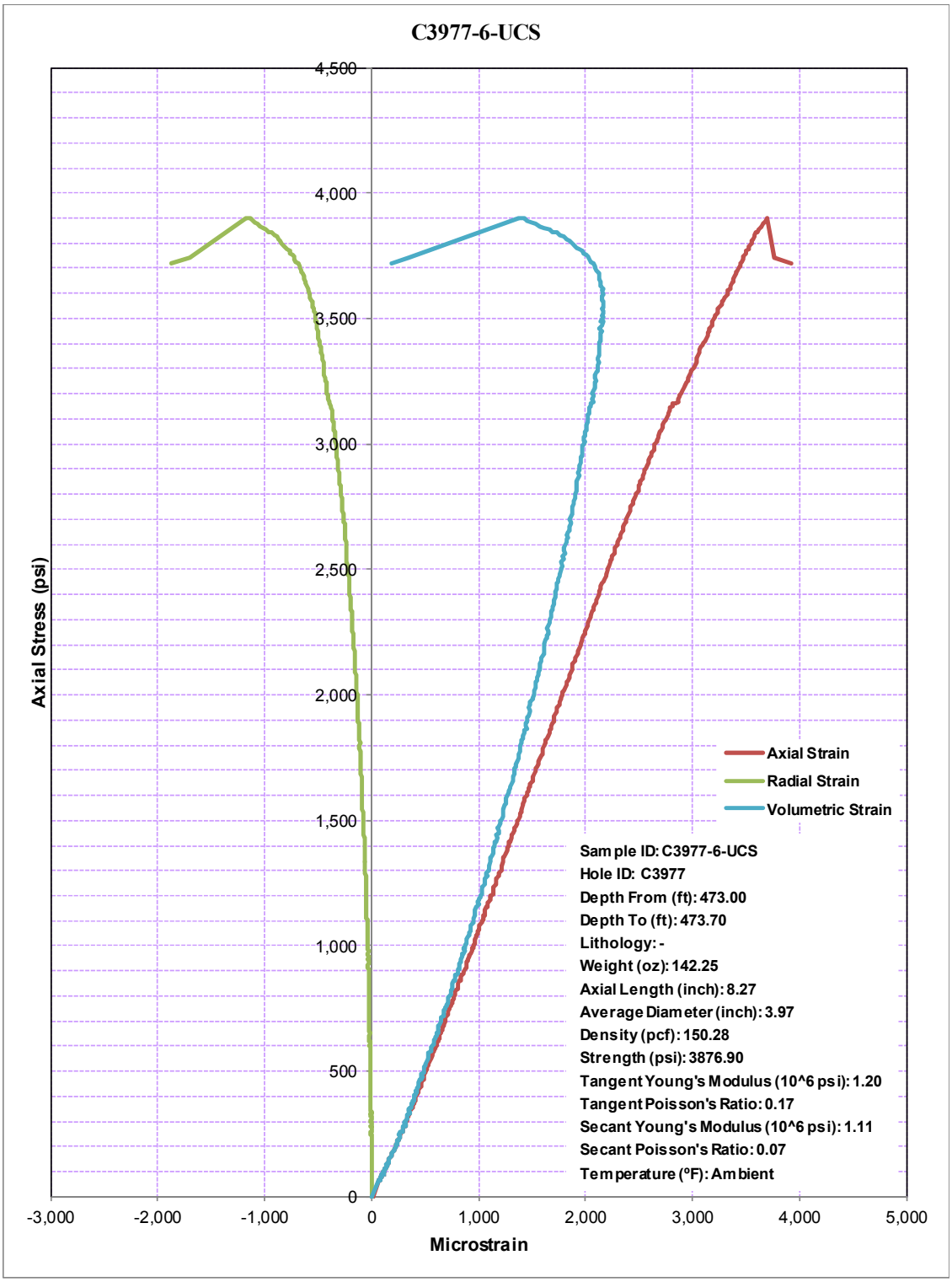
STRESS-STRAIN PLOTS FOR UNIAXIAL COMPRESSIVE STRENGTH TESTS

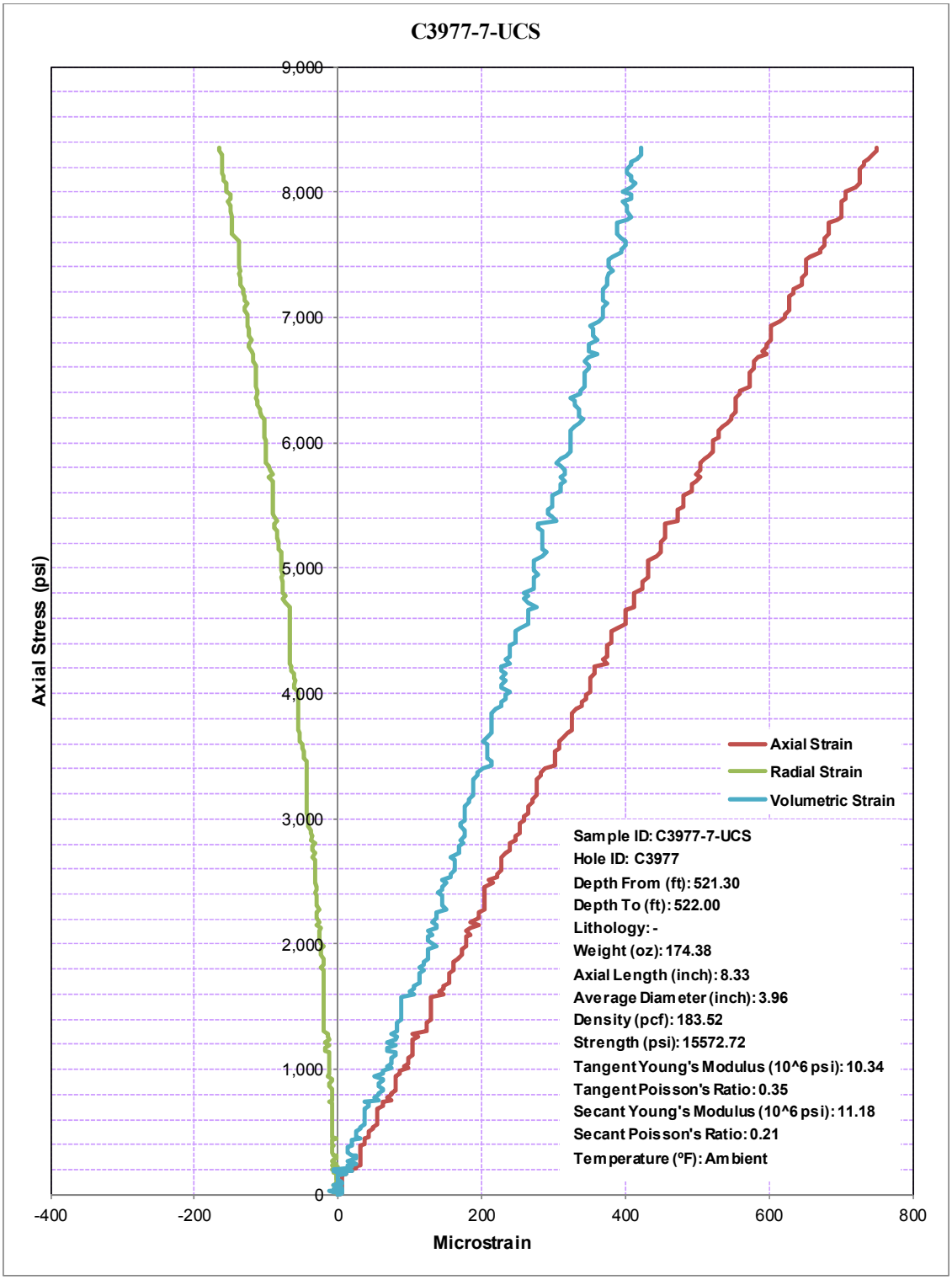

C3977-1-UCS
Axial Stress (psi)
800
700
600
500
400
300
200
100
0
-6,000
-4,000
-2,000
0
2,000
4,000
6,000
8,000
10,000
12,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-1-UCS
Hole ID: C3977
Depth From (ft): 164.30
Depth To (ft): 165.00
Lithology: -
Weight (oz): 124.19
Axial Length (inch): 8.06
Average Diameter (inch): 3.96
Density (pcf): 135.40
Strength (psi): 768.62
Tangent Young's Modulus (10^6 psi): 0.07
Tangent Poisson's Ratio: 0.20
Secant Young's Modulus (10^6 psi): 0.06
Secant Poisson's Ratio: 0.08
Temperature (°F): Ambient

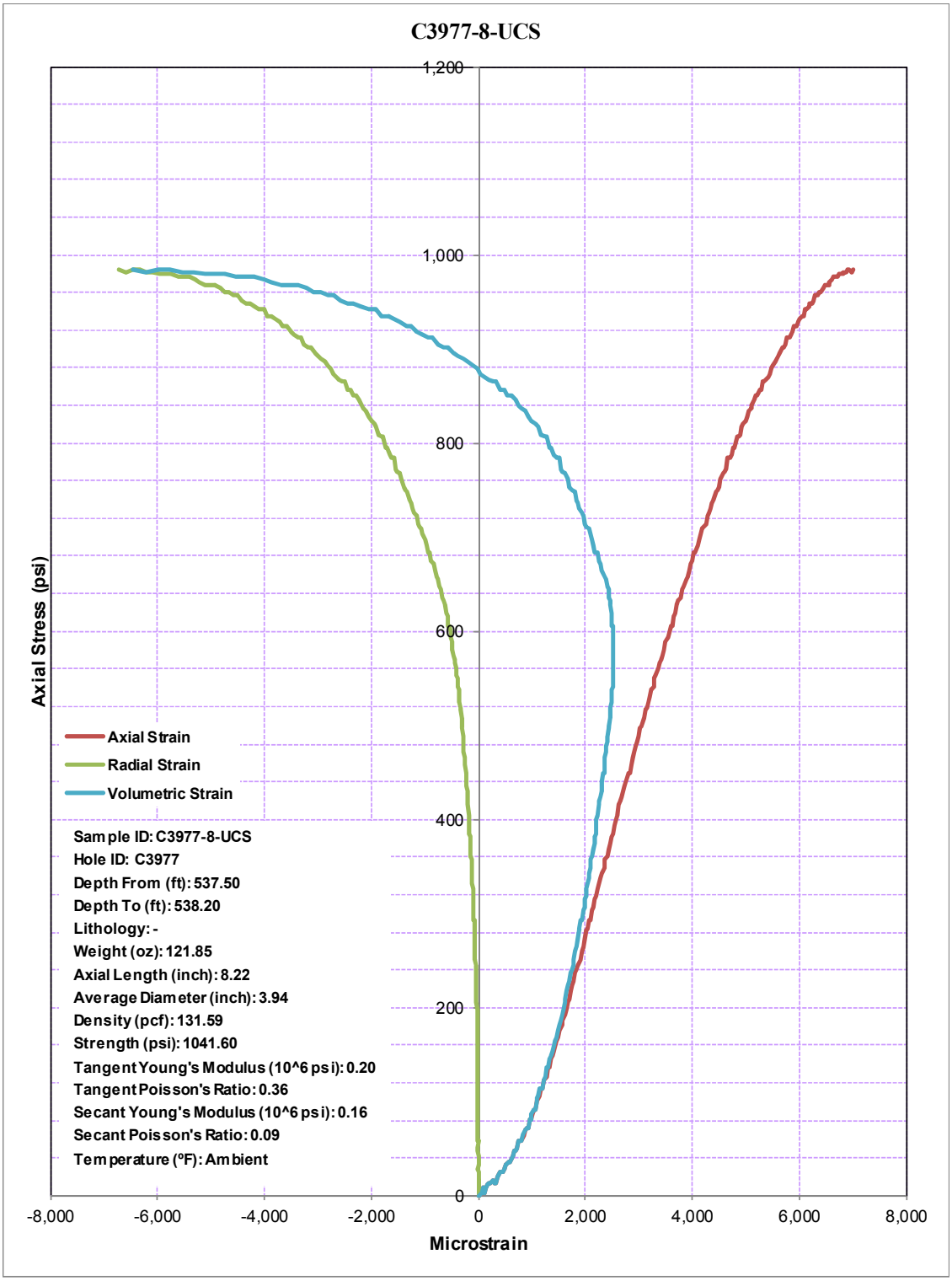

C3977-2-UCS
Axial Stress (psi)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
-500
0
500
1,000
1,500
2,000
2,500
3,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-2-UCS
Hole ID: C3977
Depth From (ft): 182.80
Depth To (ft): 183.50
Lithology: -
Weight (oz): 148.63
Axial Length (inch): 8.34
Average Diameter (inch): 3.97
Density (pcf): 155.71
Strength (psi): 16270.05
Tangent Young's Modulus (10^6 psi): 2.92
Tangent Poisson's Ratio: 0.31
Secant Young's Modulus (10^6 psi): 3.21
Secant Poisson's Ratio: 0.18
Temperature (°F): Ambient

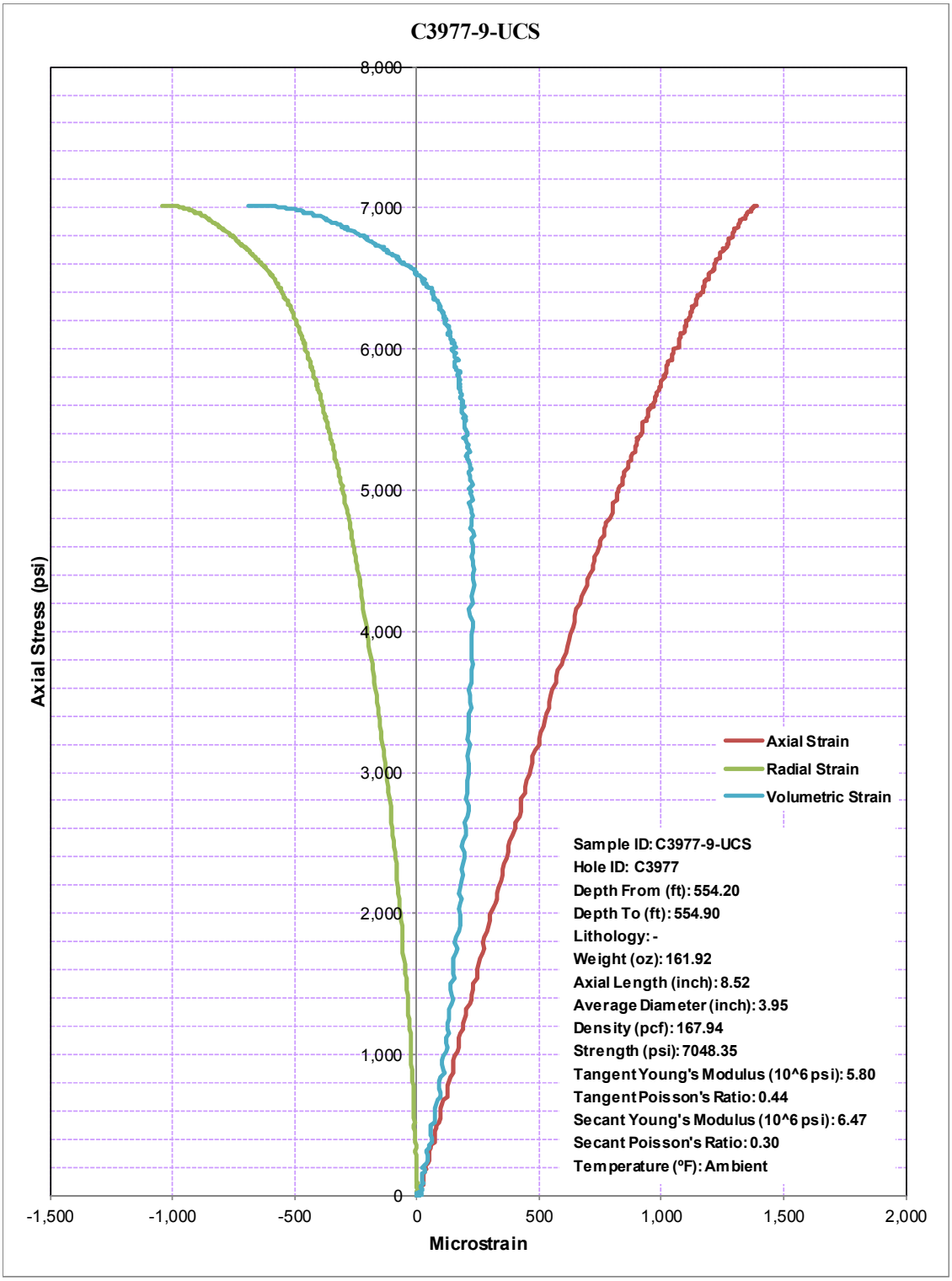

C3977-4-UCS
Axial Stress (psi)
6,000
5,000
4,000
3,000
2,000
1,000
0
-500
0
500
1,000
1,500
2,000
2,500
3,000
3,500
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-4-UCS
Hole ID: C3977
Depth From (ft): 329.00
Depth To (ft): 329.70
Lithology: -
Weight (oz): 152.93
Axial Length (inch): 8.37
Average Diameter (inch): 3.98
Density (pcf): 158.19
Strength (psi): 5615.45
Tangent Young's Modulus (10^6 psi): 2.09
Tangent Poisson's Ratio: 0.10
Secant Young's Modulus (10^6 psi): 1.50
Secant Poisson's Ratio: 0.03
Temperature (°F): Ambient

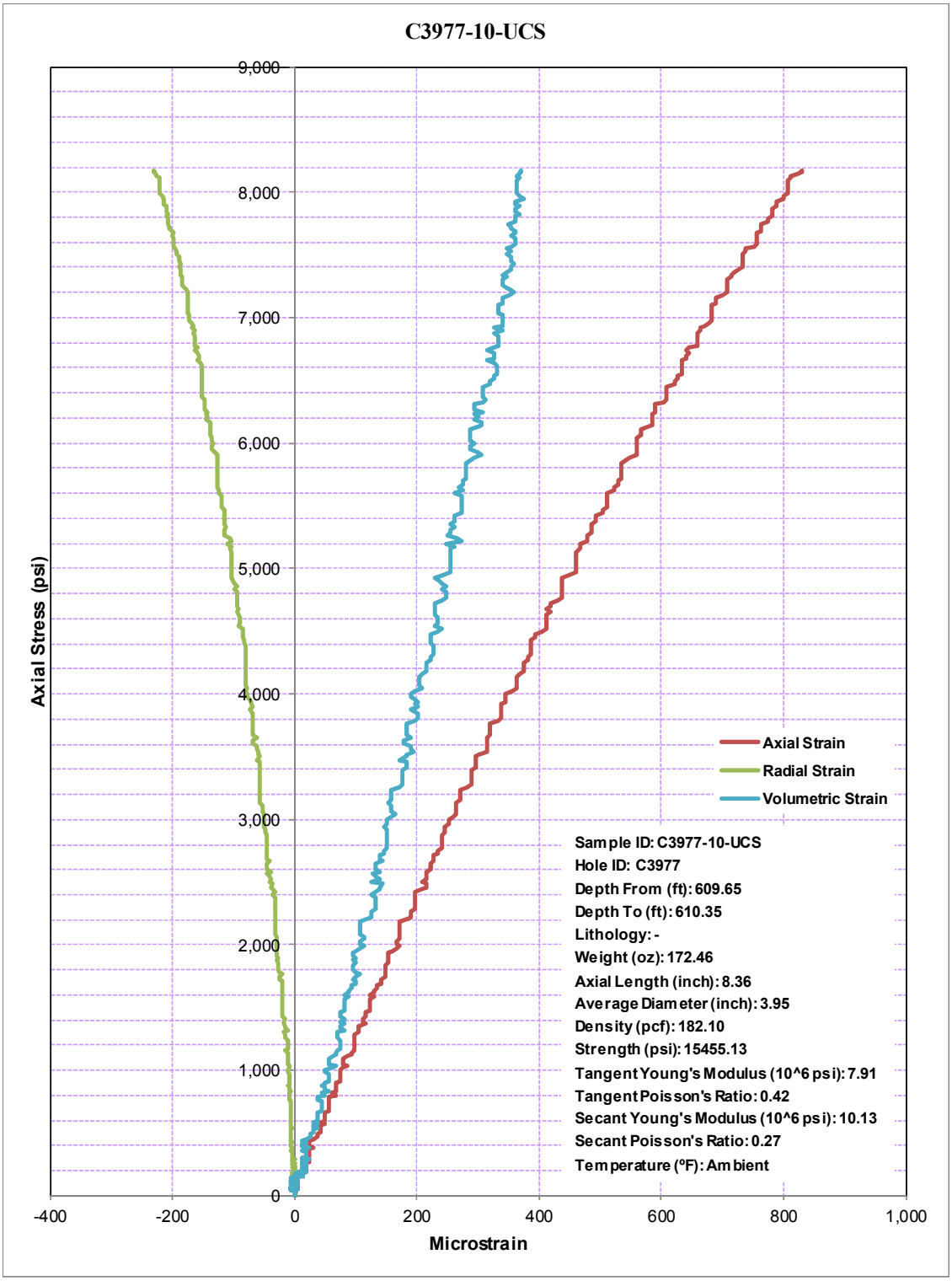

C3977-5-UCS
Axial Stress (psi)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
-1,500
-1,000
-500
0
500
1,000
1,500
2,000
2,500
3,000
3,500
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-5-UCS
Hole ID: C3977
Depth From (ft): 398.00
Depth To (ft): 398.70
Lithology: -
Weight (oz): 143.61
Axial Length (inch): 8.05
Average Diameter (inch): 3.98
Density (pcf): 155.11
Strength (psi): 3163.26
Tangent Young's Modulus (10^6 psi): 1.38
Tangent Poisson's Ratio: 0.08
Secant Young's Modulus (10^6 psi): 1.05
Secant Poisson's Ratio: 0.00
Temperature (°F): Ambient

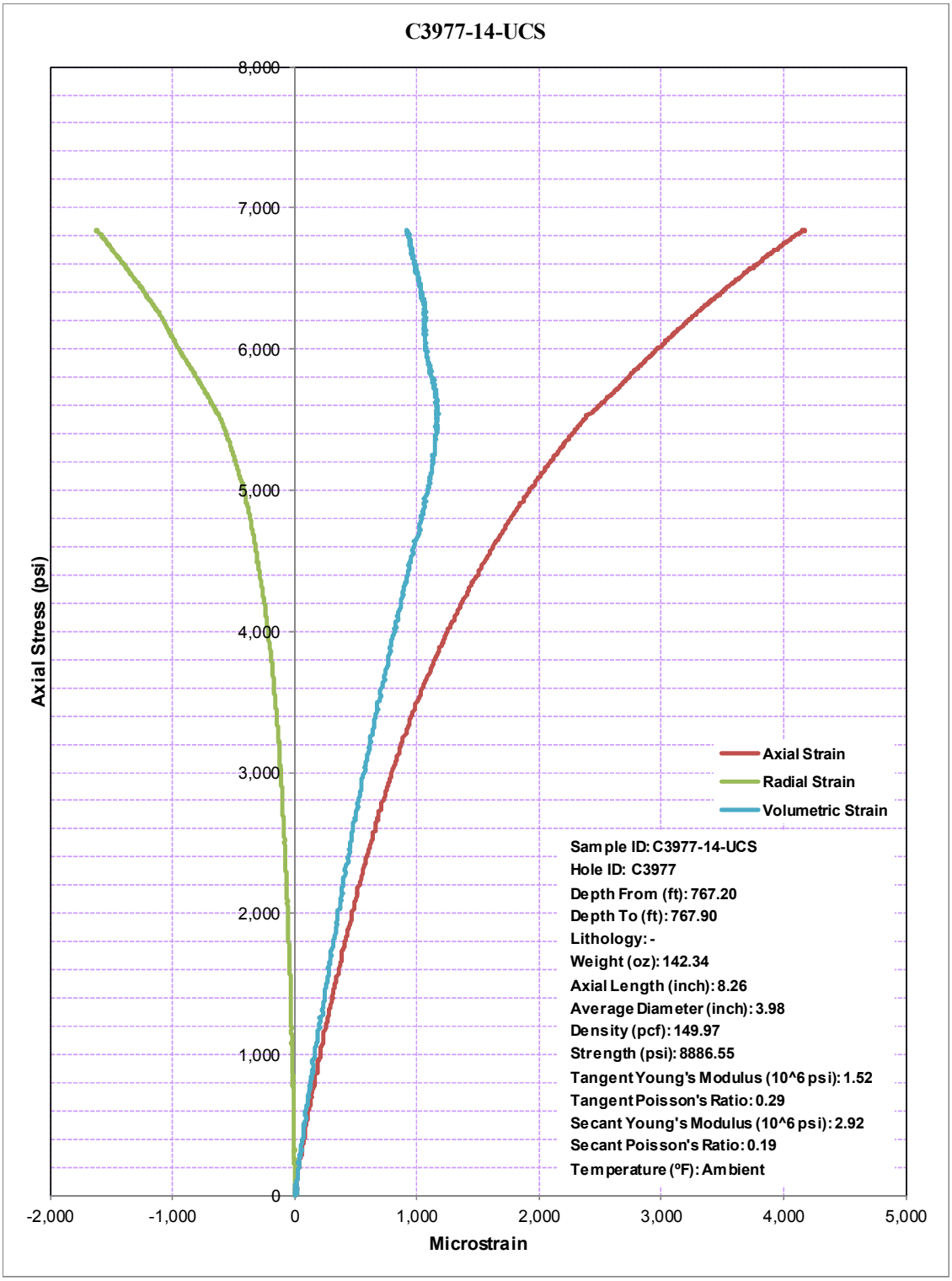

C3977-6-UCS
Axial Stress (psi)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
-3,000
-2,000
-1,000
0
1,000
2,000
3,000
4,000
5,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-6-UCS
Hole ID: C3977
Depth From (ft): 473.00
Depth To (ft): 473.70
Lithology: -
Weight (oz): 142.25
Axial Length (inch): 8.27
Average Diameter (inch): 3.97
Density (pcf): 150.28
Strength (psi): 3876.90
Tangent Young's Modulus (10^6 psi): 1.20
Tangent Poisson's Ratio: 0.17
Secant Young's Modulus (10^6 psi): 1.11
Secant Poisson's Ratio: 0.07
Temperature (°F): Ambient

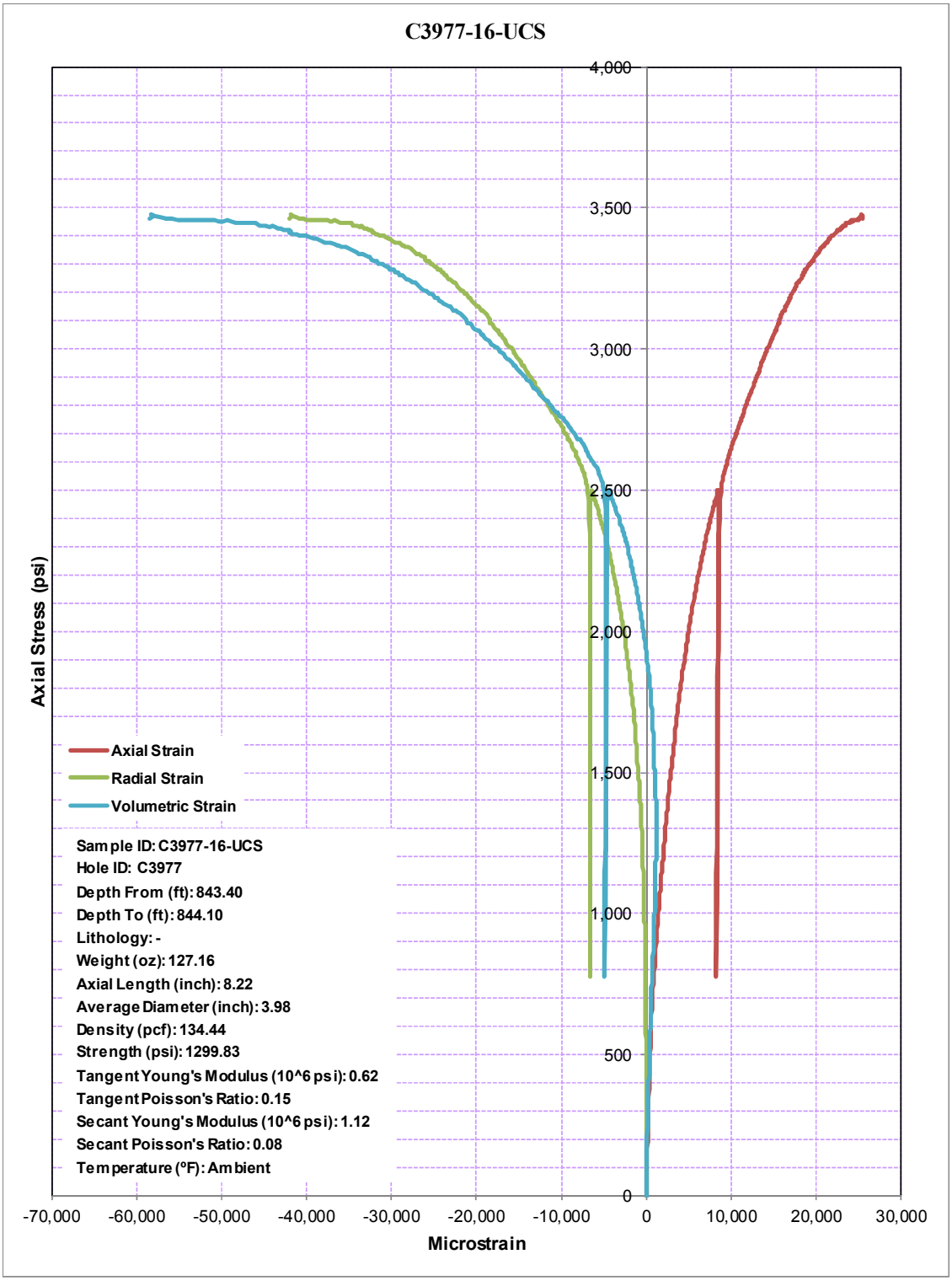

C3977-7-UCS
Axial Stress (psi)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-400
-200
0
200
400
600
800
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-7-UCS
Hole ID: C3977
Depth From (ft): 521.30
Depth To (ft): 522.00
Lithology: -
Weight (oz): 174.38
Axial Length (inch): 8.33
Average Diameter (inch): 3.96
Density (pcf): 183.52
Strength (psi): 15572.72
Tangent Young's Modulus (10^6 psi): 10.34
Tangent Poisson's Ratio: 0.35
Secant Young's Modulus (10^6 psi): 11.18
Secant Poisson's Ratio: 0.21
Temperature (°F): Ambient

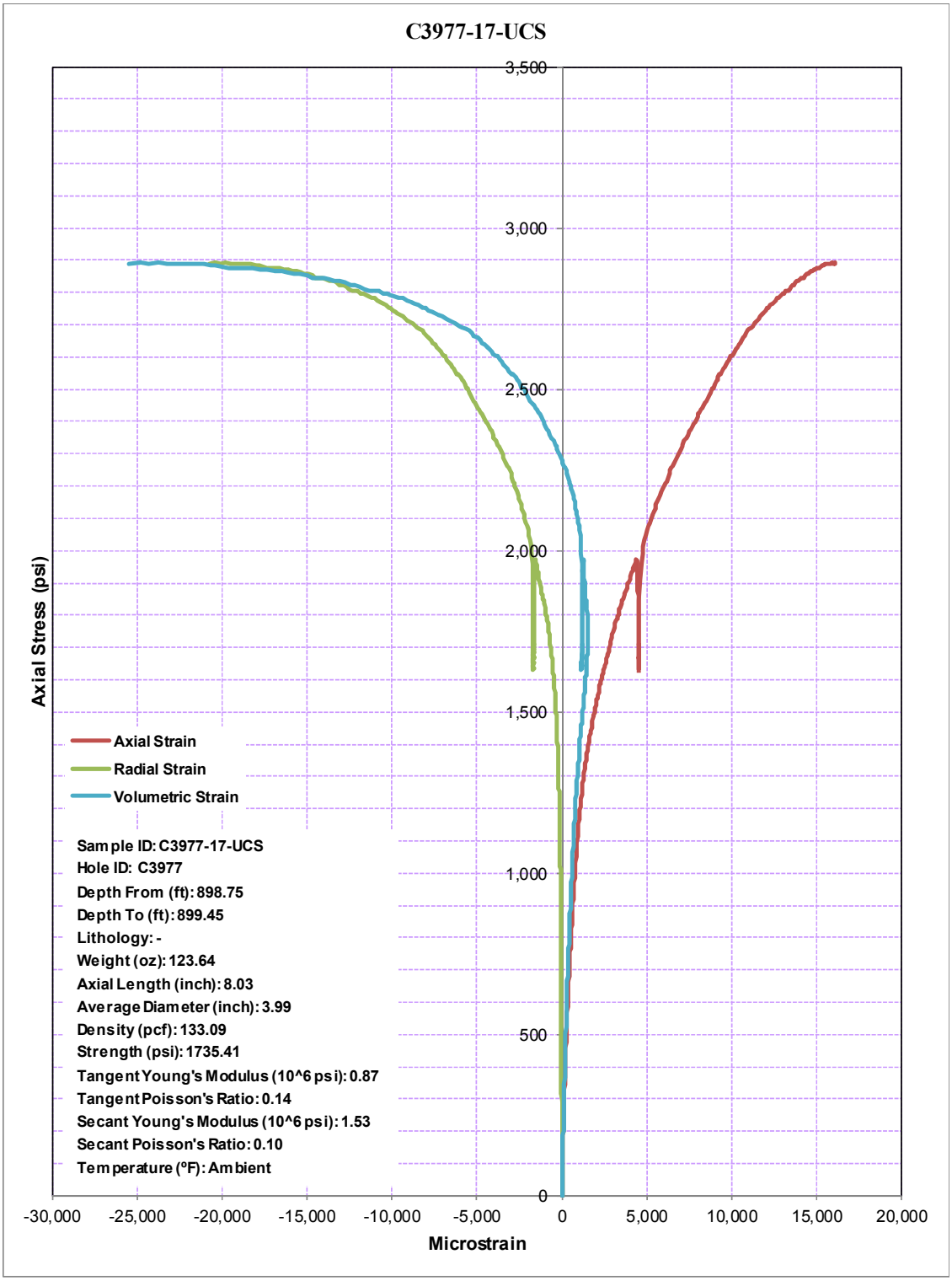

C3977-8-UCS
1,200
1,000
800
600
400
200
0
Axial Stress (psi)
-8,000
-6,000
-4,000
-2,000
0
2,000
4,000
6,000
8,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-8-UCS
Hole ID: C3977
Depth From (ft): 537.50
Depth To (ft): 538.20
Lithology: -
Weight (oz): 121.85
Axial Length (inch): 8.22
Average Diameter (inch): 3.94
Density (pcf): 131.59
Strength (psi): 1041.60
Tangent Young's Modulus (10^6 psi): 0.20
Tangent Poisson's Ratio: 0.36
Secant Young's Modulus (10^6 psi): 0.16
Secant Poisson's Ratio: 0.09
Temperature (°F): Ambient

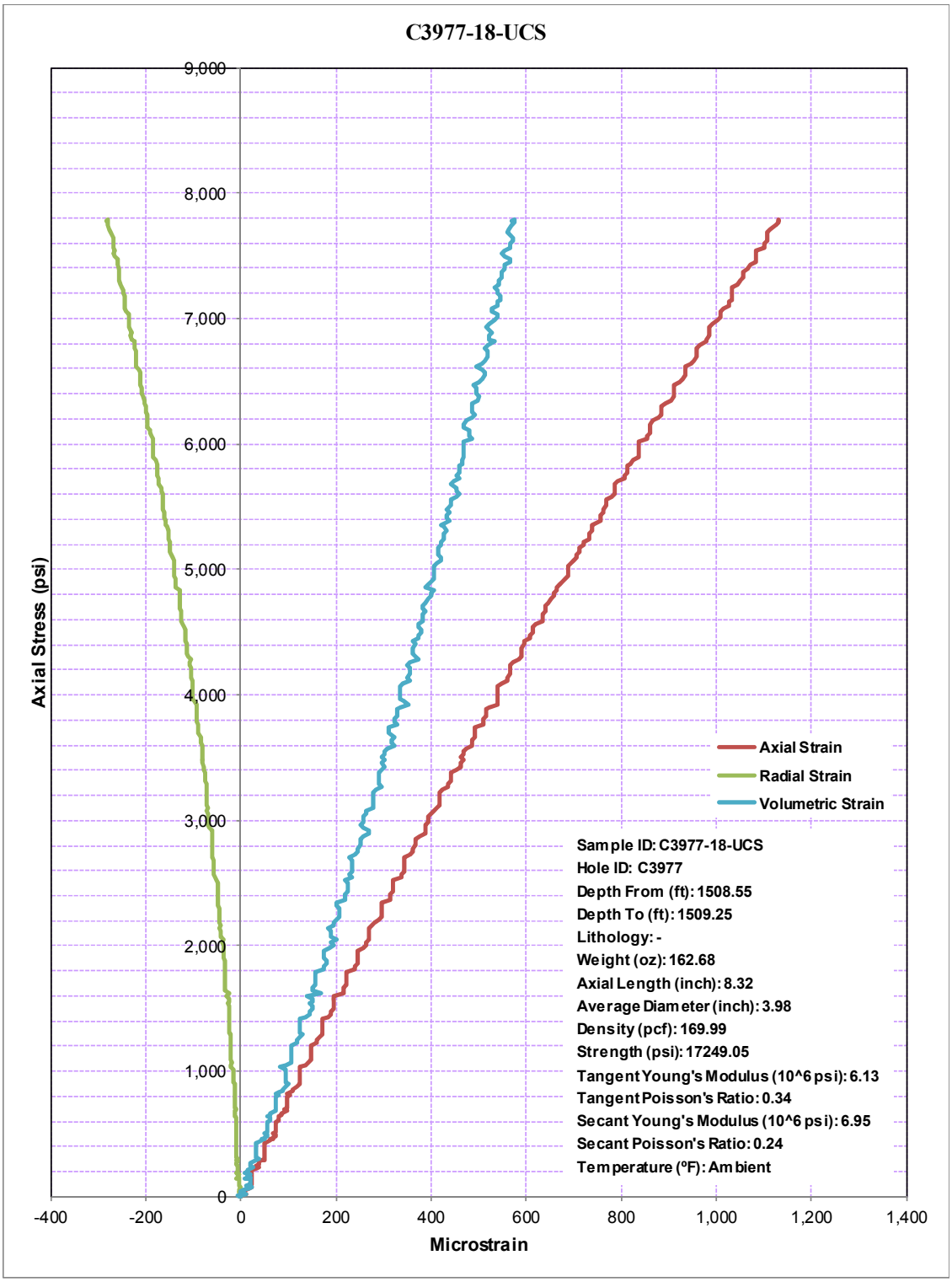

C3977-9-UCS
Axial Stress (psi)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,500
-1,000
-500
0
500
1,000
1,500
2,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-9-UCS
Hole ID: C3977
Depth From (ft): 554.20
Depth To (ft): 554.90
Lithology: -
Weight (oz): 161.92
Axial Length (inch): 8.52
Average Diameter (inch): 3.95
Density (pcf): 167.94
Strength (psi): 7048.35
Tangent Young's Modulus (10^6 psi): 5.80
Tangent Poisson's Ratio: 0.44
Secant Young's Modulus (10^6 psi): 6.47
Secant Poisson's Ratio: 0.30
Temperature (ºF): Ambient

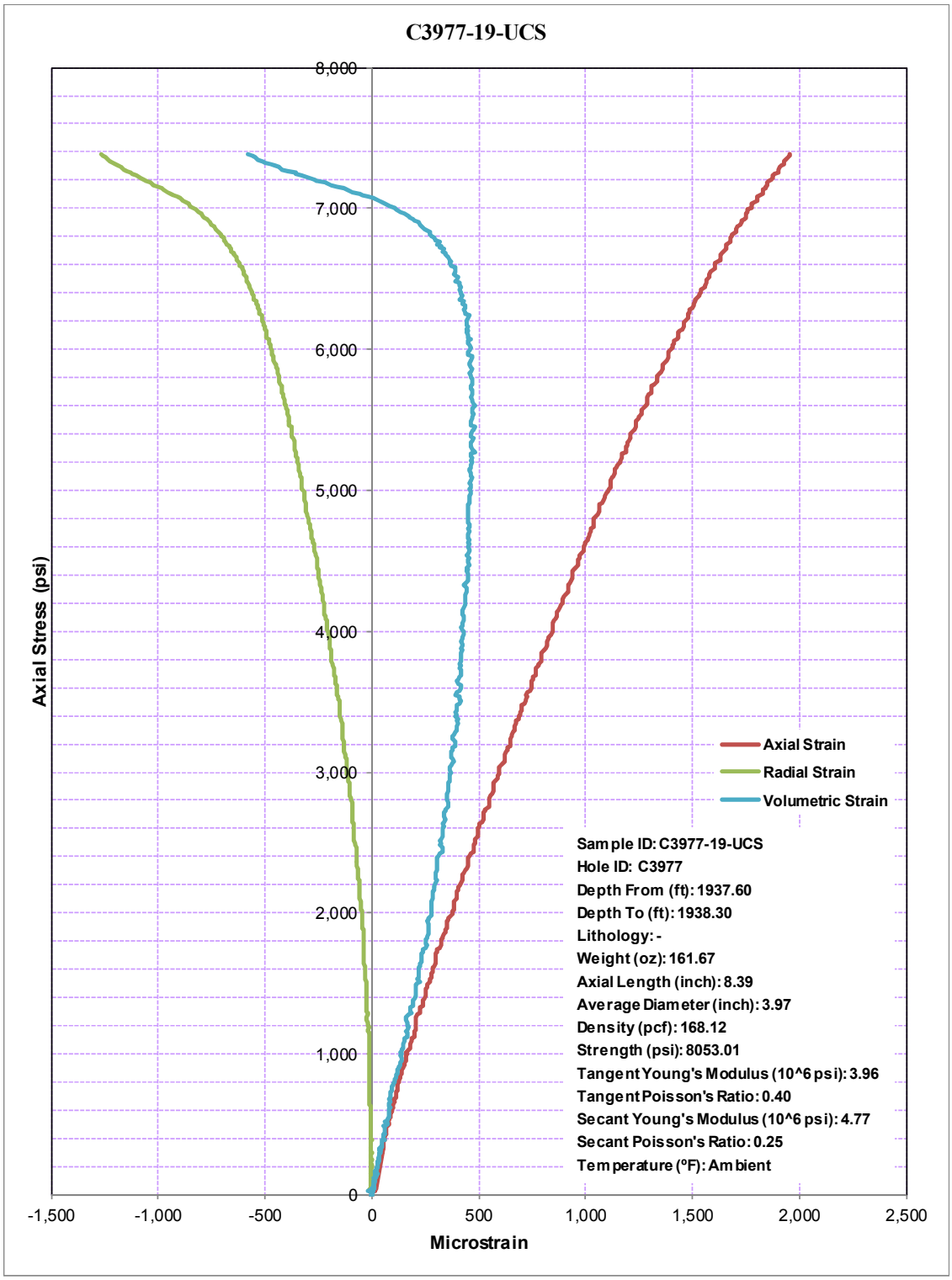

C3977-10-UCS
Axial Stress (psi)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-400
-200
0
200
400
600
800
1,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-10-UCS
Hole ID: C3977
Depth From (ft): 609.65
Depth To (ft): 610.35
Lithology: -
Weight (oz): 172.46
Axial Length (inch): 8.36
Average Diameter (inch): 3.95
Density (pcf): 182.10
Strength (psi): 15455.13
Tangent Young's Modulus (10^6 psi): 7.91
Tangent Poisson's Ratio: 0.42
Secant Young's Modulus (10^6 psi): 10.13
Secant Poisson's Ratio: 0.27
Temperature (°F): Ambient

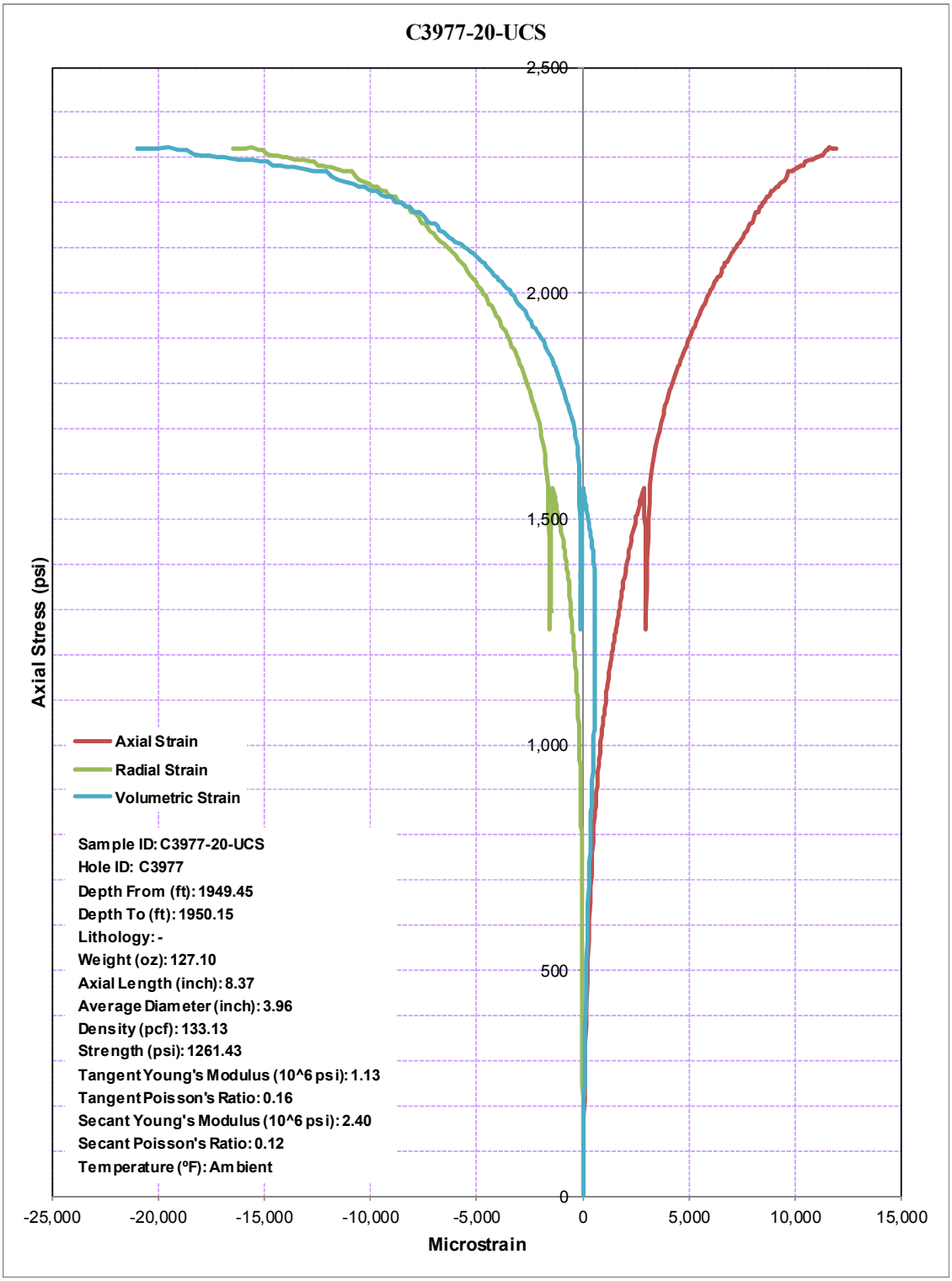

C3977-14-UCS
Axial Stress (psi)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-2,000
-1,000
0
1,000
2,000
3,000
4,000
5,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-14-UCS
Hole ID: C3977
Depth From (ft): 767.20
Depth To (ft): 767.90
Lithology: -
Weight (oz): 142.34
Axial Length (inch): 8.26
Average Diameter (inch): 3.98
Density (pcf): 149.97
Strength (psi): 8886.55
Tangent Young's Modulus (10^6 psi): 1.52
Tangent Poisson's Ratio: 0.29
Secant Young's Modulus (10^6 psi): 2.92
Secant Poisson's Ratio: 0.19
Temperature (°F): Ambient

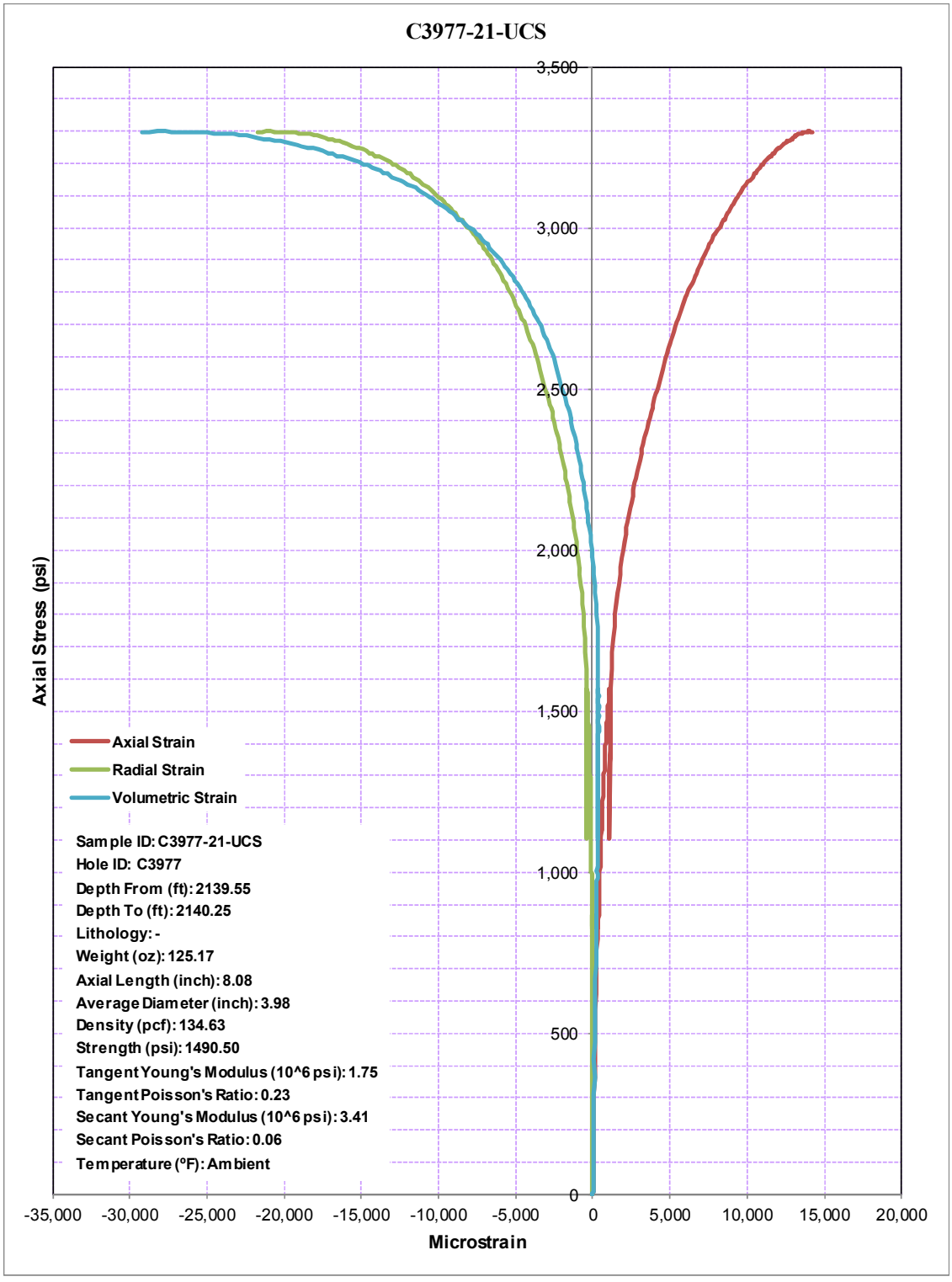

C3977-16-UCS
Axial Stress (psi)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
-70,000
-60,000
-50,000
-40,000
-30,000
-20,000
-10,000
0
10,000
20,000
30,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-16-UCS
Hole ID: C3977
Depth From (ft): 843.40
Depth To (ft): 844.10
Lithology: -
Weight (oz): 127.16
Axial Length (inch): 8.22
Average Diameter (inch): 3.98
Density (pcf): 134.44
Strength (psi): 1299.83
Tangent Young's Modulus (10^6 psi): 0.62
Tangent Poisson's Ratio: 0.15
Secant Young's Modulus (10^6 psi): 1.12
Secant Poisson's Ratio: 0.08
Temperature (°F): Ambient


C3977-17-UCS
Axial Stress (psi)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
-30,000
-25,000
-20,000
-15,000
-10,000
-5,000
0
5,000
10,000
15,000
20,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-17-UCS
Hole ID: C3977
Depth From (ft): 898.75
Depth To (ft): 899.45
Lithology: -
Weight (oz): 123.64
Axial Length (inch): 8.03
Average Diameter (inch): 3.99
Density (pcf): 133.09
Strength (psi): 1735.41
Tangent Young's Modulus (10^6 psi): 0.87
Tangent Poisson's Ratio: 0.14
Secant Young's Modulus (10^6 psi): 1.53
Secant Poisson's Ratio: 0.10
Temperature (°F): Ambient


C3977-18-UCS
Axial Stress (psi)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-400
-200
0
200
400
600
800
1,000
1,200
1,400
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-18-UCS
Hole ID: C3977
Depth From (ft): 1508.55
Depth To (ft): 1509.25
Lithology: -
Weight (oz): 162.68
Axial Length (inch): 8.32
Average Diameter (inch): 3.98
Density (pcf): 169.99
Strength (psi): 17249.05
Tangent Young's Modulus (10^6 psi): 6.13
Tangent Poisson's Ratio: 0.34
Secant Young's Modulus (10^6 psi): 6.95
Secant Poisson's Ratio: 0.24
Temperature (ºF): Ambient


C3977-19-UCS
Axial Stress (psi)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,500
-1,000
-500
0
500
1,000
1,500
2,000
2,500
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-19-UCS
Hole ID: C3977
Depth From (ft): 1937.60
Depth To (ft): 1938.30
Lithology: -
Weight (oz): 161.67
Axial Length (inch): 8.39
Average Diameter (inch): 3.97
Density (pcf): 168.12
Strength (psi): 8053.01
Tangent Young's Modulus (10^6 psi): 3.96
Tangent Poisson's Ratio: 0.40
Secant Young's Modulus (10^6 psi): 4.77
Secant Poisson's Ratio: 0.25
Temperature (°F): Ambient


C3977-20-UCS
2,500
2,000
1,500
1,000
500
0
Axial Stress (psi)
-25,000
-20,000
-15,000
-10,000
-5,000
0
5,000
10,000
15,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-20-UCS
Hole ID: C3977
Depth From (ft): 1949.45
Depth To (ft): 1950.15
Lithology: -
Weight (oz): 127.10
Axial Length (inch): 8.37
Average Diameter (inch): 3.96
Density (pcf): 133.13
Strength (psi): 1261.43
Tangent Young's Modulus (10^6 psi): 1.13
Tangent Poisson's Ratio: 0.16
Secant Young's Modulus (10^6 psi): 2.40
Secant Poisson's Ratio: 0.12
Temperature (°F): Ambient


C3977-21-UCS
Axial Stress (psi)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
-35,000
-30,000
-25,000
-20,000
-15,000
-10,000
-5,000
0
5,000
10,000
15,000
20,000
Microstrain
Axial Strain
Radial Strain
Volumetric Strain
Sample ID: C3977-21-UCS
Hole ID: C3977
Depth From (ft): 2139.55
Depth To (ft): 2140.25
Lithology: -
Weight (oz): 125.17
Axial Length (inch): 8.08
Average Diameter (inch): 3.98
Density (pcf): 134.63
Strength (psi): 1490.50
Tangent Young's Modulus (10^6 psi): 1.75
Tangent Poisson's Ratio: 0.23
Secant Young's Modulus (10^6 psi): 3.41
Secant Poisson's Ratio: 0.06
Temperature (°F): Ambient

APPENDIX D

SPLITTING TENSILE STRENGTH (BRAZILIAN) TEST DATA SHEET

Agapito Associates, Inc.
INDIRECT TENSILE STRENGTH (BRAZILIAN) TESTS

CLIENT	SRK	**HOLE NUMBER**	C3977
JOB NUMBER	337-27	**MOISTURE CONDITION**	As Received
DATE	May 23, 2017	**TEMPERATURE**	70°C

Specimen No.	Hole No.	Depth From (ft)	Depth To (ft)	Length of Interval (ft)	Weight (oz)	Diameter D_1 (in)	Diameter D_2 (in)	Axial Length (inch)	Area ($inch^2$)	Density (pcf)	Specific Gravity
C3977-1-B	C3977	163.90	164.10	0.20	33.74	3.96	3.95	2.26	12.27	131	2.11
C3977-2-B	C3977	182.60	182.80	0.20	35.21	3.98	3.98	1.99	12.44	153	2.46
C3977-4-B	C3977	329.70	329.90	0.20	43.37	3.97	3.97	2.35	12.37	161	2.58
C3977-5-B	C3977	398.70	398.90	0.20	37.71	3.96	3.96	2.18	12.29	152	2.44
C3977-6-B	C3977	472.80	473.00	0.20	37.80	3.97	3.97	2.19	12.36	151	2.42
C3977-7-B	C3977	522.00	522.20	0.20	48.77	3.96	3.96	2.33	12.30	184	2.95
C3977-8-B	C3977	538.20	538.40	0.20	36.16	3.92	3.92	2.34	12.07	138	2.22
C3977-9-B	C3977	554.90	555.10	0.20	43.69	3.95	3.95	2.19	12.24	176	2.82
C3977-10-B	C3977	610.40	610.60	0.20	48.72	3.95	3.95	2.35	12.24	183	2.93
C3977-11-B	C3977	*Not Enough Sample*									
C3977-13-B	C3977	707.75	707.95	0.20	37.03	3.96	4.01	2.50	12.47	128	2.06
C3977-14-B	C3977	768.05	768.25	0.20	37.65	3.95	3.95	2.19	12.27	151	2.43
C3977-16-B	C3977	844.35	844.55	0.20	37.78	3.97	3.97	2.46	12.37	134	2.15
C3977-17-B	C3977	898.40	898.60	0.20	41.97	3.97	3.97	2.29	12.36	160	2.57
C3977-18-B	C3977	1,507.80	1,508.00	0.20	44.10	3.96	3.96	2.30	12.30	168	2.70
C3977-19-B	C3977	1,838.30	1,838.50	0.20	39.01	3.97	3.96	2.04	12.34	168	2.69
C3977-20-B	C3977	1,949.25	1,949.45	0.20	33.13	3.95	3.95	2.20	12.25	133	2.12
C3977-21-B	C3977	2,140.25	2,140.45	0.20	35.35	3.97	3.96	2.32	12.36	133	2.13

Specimen No.	Lithological Description	Failure Load (lb)	Splitting Tensile Strength (psi)	Failure Mode Notes
C3977-1-B	–	1,555	111	
C3977-2-B	–	16,645	1,336	
C3977-4-B	–	10,870	741	
C3977-5-B	–	7,265	537	
C3977-6-B	–	5,810	426	
C3977-7-B	–	10,800	747	
C3977-8-B	–	2,945	205	
C3977-9-B	–	18,650	1,371	
C3977-10-B	–	14,005	961	
C3977-11-B	*Not Enough Sample*			
C3977-13-B	–	1,510	97	
C3977-14-B	–	14,390	1,059	
C3977-16-B	–	4,470	292	
C3977-17-B	–	8,175	573	
C3977-18-B	–	8,430	590	
C3977-19-B	–	5,685	448	
C3977-20-B	–	2,635	193	
C3977-21-B	–	2,820	195	

APPENDIX E

BEFORE AND AFTER PHOTOGRAPHS OF SPLITTING TENSILE STRENGTH (BRAZILIAN) TEST SPECIMENS



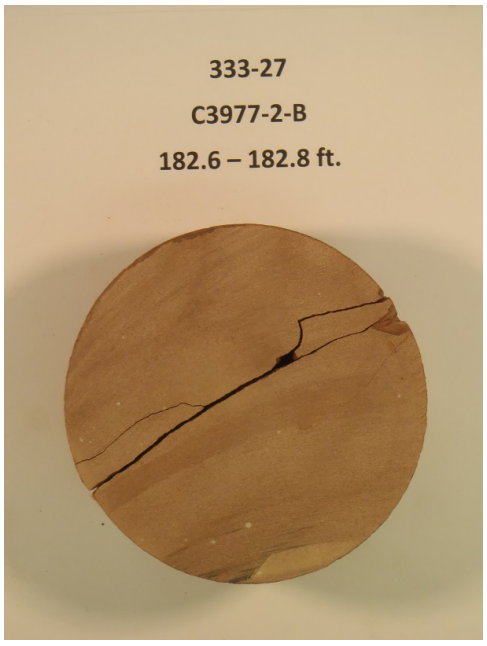
C3977-1-B (163.9-164.1 ft)—Before



C3977-1-B (163.9-164.1 ft)——After

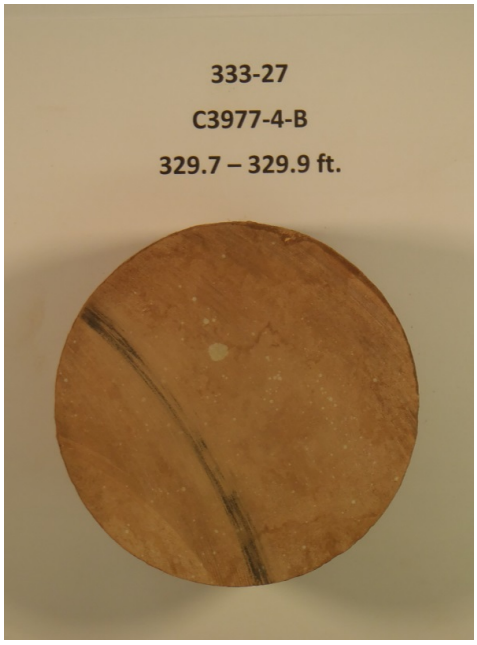


C3977-2-B (182.6-182.8 ft)—Before

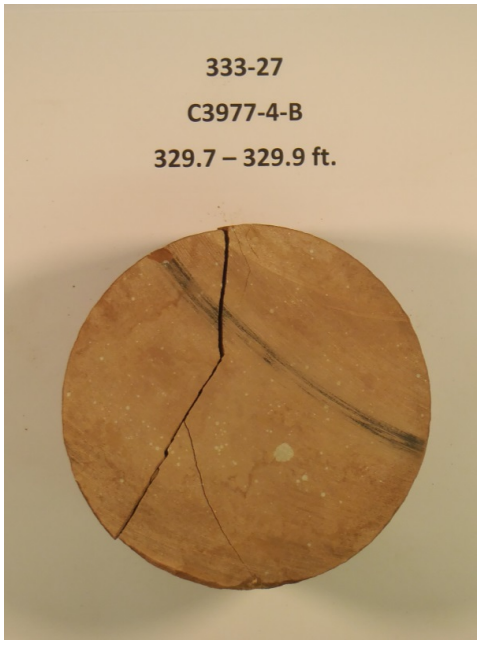


C3977-2-B (182.6-182.8 ft)—After

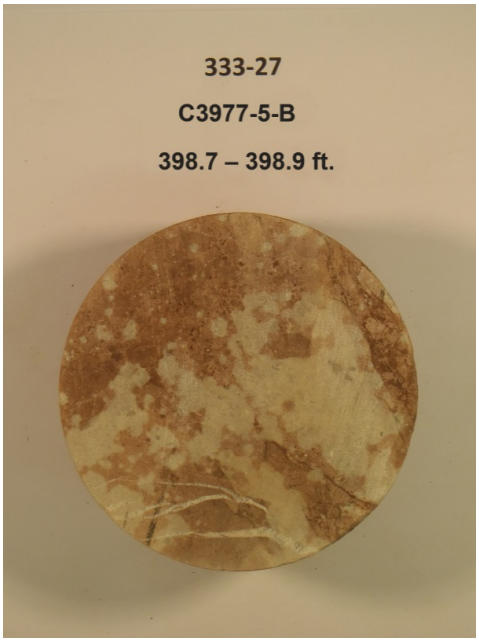
Figure E-1. Before and After Photographs of Triaxial Compressive Strength Test Specimens



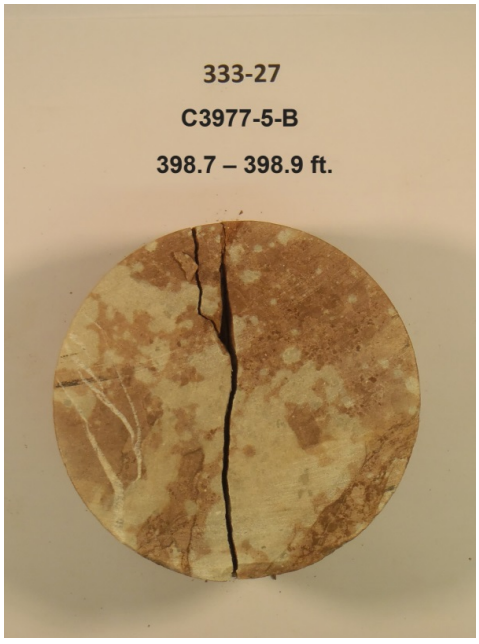
C3977-4-B (329.7-329.9 ft)—Before



C3977-4-B (329.7-329.9 ft)—After

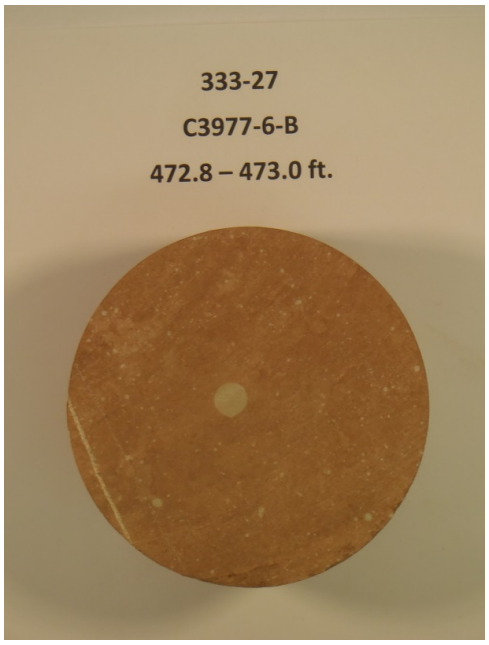


C3977-5-B (398.7-398.9 ft)—Before

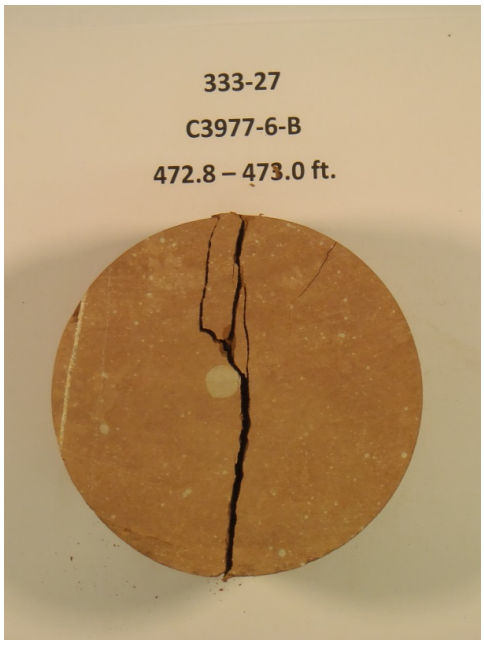


C3977-5-B (398.7-398.9 ft)—After

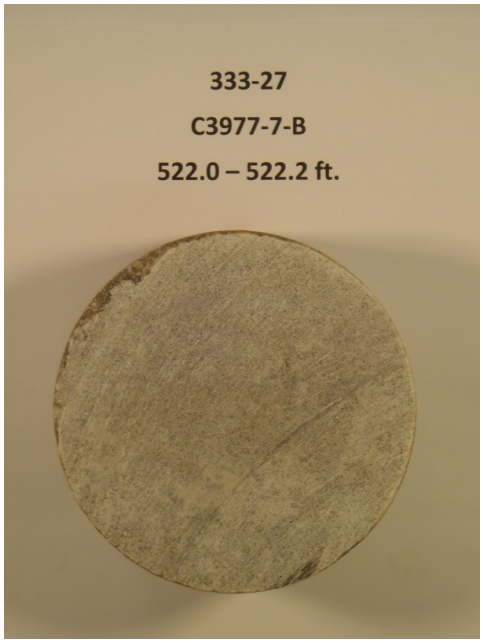
Figure E-1. Before and After Photographs of Triaxial Compressive Strength Test Specimens *(continued)*



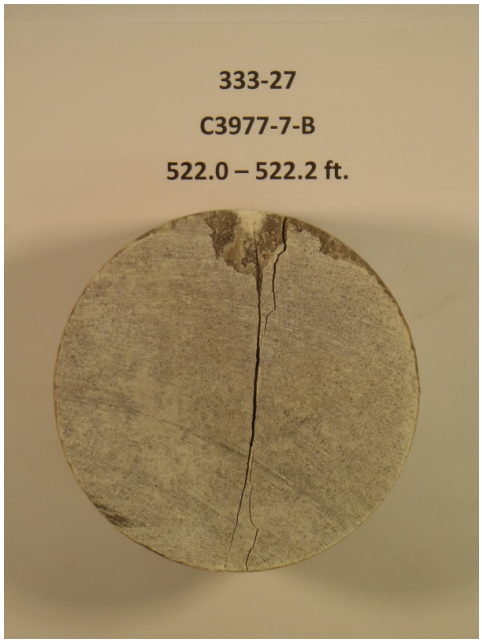
C3977-6-B (472.8-473.0 ft)—Before



C3977-6-B (472.8-473.0 ft)—After

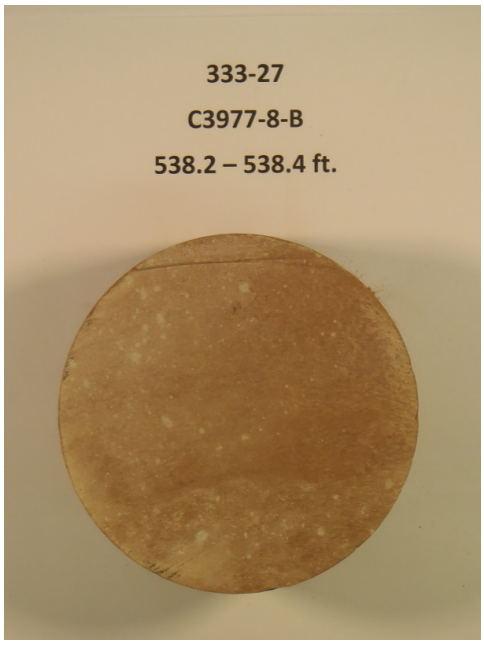


C3977-7-B (522.0-522.2 ft)—Before

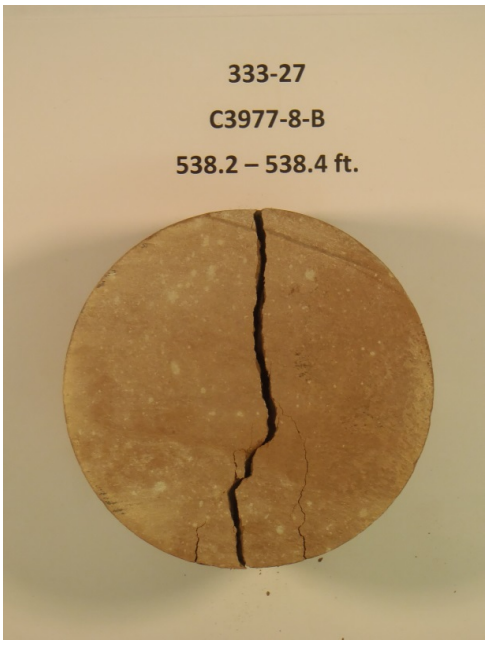


C3977-7-B (522.0-522.2 ft)—After

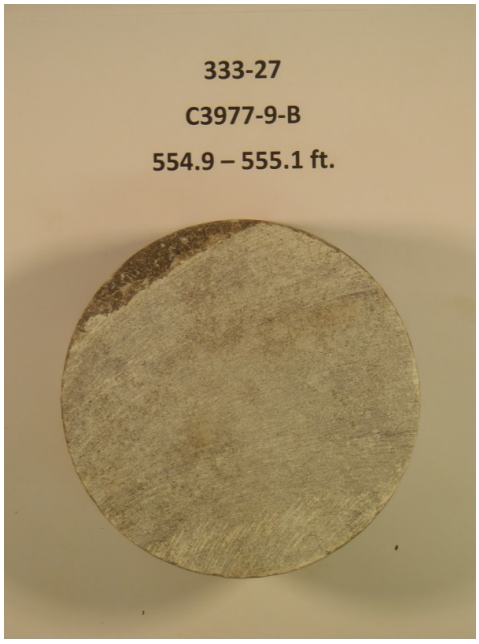
Figure E-1. Before and After Photographs of Triaxial Compressive Strength Test Specimens *(continued)*



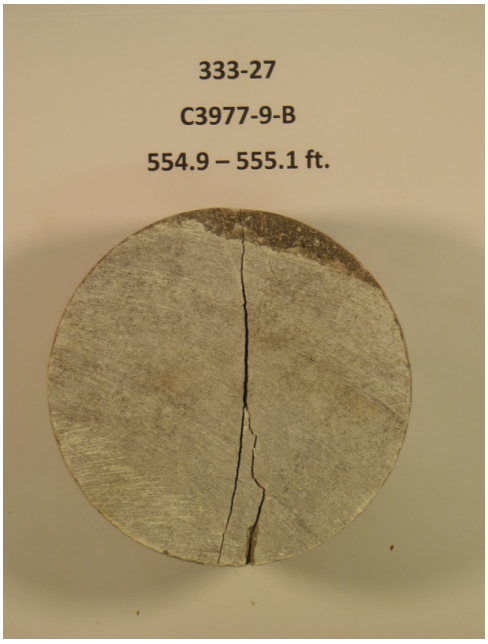
C3977-8-B (538.2-538.4 ft)—Before



C3977-8-B (538.2-538.4 ft)—After

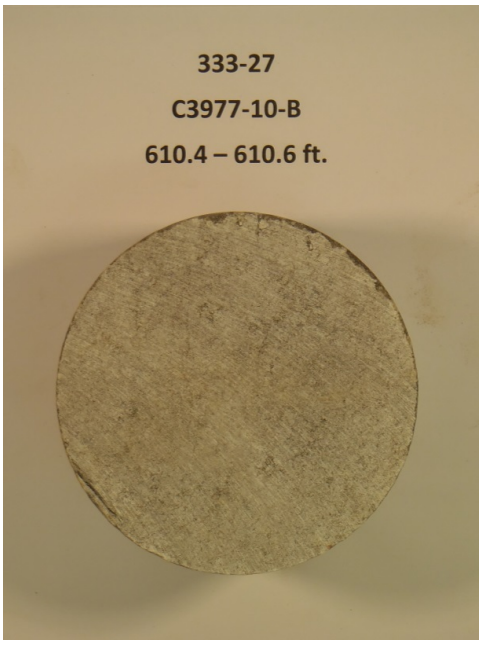


C3977-9-B (554.9-555.1 ft)—Before

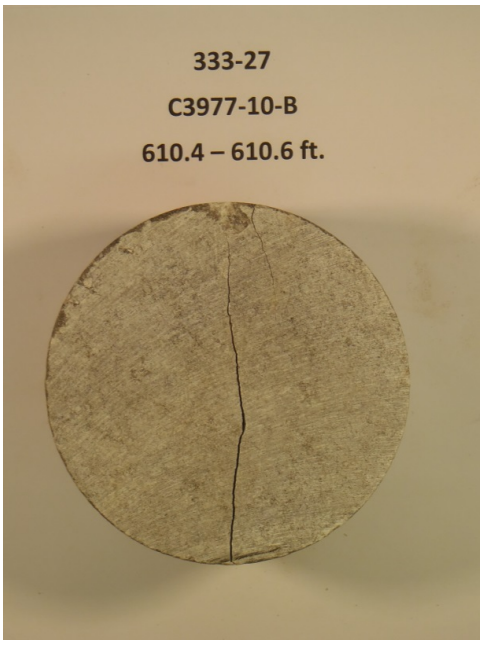


C3977-9-B (554.9-555.1 ft)—After

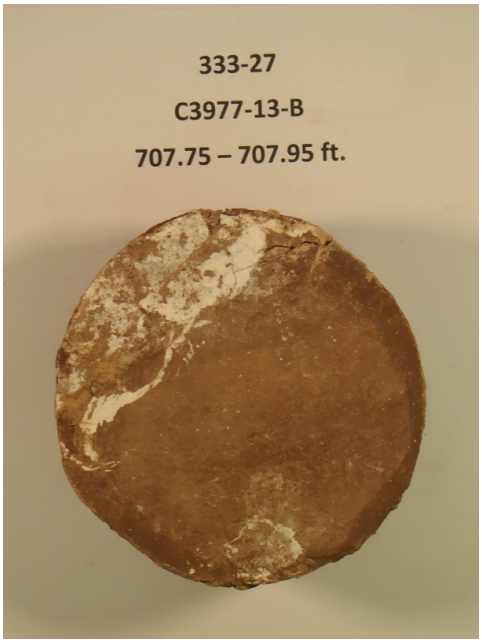
Figure E-1. Before and After Photographs of Triaxial Compressive Strength Test Specimens *(continued)*



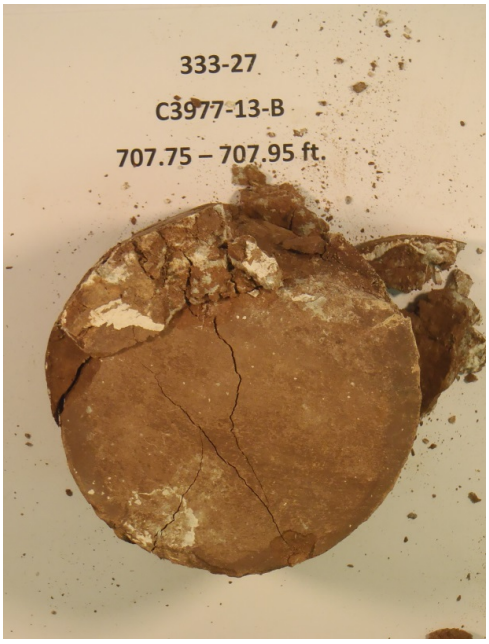
C3977-10-B (610.4-610.6 ft)—Before



C3977-10-B (610.4-610.6 ft)—After

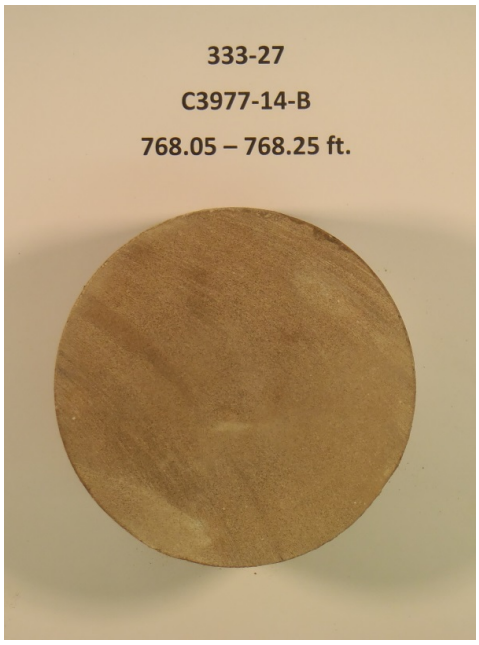


C3977-13-B (707.75-707.95 ft)—Before

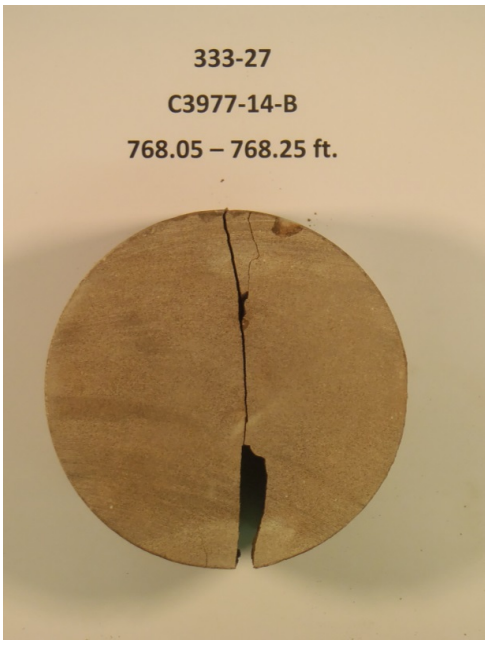


C3977-13-B (707.75-707.95 ft)—After

Figure E-1. Before and After Photographs of Triaxial Compressive Strength Test Specimens *(continued)*



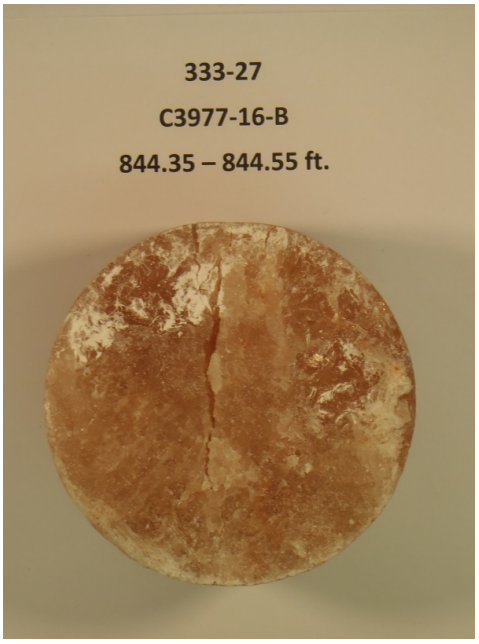
C3977-14-B (768.05-768.25 ft)—Before



C3977-14-B (768.05-768.25 ft)—After

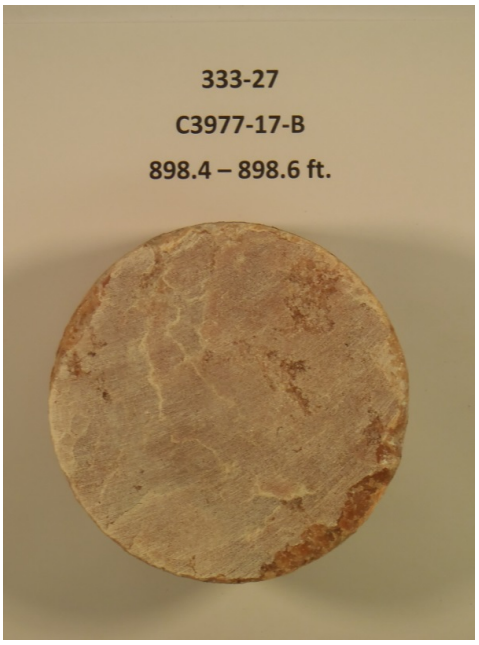


C3977-16-B (844.35-844.55 ft)—Before

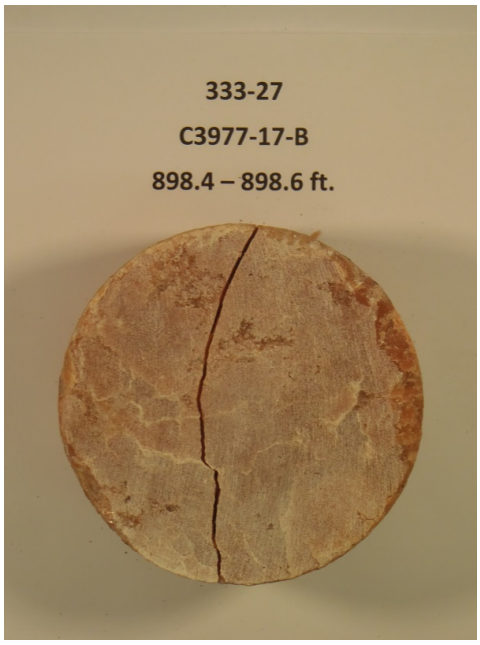


C3977-16-B (844.35-844.55 ft)—After

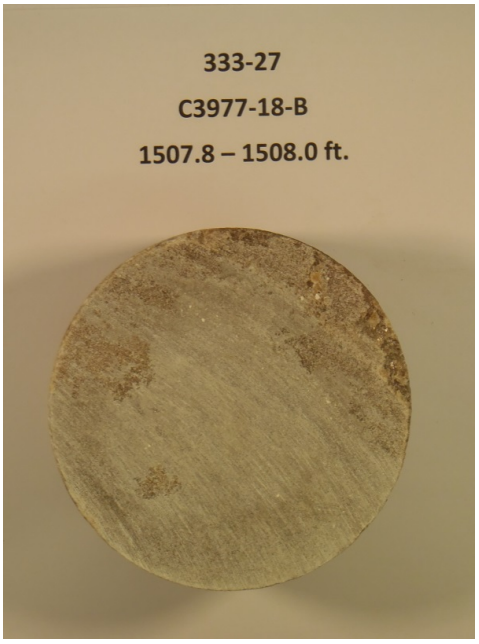
Figure E-1. Before and After Photographs of Triaxial Compressive Strength Test Specimens *(continued)*



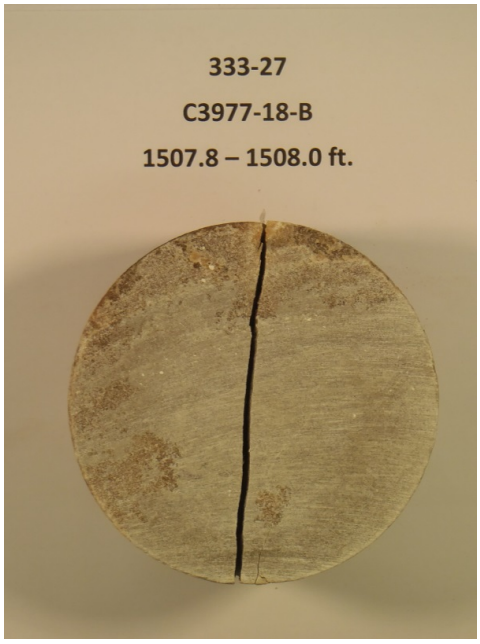
C3977-17-B (898.4-898.6 ft)—Before



C3977-17-B (898.4-898.6 ft)—After

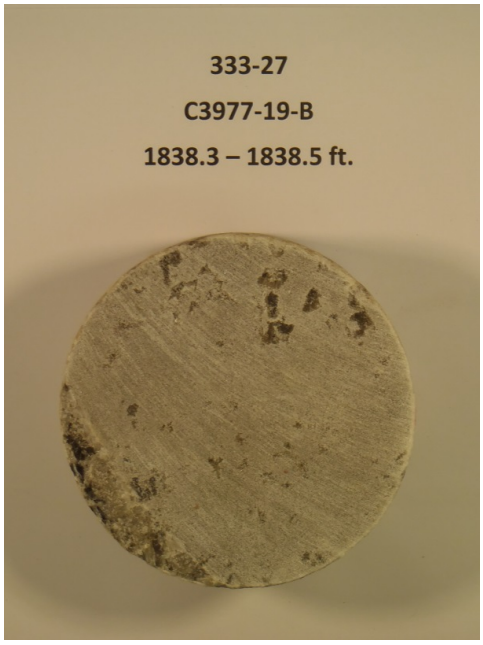


C3977-18-B (1507.8-1508.0 ft)—Before

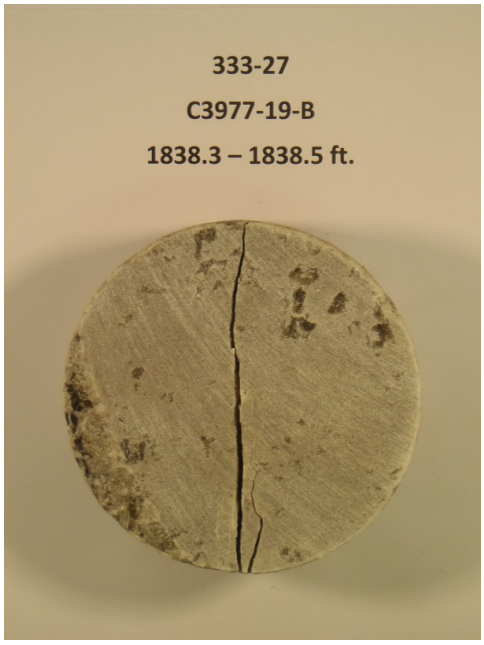


C3977-18-B (1507.8-1508.0 ft)—After

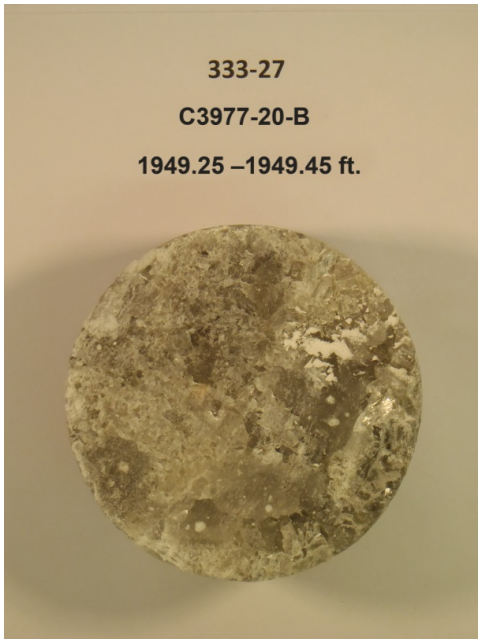
Figure E-1. Before and After Photographs of Triaxial Compressive Strength Test Specimens *(continued)*



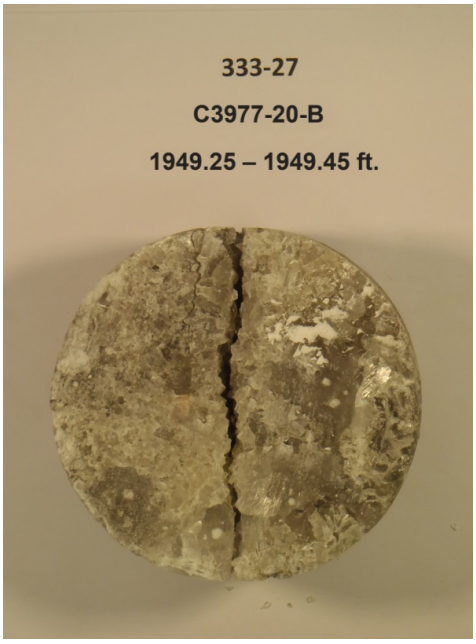
C3977-19-B (1838.3-1838.5 ft)—Before



C3977-19-B (1838.3-1838.5 ft)—After

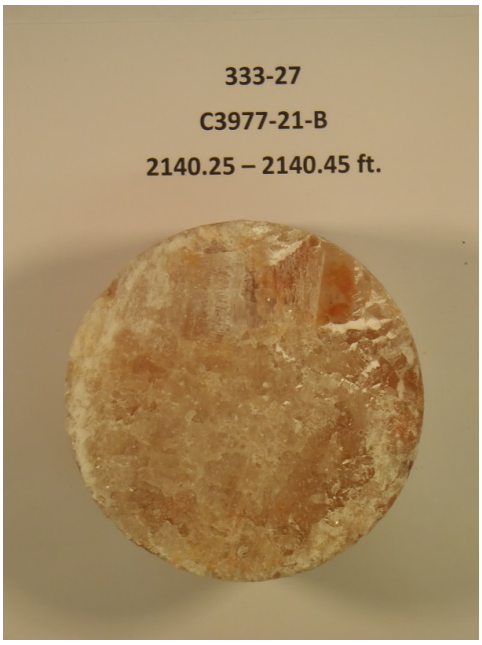


C3977-20-B (1949.25-1949.45 ft)—Before

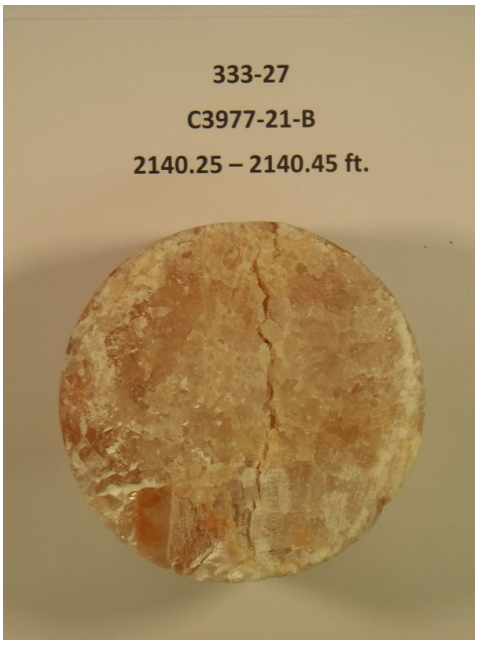


C3977-20-B (1949.25-1949.45 ft)—After

Figure E-1. Before and After Photographs of Triaxial Compressive Strength Test Specimens *(continued)*



C3977-21-B (2140.25-2140.45 ft)—Before



C3977-21-B (2140.25-2140.45 ft)—After

Figure E-1. Before and After Photographs of Triaxial Compressive Strength Test Specimens *(concluded)*

APPENDIX F

WATER CONTENT (MOISTURE) TEST DATA SHEET

AGAPITO ASSOCIATES, INC.
Consulting Engineers

WATER CONTENT TESTS

ASTM D2216 - 10

CLIENT: SRK
JOB NO: 333-27
DATE: June 1, 2017

HOLE NO: C3977
MOISTURE COND: As Received
OVEN TEMPERATURE: 230°F

SYMBOLS:

A	Mass of container Mc (oz)	**D**	Mass of container plus oven-dried sample (oz)
B	Mass of container plus sample as received Mcms	**E**	Date / Time Out of Oven
C	Date / Time in Oven	**F**	Final Mass of container plus oven-dried sample (oz) Mcds
		G	Final Date / Time Out of Oven
		H	Oven Temperature (°F)

Specimen No.	Hole ID	Depth From (ft)	Depth To (ft)	Length of Interval (ft)	A (oz)	B (oz)	C	D (oz)	E	F (oz)	G	H (°F)	Mass of Water Mw = Mcms-Mcds	Mass of Solids Ms = Mcds -Mc	Water Content w = (Mw/Ms) × 100 (%)
C3977-1-M	C3977	164.3	165.00	0.70	10.070	131.345	6/1/17 9:45 AM	128.800	6/2/17 12:05 PM	128.580	6/5/17 8:20 AM	230°F	2.765	118.51	2.3%
C3977-2-M	C3977	182.8	183.50	0.70	10.115	148.565	6/1/17 9:45 AM	145.185	6/2/17 12:05 PM	143.725	6/5/17 8:20 AM	230°F	4.840	133.61	3.6%
C3977-4-M	C3977	329.0	329.70	0.70	10.100	162.250	6/1/17 9:45 AM	161.140	6/2/17 12:05 PM	160.615	6/5/17 8:20 AM	230°F	1.635	150.52	1.1%
C3977-5-M	C3977	398.0	398.70	0.70	10.020	153.660	6/1/17 9:45 AM	152.050	6/2/17 12:05 PM	151.290	6/5/17 8:20 AM	230°F	2.370	141.27	1.7%
C3977-6-M	C3977	473.0	473.70	0.70	9.920	151.930	6/1/17 9:45 AM	148.630	6/2/17 12:05 PM	146.980	6/5/17 8:20 AM	230°F	4.950	137.06	3.6%
C3977-7-M	C3977	521.3	522.00	0.70	10.090	170.075	6/1/17 9:45 AM	169.920	6/2/17 12:05 PM	170.010	6/5/17 8:20 AM	230°F	0.065	159.92	0.0%
C3977-8-M	C3977	537.5	538.20	0.70	10.085	131.055	6/1/17 9:45 AM	128.425	6/2/17 12:05 PM	127.855	6/5/17 8:20 AM	230°F	3.200	117.77	2.7%
C3977-9-M	C3977	554.2	554.90	0.70	10.070	172.055	6/1/17 9:45 AM	169.655	6/2/17 12:05 PM	165.370	6/5/17 8:20 AM	230°F	6.685	155.30	4.3%
C3977-10-M	C3977	609.7	610.35	0.70	10.025	163.555	6/1/17 9:45 AM	163.430	6/2/17 12:15 PM	163.415	6/5/17 8:20 AM	230°F	0.140	153.39	0.1%
C3977-11-M	C3977	654.7	655.45	0.70	10.035	135.190	6/1/17 9:45 AM	130.670	6/2/17 12:15 PM	129.805	6/5/17 8:20 AM	230°F	5.385	119.77	4.5%
C3977-13-M	C3977	706.7	707.40	0.70	10.020	133.850	6/1/17 9:45 AM	127.720	6/2/17 12:15 PM	125.430	6/5/17 8:20 AM	230°F	8.420	115.41	7.3%
C3977-14-M	C3977	767.2	767.90	0.70	10.050	151.690	6/1/17 9:45 AM	150.650	6/2/17 12:15 PM	150.300	6/5/17 8:20 AM	230°F	1.390	140.25	1.0%
C3977-16-M	C3977	843.4	844.10	0.70	9.970	136.210	6/1/17 9:45 AM	136.035	6/2/17 12:15 PM	136.145	6/5/17 8:20 AM	230°F	0.065	126.18	0.1%
C3977-17-M	C3977	898.8	899.45	0.70	9.995	131.280	6/1/17 9:45 AM	130.940	6/2/17 12:15 PM	131.130	6/5/17 8:20 AM	230°F	0.150	121.14	0.1%
C3977-18-M	C3977	1,508.6	1509.25	0.70	10.060	116.365	6/1/17 9:45 AM	116.120	6/2/17 12:15 PM	116.170	6/5/17 8:20 AM	230°F	0.195	106.11	0.2%
C3977-19-M	C3977	1,957.6	1958.30	0.70	9.960	170.315	6/1/17 9:45 AM	170.195	6/2/17 12:15 PM	170.195	6/5/17 8:20 AM	230°F	0.120	160.24	0.1%
C3977-20-M	C3977	1,949.5	1950.15	0.70	9.990	136.905	6/1/17 9:45 AM	136.020	6/2/17 12:20 PM	136.345	6/5/17 8:20 AM	230°F	0.560	126.36	0.4%
C3977-21-M	C3977	2,139.6	2140.25	0.70	10.005	135.035	6/1/17 9:45 AM	134.935	6/2/17 12:20 PM	134.940	6/5/17 8:20 AM	230°F	0.095	124.94	0.1%



Stewart Brothers crew extracting core barrels. Upper barrel (20 ft long) is on pipe rack with Salado halite visible at the lower end.

NWP, Stewart Brothers crew, geology crew, and support personnel on site on next to last day of coring. March 1, 2017.



APPENDIX G

FULL TEXT OF CORE DESCRIPTIONS

OF

SALADO FORMATION

(SEE APPENDIX C)

821.9-823.2: Halitic siltstone (10R 3/2), f I a near base, becoming anhydritic upward; microlaminated to very thinly bedded, some deformation, anhydrite strata near top.

823.2-826.3: Halite, m-c IV; contains blebs and stringers of mudstone (10R 6/3), most mudstone boundaries are irregular; lower 0.5' consist of argillaceous halite with trace II-III c.

826.3-826.8: Halitic mudstone (2.5YR 4/6), m I c, some irregular halite crystals ~ 1 cm, SIC.

826.8-831.5: Argillaceous halite (10R 6/3 - 4/1), c -vc IV at base, m IV at top; possible dissolution pit at 827.5 - 828.5; mudstone blebs, drapes, and linings increase upward; upper contact is a dissolution surface.

831.5-834.5: Halite, IV, vertically elongate crystals at the base, crystals become more equant upward; trace polyhalite blebs (10R 8/4), some polyhalite drapes and linings near top.

834.5-834.9: Anhydrite (5YR 8/1), microcrystalline, with irregular zones of halite, showing possible internal collapse; lower 0.1' consists of mudstone with SIC.

834.9-844.7: Halite, f-m IV, local zones of cloudy halite, less abundant upward; some small < 0.1' deep solution pits, local macropores to ~ 0.1' diameter, macropores more abundant above 839.0; discontinuous to continuous polyhalite stringers (5YR 6/6 – 10R 6/8) draping some surfaces; upper contact E/S surface.

844.7-846.1: Halite, m IV, with irregular zones of f-m III c; moderate clay (5YR 4/4) as small blebs and irregular zones, upper contact E/S surface.

846.1-848.7: Halite, f-c IV; trace polyhalite and some clay (5YR 4/4) as small blebs and discontinuous stringers.

848.7-853.3: Argillaceous halite at base with f-c II-III a-b and local zones of IV, grading upward to halitic mudstone with I-III a,b; clay content increases upward.

853.3-855.7: Argillaceous halite, m-c IV; trace polyhalite; some clay, mudstone stringers near top.

855.7-858.0: Silty sandstone at base; sandy siltstone at top; weak stratification and SIC; halitic, trace sulfate (5YR 4/6).

858.0-863.7: Silty halite, m-c IV, with some I-III a-b; siltstone in large blebs, some to 0.1' diameter.

863.7-866.2: Halite, f-m IV; trace irregular polyhalite and clay stringers, local polyhalite blebs.

866.2-866.7: Halite, f IV, in pods; slightly argillaceous (2.5YR 4/6).

866.7-870.0: Halite, f-c IV, some cements, some cloudy halite; trace polyhalite blebs, 0.1' thick polyhalite bed at base.

870.0-871.5: Argillaceous halite, f-c II-III c with some IV, in pods; sandstone in upper 0.1'.

OVERLAP - SUCCEEDING CORES WERE MARKED WITH OVERLAPPING DEPTHS

869.0-871.1: Silty halite, m I-III a-c, siltstone shows incipient peds bounded by halite coatings; below 870.3, possible podular textures.

871.1-873.9: Halite, m-c IV; argillaceous in the upper part with local I a in stringers/blebs of siltstone; stringers/blebs of polyhalite below 873.2.

873.9-876.0: Halite, m-c IV, abundant cement, some displacive boundaries with trace amounts of clay and polyhalite.

876.0-877.5: Halite, f-m IV, some passive cements; trace polyhalite blebs/discontinuous stringers; some clay (5YR 4/4) in large blebs, appears translocated.

877.5-882.3: Halite, m-c IV, abundant cement, cloudy halite in lower part; trace polyhalite blebs and crustal drapes below 878.5; above 878.5, trace siltstone an as discontinuous stringers and

blebs to 1" diameter, some crystal drapes, trace polyhalite.

882.3-883.5: Halite, f-m IV in pods; stringers and irregular zones of sand and clay (2.5YR 4/4-5G 7/1 in upper 0.1').

883.5-885.9: Sandy halite (5YR 4/6), c-vc I-III a-b; contains sandstone blebs/irregular zones; lower contact gradational.

885.9-896.7: Halite, m-vc IV, most vc, abundant cement, trace to some cloudy halite near base, local macropores and some dissolution pits; below 890.5, polyhalitic with discontinuous stringers, blebs, and crystal drapes; above 890.5, becomes argillaceous and sandy (5YR 4/6) in blebs and irregular zones, some possible vertical translocation in two pits, some displacive margins.

896.7-897.4: Polyhalite (5YR 8/4), microcrystalline, hint of stratification, halitic and upper part.

897.4-898.4: Halite, m-c IV; polyhalitic as stringers and crystal linings.

898.4-898.6: Polyhalite, microcrystalline, hint of stratification, halitic.

898.6-899.8: Halite, m IV; local polyhalite blebs.

899.8-902.8: Halitic mudstone (2.5YR 4/4), shows incipient peds and SIC; rare to abundant f-c I-III b-c, fines upward, halite stringers fill voids between peds; local stringers of anhydrite.

902.8-903.7: Argillaceous halite, f-c, IIIc to IV, mostly cements, crystal size decreases upward; mud blebs and stringers with some translocation; anhydrite stringers

903.7-904.9: Halite, f-c IV, possible pods; slightly argillaceous; trace anhydrite and stringers and blebs, stringers show some translocation.

904.9-909.5: Halite, m-c IV, abundant cements, local displacive boundaries, some I a; moderately argillaceous in small to large blebs and stringers, mud content increases upwards, some translocation into pits, irregular zones of mud in upper 1'.

909.5-914.5: Halite, m-vc IV, f IV in lower 0.3', stratified at base with abundant cloudy halite, some cements increasing upward, some large MP; polyhalite has stringers and blebs.

914.5-919.0: Argillaceous and silty halite, f IV, irregular pods of halite bounded by stringers and irregular zones of mudstone (5YR 5/4), local I-II b-c in muddy zones; below 917.3, clay content decreases, mud lags and some anhydrite and polyhalite stringers are present; upper 0.4' consists of halitic mudstone with f-m I-II a-c.

919.0-924.2: Halite, m-vc IV, moderate cements that base, becoming abundant at top; 2' deep pit with c-vc IV cement; polyhalite occurs below 921.0 as discontinuous stringers, blebs, and solution lags; clay in lower 1.5' occurs as blebs and stringers.

924.2-924.9: Argillaceous halite, f-m IV in pods, rare f I a-c in solution lag at base.

924.9-929.3: Halite, m-c IV, vc IV as cements, local MP; below 926.8, polyhalitic with some anhydrite, halitic polyhalite and anhydrite bed between 927.85-928.0; above 926.8, argillaceous (2.5YR 4/4, locally 5GY 7/1) and polyhalitic as blebs and stringers, some with displacive margins.

929.3-934.4: Sandstone (5YR 6/6), very fine to fine, well sorted, equant, with rounded to angular grains; 98% quartz, 2% dark grains, some orange quartz; 2.5Y 8/1 in irregular zones near top and local 1 mm reduction spots; trace to some f I a-b; 0.6' deep, halite-filled desiccation crack at upper contact.

934.4-936.3: Argillaceous halite at base grading to halitic mudstone at top, m-c II-III b-c at base, m-c I a in upper 0.5'.

936.3-938.7: Halite, m-vc IV, moderately abundant cements; mud and polyhalite as blebs and discontinuous stringers; local displacive

margins with clay; gray clay and polyhalite at lower contact.

938.7-944.1: Polyhalite, microcrystalline, hint of subhorizontal strata; separated into two beds by a 0.4' thick bed of halite, anhydritic near the top of each bed, lower bed contains 3 mm high HPAGS in mounds near the top of the bed; halite also occurs in thin, discontinuous subhorizontal laminae and irregular zones. Between 942.7 – 944.1: Halite, m-vc IV, moderately abundant cements, some MP; polyhalite occurs as blebs, solution lags, crystal drapes, and thick laminae; polyhalite bed occurs between 943.7 – 943.9.

944.1-948.0: Halite, f-m IV, in pods; argillaceous, clay and stringers and blebs; upper contact E/S.

948.0-950.3: Argillaceous halite, IIIc, abundant expansive cements; with blebs and local discontinuous stringers of clay; upper contact diffuse.

950.3-959.0: Halite, m-vc IV, small pits and abundant cement near top, local MP and dissolution pits to 0.5' deep, possible efflorescent crusts with clay stringers/drapes between 944.5-950.0; polyhalitic as irregular stringers and drapes; local E/S, some with clay concentrations (944.5) and 0.1' of halitic siltstone with some thin laminae (956.5); trace clay drapes and stringers below 956.5; upper contact dilated E/S.

959.0-959.9: Halitic mudstone; upper half contains abundant f Ia-c (5YR 5/4 – 5G 7/1); lower part has less halite and contains f-m Ib-c; unit cut by halite-filled desiccation crack; upper contact E/S.

959.9-962.5: Argillaceous halite, f-m IV in pods bounded by mudstone zones (2.5YR 4/4) containing m-c I-IIIa-c; local subvertical halite-filled fractures, 0.4' deep halite-filled desiccation crack originates at upper contact.

962.5-968.7: Halite, f-m IV in pods; c-vc IV in pits, MP, and zones of cement; local solution pits and MP; trace polyhalite as blebs and discontinuous stringers locally concentrated in pods; trace to some mudstone (2.5 YR 4/4) as irregular blebs and discontinuous laminae and stringers, some with m-c I-IIa-b, some blebs show vertical translocation; upper contact E/S.

968.7-978.3: Halite, m-vc IV, some VO MP near top, abundant cements; polyhalite below 977.6 and above 971.0, occurs disseminated discontinuous stringers and blebs, some laminae in the upper part; anhydrite laminae, stringers, blebs occur from 971.5-976.0, content decreases upward; upper contact E/S with clay-lined pit to 1.0' deep.

978.3-979.4: Polyhalite, microcrystalline, 2.5YR 7/6, thin laminae to laminae, local cross laminae, lower part deformed; lower 0.2' consists of mudstone ((5G 7/1) mixed with angular pebble-size clasts of polyhalite (breccia due to syndepositional dissolution and collapse); upper contact sharp.

979.4-983.6: Halite, m-c IV at base, m IV at top, possible VO prismatic halite at base, some halite cements; E/S near top overlain by f IV (efflorescent crust?), truncated by the upper contact; contains trace polyhalite as subhorizontal stringers and local blebs; upper contact sharp.

983.6-986.4: Halite, m-vc IV, most clear with large fluid inclusions, local MP, some pods of f-m IV near base; trace polyhalite near base; irregular laminae of mudstone (2.5YR 4/4) drapes E/S, some mudstone stringers and blebs, halite shows some displacive growth at mudstone contacts; upper contact sharp, E/S.

986.4-990.3: Halite, m-vc IV, cements become abundant upward, local VO MP, rare solution pits; trace polyhalite as irregular blebs; trace clay (2.5YR 4/4, with local 5GY 6/1) as blebs; upper contact E/S marked by gray clay.

990.3-1005.2: Anhydrite, microcrystalline. Between 990.3-997.5: HPAGS are abundant, 1-3 mm tall above 991.5, 0.25"-1" tall between 991.5 and 996.5, occur in mounds below 993.5; anyhydrite shows wavy to locally contorted thin laminae to thin beds, possible stylolites below

996.5. Between 997.5-1001.4: horizontal thin laminae at base grading to wavy thick laminae at top, strata are locally convoluted, carbonate rich at the base and mainly anhydrite at the top of strata. Below 1004.4: slumped strata above possible teepee structure at 1002.5, wavy laminae below 1002.5, carbonate-rich and porous from 1001.9-1004.7, soft sediment deformation in breccia mixed with red claystone (10R 4/3) at the base.

1005.2-1005.8: Mudstone (5R 6/1 with irregular zones of 10R 4/3), hints of irregular micro-thin laminae, some subhorizontal to subvertical halite-filled fractures.

1005.8-1008.5: Halite, m-c IV, possible pods with f-m IV near top, abundant cement; local polyhalite blebs and crystal drapes; argillaceous above 1007.7, clay content increases upward, clay occurs as blebs and discontinuous stringers, possible clay-filled dissolution pipe at top.

1008.5-1008.9: Halite, f-c IV, possible pods, mostly m-c cement.

1008.9-1010.0: Halite, m-vc IV, abundant cement, f IV near top; anhydrite content increases upward, crystal linings and blebs; clay occurs as disseminated blebs and irregular laminae.

1010.0-1013.7: Halite, c-vc IV, mostly cement; argillaceous (7.5YR 5/3 with local 5G 6/1) in upper 0.5' with c-vc I-IIIa-b; ~1.5' deep pipe and large macropore near middle of unit; anhydrite stringers and blebs with polyhalite blebs in the lower part of unit.

1013.7-1014.1: Anhydrite, microcrystalline, wavy lamina to thin beds, possible halite PAG sand near base, no clay at base.

1014.1-1018.3: Halite, m-c IV in upper part with trace polyhalite blebs, c-vc IV below E/S with trace discontinuous anhydrite stringers, halite cements become more abundant upward, local MP near the base; discontinuous 0.05' thick anhydrite bed at base.

1018.3-1018.6: Anhydrite, microcrystalline, HPAGS to 0.5" tall, trace gray clay at base.

1018.6-1023.0: Above 1019.8: halite, c-vc IV, abundant cement; trace clay as blebs, discontinuous stringers, some with displacive boundaries. Below 1019.8: halite, m-c IV, vc IV in MPs; trace polyhalite blebs at base, content decreases upward;

1023.0-1029.0: Halite, m-c IV, local vc IV in MP, pods of f-m IV above 1024.0; trace clay (2.5YR 4/4) as irregular stringers and blebs, some with displacive boundaries, clay content increases above 1029.0; trace polyhalite as blebs.

1029.0-1030.3: Polyhalite (2.5YR 7/6), microcrystalline; upper 0.2' appears to be a solution lag accumulated over a core of m IV polyhalitic halite; remainder shows parallel, wavy to contorted laminae to thin beds; lower 0.3' contains carbonate interbeds; unit underlain by thin bed of clay (5G 7/1).

1030.3-1034.8: Upper 0.4': mudstone (5YR 4/4-5G 7/1), with some SIC and peds. Below 1030.7: halite, m-c IV with vc IV in MPs and pit; polyhalite crystal drapes, stringers, and blebs, some vertically translocated, shows some displacive margins; clay as blebs and infiltrated material into paleokarst; paleokarst zones show some m Ia-b; below 1033.8, shows subhorizontal, discontinuous polyhalite stringers; lower 0.1' consists of structureless polyhalite with irregular contacts.

1034.8-1045.6: Halite, m-c IV, vc IV in MP, f-m IV with polyhalite crystal linings below 1045.0; trace polyhalite blebs and discontinuous stringers, large blebs at 1038.5 and 1041.1; between 1041.3-1042.3: trace clay blebs and discontinuous stringers, no polyhalite.

1045.6-1046.0: Polyhalite (2.5YR 7/6), microcrystalline; HPAGS to 3 mm; thin laminae to very thin beds, slumped over lower contact.

1046.0-1050.5: Halite. Above 1053.4: f-c IV with local II-IIIc, some pods, some displacive cements;

some vertically translocated clay and polyhalite blebs. Below 1053.4: m-c IV in three sequences; each sequence: trace polyhalite at base with trace clay at top, cements are abundant in the upper part of sequences.

1050.5-1050.9: Polyhalite, microcrystalline; upper part is a solution lag overlying a core of f IV halite; 2-5 mm HPAGS in middle of unit; anhydrite in irregular zones in the lower part.

1050.9-1058.2: Halite, m-c IV, some cement, some primary halite; trace polyhalite and clay as blebs and discontinuous strings; E/S at 1053.4 draped with polyhalite, E/S at 1055.0 and 1055.9 draped with clay; clay blebs and stringers with moderate halite cement between 1055.0-1055.9; mud-filled cave with m-c I-IIa occurs between 1056.0-1056.7; lower contact marked by E/S with polyhalite solution lag.

1058.2-1065.5: Halite, f-m IV in pods, halite bounding pods and below 1064.0 is m-c IV cement; polyhalite and clay blebs and stringers occur within and bound pods; below 1064.0, clay occurs as blebs, solution lags, and discontinuous stringers, many showing vertical translocation.

1065.5-1073.6: Halite, m-c IV, vc IV in probable pits or MP; trace to some polyhalite; trace anhydrite near base. Some polyhalite blebs, solution lags and crystal linings between 1065.5-1066.4. Between 1066.4-1069.1: 0.1' thick polyhalite bed at base; overlain by 1' zone of possible pit filling with large polyhalite blebs and solution lags dilated by halite cements with some displacive margins; remainder shows trace polyhalite blebs and discontinuous stringers. Between 1069.1-1071.5: possible pipe filling with large blebs of polyhalite with irregular-angular margins with vc IV, some Ib within blebs; lower 1' shows trace polyhalite blebs and subhorizontal stringers. Between 1071.5-1073.6: vc IV, probable pit filling with solution lags and blebs of polyhalite with displacive margins, some I-IIa-c; some stringers and crystal drapes of polyhalite.

1073.6-1074.3: Halitic mudstone (2.5YR 4/1-5G 7/1) in upper 0.2' with m-c I-IIa-c near top; lower contact irregular over 0.1'. Lower part is argillaceous halite with f IV, clay is disseminated; lower contact an E/S surface with clay.

1074.3-1075.6: Halite, m-c IV, with polyhalite blebs, stringers, and crystal linings.

1075.6-1076.1: Halitic mudstone, reddish-brown, with m-c I-IIIa-b; paleo-cave filling.

1076.1-1084.0: Above 1078.5: halite m-vc IV, abundant cement; contains large blebs (to 0.5"-1") of clay (2.5YR 4/1-5G 7/1) with f-m Ia-b; polyhalite occurs as solution lags and large blebs; some polyhalite and anhydrite stringers. Between 078.5-1079.0: halite, f IV in pods, bounded by stringers and zones of reddish-brown clay. Below 1079.0: halite, m-vc IV, cements dominate upward; trace polyhalite as blebs and stringers; becomes argillaceous above 1082.7 with small to large blebs and stringers of gray clay.

1084.0-1084.4: Polyhalite (2.5YR 7/8-5/8), microcrystalline, appears to be collapsed, upper 0.1' appears dilated with m-c I-IIIb-c.

1084.4-1093.6: Above 1089.0: Halite, c-vc IV, abundant clear cement with large fluid inclusions; trace polyhalite as large blebs, discontinuous stringers, and a solution lag in pit; trace anhydrite blebs and stringers. Below 1089.0: Halite (orange), m IV at base with abundant cloudy halite, c-vc IV at top with abundant clear cement; trace polyhalite blebs and stringers.

1093.6-1094.4: Polyhalite (2.5YR 7/8), microcrystalline; upper part shows fenistral fabrics with polyhalite PAG crystals growing into halite-filled voids; lower part shows hints of wavy strata with possible soil textures (peds?) and local prism cracks; thin, irregular zone of halite, f-m IV with crystal drapes overlies interlaminated anhydrite (greenish gray) and carbonate occur near the base; overlies gray clay.

1094.4-1107.3: Above 1095.2: argillaceous halite, m-c II-IIIb-c; upper contact marked

by 1" thick fibrous halite-filled fracture; lower contact gradational. Below 1095.2: halite, m-c IV, some MP; trace to some reddish-brown clay, content increases upward, occurs as blebs and discontinuous stringers; E/S at 1098.0 marked by reddish-brown clay, trace polyhalite blebs above and below the E/S.

1107.3-1112.7: Halite, m-vc IV; above 1108.2, trace reddish-brown clay blebs, becoming large in upper 0.3'; color changes from orange below E/S at 1108.2 to transparent above; E/S marked by pits with translocated polyhalite and polyhalite solution lag, gray clay occurs in the overlying halite; below the E/S, trace polyhalite at base, content increases upward, some large polyhalite blebs with a-c margins; polyhalite solution lag at 1111.3; cloudy halite abundant in lower 0.5'; lower contact marked by E/S capped with polyhalite solution lag.

1112.7-1116.3: Above 1115.0: halite, c-vc IV, abundant clear cements with large fluid inclusions, local pods of m IV; trace polyhalite blebs; some clay blebs and stringers showing vertical translocation. Below 1115.0: halite, m-c IV; trace to some polyhalite and reddish-brown clay as blebs and sand-size breccia clasts?, blebs show vertical alignment; lower contact gradational.

1116.3-1123.0: Anhydrite, microcrystalline; abundant halite above 1121.3, possible dissolution and collapse of HPAGS, bedding very contorted; interbedded with polyhalite between 1120.0 and 1121.3; mainly polyhalite between 1121.3-1122.5; wavy to contorted laminae of polyhalite and anhydrite below 1122.5; HPAGS from 1/4"-2" tall, mound of HPAGS at 1122.1; lower 0.1' consists of gray clay.

1123.0-1130.4: Above 1124.0: halite, c-vc IV overlying f IV pods. Below 1124.0: halite, f-vc IV, mostly m-c IV; blebs and stringers of polyhalite; possible potash minerals dissolved from core; between 1127.3-1127.8, polyhalite solution lags with dilated fabric and displacive margins with halite; subhorizontal polyhalite solution lags and stringers below 1129.0, locally dilated with a-c halite margins.

1130.4-1138.3: Between 1130.4-1131.0: anhydrite, microcrystalline, halite in irregular zones. Between 1131.0-1131.5: halite, m IV, trace polyhalite, local MP. Between 1131.5-1131.8: anhydrite, microcrystalline, hint of stratification, HPAG sand. Between 1131.8-1133.7: halite, f-vc IV, some MP; some stringers and blebs of anhydrite; irregular anhydrite bed at 1133.0; trace polyhalite; possible HPAG sand in upper 0.2'. Between 1133.7-1134.2: anhydrite, microcrystalline, trace polyhalite, irregular upper surface with possible solution lag. Between 1134.2-1134.9: halite, m-vc IV, some MP, trace to some polyhalite as crystal linings, stringers, solution lags, and blebs with displace margins with halite. Between 1134.9-1135.4: anhydrite, microcrystalline, HPAGS ¼" tall at base and 2" tall at top, hints of strata. Between 1135.4-1136.4: Argillaceous anhydrite, nodular at base, isolated nodules at top, nodules 1/4"-1/2" diameter, clay is gray, lower contact gradational. Between 1136.4-1138.0: anhydrite, microcrystalline, microlaminated to thinly laminated, irregular to wavy; HPAGS 1/8"-1/2" tall; lower contact sharp, marked by gray clay.

1138.0-1138.3: Mix of polyhalite and halite; polyhalite occurs as blebs and in irregular subhorizontal zones and laminae, appears slumped and disrupted, locally shows displacive boundaries with halite; halite is c-vc IV.

1138.3-1140.3: Halite, c-vc IV, local MP; trace polyhalite as blebs and stringers near top; anhydrite blebs and stringers near base.

1140.3-1143.1: Anhydrite, microcrystalline; locally thinly laminated to laminated, wavy; some possible nodules below 1142.0; gray clay parting at ~1143.0, strata locally disrupted; some f-m I-IIb-c in upper 0.2'.

1143.1-1149.4: Halite, m-c IV, vc IV in MPs; rare anhydrite blebs and stringers above 1146.0, near the top some stringers show dilation with local

f-m I-IIa-b; irregular solution lag and stringers of polyhalite below 1147.1 show displacive boundaries; irregular laminae of polyhalite with HPAGS to 1/4" tall at 1147.6 overlies thin laminae of gray clay; trace polyhalite blebs and stringers below 1147.6.

1149.4-1153.2: Above 1150.2: argillaceous halite and halitic mudstone, mostly f IV in pods; some thin (mm-scale) halite filled fractures. Below 1150.2: halite, m-c IV; above 1152.0, polyhalite and reddish-brown clay as blebs and stringers, some showing vertical orientations, some polyhalite crystal linings; trace polyhalite blebs and stringers and some cloudy halite in lower 1'.

1153.2-1176.2: Argillaceous halite in upper 0.3'. Above 1154.3, f-m IV in pods, possible clay-filled dessication crack; trace disseminated reddish-brown clay. Below 1154.3, halite, m-vc IV, local MP with vc IV; trace reddish-brown clay as blebs and stringers between 1159.0-1161.0 and above 1156.5; trace polyhalite blebs; large irregular blebs and solution lags of polyhalite between 1164.5-1168.1, some with displacive boundaries, some with vertically-oriented fabric; lower contact marked by 0.1' thick polyhalite bed, probable solution lag.

1176.2-1178.1: Argillaceous halite and halitic mudstone, f IV in pods, zones of mudstone with f-m I-IIIb-c; mud is reddish-brown; some polyhalite near base; lower contact gradational.

1178.1-1184.0: Halite, m-c IV above 1180.0, m-vc IV below 1180.0; local polyhalite solution lags with I-IIIa-c; large clay (reddish-brown) and polyhalite blebs show vertical translocation between 1180.0-1181.0; polyhalite bed collapse into pits between 1182.0-1182.2; slumped and collapsed polyhalite bed between 1183.1-1183.3.

1184.0-1184.5: Polyhalite, microcrystalline, shows collapse features, discontinuous zones of halite near top, lower contact irregular.

1184.5-1191.4: Halite, m-vc IV, local MPs; E/S with gray clay at 1185.0, trace clay above E/S; trace polyhalite, polyhalite concentration increases between ~1187.0-1187.4, possible E/S with dilation; polyhalite bed near base shows displacive margins; primary halite near base.

1191.4-1191.9: Anhydritic polyhalite, hint of subhorizontal strata, some halite in irregular zones.

1191.9-1197.2: Halite, m-vc IV, local large MP, some cloudy halite near base; trace polyhalite blebs, irregular polyhalite laminae near top; near 1195; clay occurs on dilated E/S; gray clay stringers near the base.

1197.2-1210.0: Above 1198.3: argillaceous halite overlain by halitic mudstone, m-vc I-IIIa-c, mostly c, reddish-brown. Between 1198.3-1204.8: halite, f-vc IV; pods of f-m IV are bounded by irregular stringers of brown clay and polyhalite and zones of m-c IV cement, cements contain trace polyhalite and clay stringers and blebs; above the E/S, large blebs and subhorizontal stringers of clay show a-b margins with halite; core crosses the edge of a solution pit in the upper part of the unit, stringers and blebs of clay and polyhalite are vertically-oriented within the pit, while stringers of polyhalite and clay are subhorizontal outside the pit. Below 1204.8: halite, m-vc IV; local MP and pits; moderate amounts of cloudy halite in lower 1.5'; trace polyhalite as stringers and blebs, some stringers show displacive "a" boundaries with halite in lower 2'; trace clay (reddish brown, locally gray) above 1208.0 as irregular stringers and some blebs; E/S at 1206.2 is marked by gray and reddish-brown clay with some m-c I-IIIa; upper contact E/S marked by reddish-brown clay.

1210.0-1212.1: Interbedded polyhalite and halite. Between 2110.0-1210.7: Polyhalite, microcrystalline, halitic; contains discontinuous zone of halite consisting of bottom-growth m IV with polyhalite crystal drapes overlying I-IIIb-c at the base; polyhalite shows collapse textures where halite is absent. Between 1210.7-1211.4: Halite, f-m IV, some vertically-oriented crystals (bottom growth?); polyhalitic as small blebs, crystal linings, and an irregular laminae near

the base. Between 1211.4-1211.8: Polyhalite, microcrystalline; contains local irregular cores of halite bounded by polyhalite showing collapse fabrics. Between 1211.8-1212.1: Mudstone, gray.

1212.1-1225.1: Halite, f-vc IV; pods of f-m IV occur above 1220.0 and are bounded c-vc IV passive cements, expansive cements occur between 1214.5-1217.0; local MP and shallow pits; trace to some polyhalite (orange) and clay (gray) in alternating zones as blebs, discontinuous stringers and crystal drapes; local bottom growth halite; solution lags of polyhalite and clay (brown to gray) occur on E/S at 1220.8 and 1222.3; between the E/S clay (brown) and polyhalite occur as discontinuous stringers and solution lags; below 1222.3, halite is orange and contains subhorizontal stringers and solution lags of polyhalite, local MP, moderate cements.

1225.1-1229.2: Halite, f-c IV; above 1226.2, f IV pods containing disseminated brown clay are bounded by small blebs and zones of brown clay with a trace of disseminated polyhalite; 0.1' deep dissolution pits containing translocated brown clay and polyhalite originate at an E/S at 1226.2, clay overlies polyhalite; below 1226.2, trace to some brown clay and polyhalite as VO blebs; upper contact E/S; brown clay overlies lower contact.

1229.2-1229.5: Polyhalite, microcrystalline, possible deformed strata, local crackle texture (solution lags?), overlies 0.1' of gray clay.

1229.5-1236.0: Halite, m-c IV with moderate cement above 1231.0, m-vc IV with abundant vc cements and possible MP below 1231.0, possible bottom growth halite near base; polyhalite occurs as locally abundant small to large blebs, some subhorizontal blebby stringers, some vertically translocated stringers; trace gray clay near top.

1236.0-1237.6: Polyhalite, microcrystalline; weak wavy thin laminae to laminae near base, strata slumped around halite core; halite and polyhalite PAGS 0.1" – 1" high near top; 1" thick bed of halite underlies upper 1.5" of polyhalite; 0.1' thick bed of gray clay at base.

1237.6-1240.5: Halite, m-c IV, abundant cements, trace cloudy halite, some MP; trace anhydrite blebs; 0.2' of f IV in pods near top.

1240.5-1252.3: Between 1240.5-1241.2: halite, f IV in pods; trace anhydrite and gray clay, some small MP. Between 1241.2-1245.3: halite, m-vc IV, orange, some cements, mostly in pits and MP, some cloudy halite; trace to some polyhalite as blebs, blebby stringers, and stringers, some with displace boundaries, polyhalite content decreases above 1242.4. Between 1245.3-1246.2: halite, m-vc IV, abundant cement; trace anhydrite. Between 1246.2-1247.2: halite, m-c IV, polyhalitic at base, as blebs and crystal linings; argillaceous at top (gray clay) in irregular pods of f-m IV; upper E/S is marked by gray clay. Between 1247.2-1249.0: halite, m-vc IV, orange, some cloudy halite; trace to some polyhalite, content increases upward, polyhalite occurs as blebs and stringers, some with displacive boundaries; upper E/S marked by gray clay. Between 1249.0-1250.4: halite, f-c IV, some MP and moderate amount of cloudy halite below 1249.5; f-m IV in pods with c IV passive cements in upper 0.5'; trace brown (base) to gray (top) clay in upper 0.5'; upper E/S is dilated and marked by trace gray clay. Between 1250.4-1251.7: halite, f IV in pods with local MP at top, c-vc IV cements abundant at base; trace polyhalite as blebs and crystal linings; trace disseminated gray clay; upper E/S is dilated. Between 1251.7-1252.3: halite, m-c IV, trace polyhalite as subhorizontal stringers and blebs; upper E/S shows small pit and gray clay and polyhalite solution lags.

1252.3-1259.6: Halite, m-vc IV, local MP and dissolution pits, some primary halite below 1258.4, moderately abundant cements become more common upward; above E/S at 1253.6, f-m IV in pods and m-vc I-IIIa-b in halitic mudstone (brown) and argillaceous halite; between 1253.6- 1257.5, trace to some subhorizontal to subvertical polyhalite stringers with blebs and

crystal drapes; below 1257.5, polyhalite laminae, blebby laminae, and stringers are spaced 3"-4"; potash minerals (?) dissolved by drilling fluids above 1256.0; upper E/S is sharp.

1259.6-1260.5: Polyhalite, microcrystalline, wavy strata near base; irregular zones of polyhalitic halite; possible halite PAG sand grains; upper contact sharp and irregular, depositionally continuous with the overlying unit; lower contact sharp, no clay.

1260.5-1262.6: Halite, m-c IV, with some vc IV, some cements and cloudy halite, local MP; trace polyhalite as blebs and crystal innings in lower part; some polyhalite in upper part as laminae and subhorizontal stringers.

1262.6-1269.0: Halite, m-c IV, with local vc IV in MPs and pits, equal parts cloudy halite and cements, possible bottom growth halite near base, cements more abundant and show dilation (?) above 1267.6; trace to some clay above 1264.5 with pods of f-m IV, with some MPs and pits; clay in lower part mostly consists of blebs and crystal linings; possible potash dissolved out of clay blebs by drilling fluids above 1267.6; in lower part, pit filled with brown clay shows displacive halite boundaries; lower contact marked by polyhalite laminae; upper contact E/S.

1269.0-1269.6: Halite, m-c IV, abundant cloudy halite, some cements; trace polyhalite as subhorizontal stringers.

1269.6-1270.0: Polyhalite, microcrystalline, contains halite as f I-IIIa-b in irregular zones; contacts irregular and dilated.

1270.0-1271.8: Halite, m-c IV, trace vc IV, abundant cloudy halite, some halite cements, possible preserved efflorescent crust near base; trace polyhalite as local blebs, crystal linings, and continuous to discontinuous subhorizontal stringers.

1271.8-1277.5: Above E/S at 1272.2: halite, f IV in pods bounded by zones of m-c IV cements; slightly argillaceous and polyhalitic; dissolution pit at lower E/S is 0.2' deep and contains translocated clay. Below 1272.5: halite, m-c IV, trace possible primary halite in lower part of unit, some vc IV as cements and in MPs; trace to some polyhalite as blebs, crystal linings, and blebby laminae, some show displacive boundaries.

1277.5-1278.9: Upper 0.3': halite, f-m IV, possible pods (?). Remainder: halite, m-c IV, local vc IV in MP, trace polyhalite blebs.

1278.9-1279.6: Above E/S at 1279.6: halite, f IV in pods bounded by c-vc IV cements, overlies m-c IV with some cement; trace gray clay near top; upper contact E/S with gray clay.

1279.6-1286.4: Between 1279.6-1281.3: halite, m-vc IV, abundant cements; moderately abundant brown clay blebs near base, clay content decreases upward; trace to some polyhalite near top; upper contact E/S with ~0.3' of relief. Between 1281.3-1282.6: argillaceous halite (DMRH), f-c II-IIIa-c, clay occurs as blebs and irregular zones, some with a vertically-oriented fabric. Below E/S at 1282.6: polyhalitic halite, m-c IV, abundant c-vc IV cements; polyhalite occurs as irregular blebs and discontinuous stringers, some blebs show vertical translocation near top; trace to some clay showing vertical translocation into pits, brown above 1284.7, gray between 1284.7-1285.3; disrupted, irregular bed of polyhalite between 1285.6-1285.7.

1286.4-1295.3: Above 1287.0: Argillaceous halite, f IV, in pods, trace c IV cement, upper contact E/S. E/S at 1287.0 shows 0.3' relief. Between 1287.0-1289.3: halite, m-c IV; trace brown clay and polyhalite blebs, clay content increases upward, some vertical translocation fabrics near top. Between 1289.3-1292.0: halite, c-vc IV, mostly cement; trace polyhalite blebs. Below 1292.0: halite, vc IV, mainly cement; trace to some large blebs and blebby laminae of polyhalite, some showing vertical translocation into pits; local zones of possible efflorescent crust preserved near 1292.

1295.3-1299.0: Polyhalite, microcrystalline, locally interbedded with anhydrite; local irregular zones of halite and HPAGS, upper 0.1' appears to be HPAG sand, HPAGS to 1/8" – 1/2" high in locally domed beds; lower part contains irregular zones of halite bounded by polyhalite with disrupted and collapsed bedding; collapsed zone 0.3' deep into underlying unit; irregular zone of gray clay at base.

1299.0-1300.8: Halite, m-c IV, abundant cement, come vc IV in MP near top; trace gray clay above 1299.5; trace polyhalite as blebs, crystal drapes, and a 0.1' thick collapsed bed.

1300.8-1308.1: Halite, f-vc IV; above 1301.7, pods of f-m IV bounded by zones of m-c IV cement. Between 1301.7-1302.7: halite, m-c IV, c-vc IV cements moderately abundant. Between 1302.7-1305.7: halite m-c IV, moderately abundant cements, some MP and pits filled with c-vc IV, trace anhydrite and polyhalite stringers and crystal drapes. Between 1305.7-1308.1: halite, f-m IV; abundant primary halite at base, content decreases upward; cements are rare at the base, become more common upward; shows bottom growth halite at base and MPs at top.

1308.1-1311.0: Polyhalite, microcrystalline, interbedded with irregular halite beds 1/4" to 0.1' thick; halite is f-m IV showing polyhalite crystal drapes; local HPAGS 1/4" high near the middle of the unit; 0.4' thick bed of m IV halite overlies 0.1' thick bed of polyhalite at the base, halite shows possible bottom growth; lower contact slumped into pit and marked by irregular laminae of gray silt.

1311.0-1316.8: Halite, m-c IV, some to abundant primary near base, primary content decreases upward, cements and small MPs increase upward, cement moderately abundant near top; trace polyhalite as continuous to mainly discontinuous subhorizontal stringers and zones (0.1' thick) of blebs; alternating zones of polyhalitic halite and clear halite forms beds 0.2'-0.5' thick; upper contact irregular over 0.1'.

1316.8-1324.0: Halite, f-m IV in pods, some c-vc IV cements; in place at top and occurs as irregular blocks floating in a brown halic siltstone (cave?); siltstone contains m-vc I-IIIa-b; lower contact a very irregular solution boundary with 0.2' of relief.

1324.0-1332.3: Above 1326.0: halite, f-m IV in pods bounded by vc IV cement; moderately abundant siltstone blebs translocated into pits, shows strong vertical fabrics; moderately abundant polyhalite as irregular blebs; upper surface possibly dissolved syndepositionally (possible cave floor?). Between 1326.0-1329.0: halite, m-vc IV, abundant halite cement; argillaceous and silty as large irregular blebs translocated into pits near top. Below 1329.0: polyhalitic halite, m-c IV; vc IV in MP, possible primary halite near base, cement content increases upward; polyhalite occurs as rare blebs (some with displacive margins), discontinuous subhorizontal stringers, blebby laminae, and an irregular thin (0.1') bed; upper E/S marked by a polyhalite stringer; some anhydrite near base.

1332.3-1336.8: Halite, m-c IV, some vc IV in MP, trace primary halite, abundant cements; trace polyhalite as rare blebs and crystal drapes; orange color below 1334.2; above 1333.0, halite occurs as f-m IV in pods with trace clay and polyhalite stringers; E/S at 1334.7 has no clay; upper contact an E/S.

1336.8-1338.6: Halite, m-c IV, some vc IV in MP, cements abundant; some f-m IV pods near top.

1338.6-1349.6: Above 1340: halite, f IV in pods with zones of m-c IV cement; moderately abundant polyhalite blebs and solution lags that exhibit a vertical texture; upper contact irregular, marked by 1/4" brown clay. Between 1340-1342: halite, m-c IV, rare vc IV in MP, trace primary halite, abundant halite cement; some polyhalite as discontinuous stringers and thin laminae; local blebs of polyhalite, some with displacive margins, some show limited vertical translocation; trace gray clay. Below 1342: halite, c-vc IV, orange, some MP; trace polyhalite as rare

subhorizontal stringers and crystal drapes/blebs, content increases upward, local boxwork fabric.

1349.6-1357.6: Above 1352.0: Halitic siltstone and silty halite; contains f-vc I-IIIa-b halite crystals, local f IV in pods; weakly bedded near top. Between 1352.0-1352.6: halite, m-c IV; trace polyhalite and brown clay blebs; highly disrupted polyhalite bed between 1352.0-1352.2. Between 1352.6-1353.7: siltstone, reddish-brown, dipping laminae and very thin beds, rare m-c Ia-b, possible cave fill (?). Between 1353.7-1355.7: halite, m-c IV, some cement, f-m IV near top; disseminated brown clay and polyhalite blebs; local subhorizontal polyhalite solution lags; upper contact sharp, dissolution boundary. Between 1355.7-1357.6: halite, m-c IV, some vc IV cement, trace primary halite, orange; trace polyhalite as blebs and stringers; disrupted polyhalite bed between 1356.9-1357.1; polyhalite laminae at lower contact; upper contact gradational.

1357.6-1360.7: Above 1358.3: halite, f IV in pods, m-c IV cements; trace disseminated clay and polyhalite, some stringers, upper contact sharp, dissolution surface. Below 1358.3: halite, f-m IV, c-vc IV in MPs, orange; trace polyhalite and anhydrite as stringers and crystal linings; trace disseminated gray clay near top; upper contact E/S marked by polyhalite and gray clay stringer.

1360.7-1374.5: Above 1362.8: sandy halitic siltstone and silty halite, brown, contains f-c I-IIIa-b halite crystals; some irregular zones of f IV halite in pods, contains trace disseminated polyhalite, pods bounded by siltstone; upper contact E/S topped with stringer of gray clay and polyhalite. Between 1362.8-1365.5: halite, m-c IV, some vc IV in MP; trace polyhalite and reddish-brown clay blebs and stringers above 1364.5, content increases upward; halite clear below 1364.5; upper contact very irregular (0.1' relief) E/S. Between 1365.5-1368.5: halite, m-c IV, trace primary halite, abundant cements, some vc IV in MPs, orange below 1366.0, gray to clear above 1366.0 and in pit; trace reddish-brown clay blebs and stringers above 1366.0, content increases upward; trace to some polyhalite blebs, crystal linings, and stringers, content increases near middle of unit; upper contact E/S, marked by reddish-brown clay. Below 1368.6: halite, f-m IV, c IV in MP, some primary halite near base, moderately abundant cements, orange except in upper 0.2' which contains brown and gray clay; trace polyhalite as small blebs and crystal linings; trace dissolved langbeinite in MPs near 1369.0, abundant langbeinite in MP near base; upper contact E/S with brown clay to 1/4" thick.

1374.5-1386.4: Above 1377.1: Silty halite, mostly f-vc I-IIIa-c, possible pods of f-m IV in polyhalite matrix; some f-c IV with III near base; some fine displacive langbeinite crystals near top, abundant large langbeinite crystals to 3" across near middle of unit; lower contact E/S with pit filled with clay and langbeinite; upper contact E/S with no clay or polyhalite accumulations. Between 1377.1-1380.3: halite, f IV in upper 0.5', remainder f-m IV with local c-vc IV cement and in MPs; trace polyhalite as disseminated blebs; trace reddish-brown clay as blebs and subvertical stringers; trace gray clay in lower 0.2'; upper contact E/S with clay- and langbeinite-filled pit. Below 1380.3: halite, f-m IV, with c-vc IV cement, orange, local MPs and pits; some polyhalite beds and discontinuous blebby laminae near base; polyhalite stringers and blebby zones subhorizontal below 1383.0, becomes more dispersed upward; abundant polyhalite crystal linings near base; local Ia-b in polyhalite zones near base; upper contact E/S with no clay or polyhalite lags.

1386.4-1387.7: Polyhalite, microcrystalline, disrupted bedding near top and base, HPAGS 1/4" high near top; local zones of halite; irregular zone with langbeinite near the middle of the unit; 1/4" thick gray clay at the base; upper contact sharp and disrupted.

1387.7-1394.3: Halite, m-c IV, some vc IV in MPs and pits, some f IV locally, abundant cements, mostly orange; trace polyhalite and rare anhydrite as blebs, blebby laminae, discontinuous

subhorizontal stringers; some langbeinite above 1388.5 and near lower contact, possibly in MP; minor exposure surface topped with anhydrite at 1391.3 and gray clay at 1393.5; upper contact dissolution surface.

1394.3-1395.9: Halite, m-c IV, possible vc IV in MPs and pits; orange below 1395.3 with trace polyhalite blebs, gray above with trace gray clay stringers; some langbeinite at top, langbeinite content decreases downward; upper contact E/S, dilated with no accumulation of clay or sulfate.

1395.9-1404.3: Above 1398.5: halite, f-m IV in pods, m-c IV cements near top and in lower 0.5'; trace to some reddish-brown clay as stringers, blebs, and disseminated material; trace disseminated polyhalite; upper contact E/S, dilated, no accumulation of clay or sulfate. Between 1398.5-1400.0: halite, f IV in pods, subhorizontal stringers of reddish-brown clay; disseminated polyhalite as POS (?) and some blebs; upper contact E/S with 0.5' relief with I-IIIa-b in reddish-brown clay, possible langbeinite in clay. Between 1400.0-1403.2: halite, m-c IV, abundant cements above 1402.6; trace to some polyhalite and reddish-brown clay blebs, some blebs show vertically-oriented fabric, content increases upward; disrupted polyhalite bed 0.1'-0.2' thick at the base; upper contact gradational. Below 1403.2: halite, m-vc IV, clear, possible MP filling.

1404.3-1409.8: Above 1407.0: halite, m-c IV, local pits filled with c-vc IV; trace to some polyhalite blebs and stringers; langbeinite and leonite abundant between 1405-1406 as displacive crystals with soluble rims; upper contact E/S with solution pit with ~1' relief, no clay. Below 1407.0: halite, m-c IV, abundant cement, orange; trace to some polyhalite as disrupted beds, subhorizontal stringers and laminae near the base; some displacive halite in polyhalite near base; upper contact gradational.

1409.8-1412.1: Polyhalite, microcrystalline, wavy thin beds show low-angle cross-cutting relationships near the base, some disrupted beds; irregular zones of halite, m-c IV and II-IIIa-c, halite content increases upward above 1411.7; gray clay 1/8" thick at base; upper contact very irregular.

1412.1-1417.4: Halite, m-c IV; possible primary halite near the base, content decreases upward; halite cements become more common upward; orange from base to 1412.8; trace polyhalite blebs and discontinuous stringers; disrupted polyhalite bed showing collapse into solution pit near middle of the unit; trace gray clay in MP above 1412.8, shows vertical translocation; upper contact sharp dissolution surface.

1417.4-1418.0: Polyhalite, microcrystalline, hint of subhorizontal stratification; local irregular zones of halite; no clay at base; upper contact sharp, wavy.

1418.0-1421.0: Halite, m-c IV, alternating zones of orange to gray 0.5'-1' thick, some f IV in gray zones (efflorescent crust?), possible primary halite in orange zones, local MPs above 1420; trace polyhalite blebs; trace gray clay stringers and blebs in gray zones; upper contact sharp.

1421.0-1436.5: Above 1427.1: halite, f-m IV in pods, c-vc IV in MPs and cements, pods become better defined upward, f-m IV with no pods in lower ~1.5'; argillaceous with trace to some clay, highest concentration between 1421.3-1425.3 with some thick (0.25'-0.5') argillaceous zones, clay mostly gray above 1422.0, reddish-brown clay occurs between 1420.0-1425.8, gray clay below 1425.8; E/S at 1422.5 shows irregular surface over 0.1' and up to 0.1' of reddish-brown clay as a solution lag; other E/S capped by reddish-brown clay; trace to some large polyhalite blebs; upper contact E/S capped by gray clay. Between 1427.1-1429.0: halite, m-c IV, some MPs, orange grading to gray above 1427.8; trace polyhalite blebs, local large blebs of polyhalite to 1" across show vertical displacement into pit; upper contact E/S, dilated, disseminated gray clay. Between 1429-1432.0: halite, c-vc IV, orange, abundant cement; large blebs of anhydrite or polyhalite show vertical displacement, isolated small blebs of polyhalite

occur, disrupted bed of polyhalite or anhydrite at 1430.8; upper contact gradational. Below 1432.0: halite, mainly m-c IV with some f IV, c-vc IV in MP, abundant primary halite, local vertically-oriented halite crystals with drapes of polyhalite, orange; trace to some polyhalite as stringers, crystal drapes, and flat to disrupted laminae and beds, disrupted bed of polyhalite between 1434.4 and 1435.0; upper contact gradational to diffuse.

1436.5- 1438.2: Polyhalite, microcrystalline; wavy to deformed laminae, some slumping at the base; strata deformed around cores of m IV halite; deformed gray clay laminae in lower part; lower 0.3' consist of gray clay with irregular breccia (?) clasts of polyhalite; upper contact sharp.

1438.2-1445.2: Above 1439.0: halite, f-m IV; argillaceous (gray) zone 0.2' thick at 1438.5, some discontinuous gray clay laminae near top. Between 1439.0-1441.0: halite, m-c IV, c-vc IV in MPs, orange; trace polyhalite blebs and subhorizontal stringers; 0.1' thick polyhalite bed at base, upper contact E/S, no clay. Between 1441.0-1441.5: halite, f IV, cloudy to clear. Below 1441.5: halite, f-m IV, orange below 1444.0; contains irregular masses of c-vc langbeinite and displacive langbeinite crystals (some a, mostly c, boundaries); trace polyhalite blebs and stringers; trace clay blebs between 1442.5-1443.5.

1445.2-1451.1: Above 1447.1: halitic mudstone, reddish brown, gray zone above 1445.6; f-m I-IIIa-b halite crystals; moderately abundant polyhalite blebs. Between 1447.1-1449.2: halite, f-m IV in pods bounded by reddish-brown clay stringers and disseminated blebs; some polyhalite blebs, upper contact E/S with reddish-brown clay. Between 1449.2-1451.1: halite, f-c IV, abundant cements; trace polyhalite and gray clay as disseminated blebs, some with displacive margins, some showing vertical translocation, some boxwork fabric; reddish-brown clay and polyhalite vertically translocated in and near a desiccation crack at the upper contact; E/Ss near base and at upper contact with reddish-brown clay. Below 1451.1: halite, f-m IV at base, m-c IV at top, arrange, abundant cloudy halite with some cements at base, cements become more abundant upward, some c-vc IV in MPs, some small vertically-oriented MPs; polyhalite as stringers, blebby laminae, and discontinuous/disrupted laminae in lower part, polyhalite crystal drapes near base, trace disseminated polyhalite blebs; upper contact E/S with no clay.

1457.4-1458.1: Polyhalite, microcrystalline, separated into an upper and lower bed by a 0.3' thick halite bed. Upper polyhalite bed is 0.2' thick and shows hints of stratification. Middle halite bed is 0.3' thick and consists of f-mIV, orange halite with a trace of polyhalite. Lower polyhalite bed shows disrupted laminae, some with gray clay drapes at the base, and gray clay at the base.

1458.1-1462.2: Halite, f-m IV, c IV cements, local vc IV in MPs, m-c IV in middle of unit, f IV in upper 1/2", abundant primary halite near base with some small vertically-oriented MPs, orange, beds 0.1-0.3' thick; trace subhorizontal polyhalite and anhydrite stringers; trace gray clay in upper 0.1'; upper contact sharp dissolution surface.

1462.2-1471.2: Above 1466.5: argillaceous halite, f-m IV in pods, m-vc IV cements locally, some pods bounded by pits filled with m-vc IV, local irregular mudstone-filled zones with f-m I-IIIa-c; trace disseminated polyhalite; local vertically-oriented zones of clay, clay grades from reddish-brown at the base to gray above 1463.0; E/S at 1463.9 has gray clay; upper 0.2' contains very little clay and has f IV halite; upper contact gradational, dilated (?). Between 1466.5: halite, m-vc IV, f-m IV in lower 0.5', abundant cement, orange; some (near base) to trace (upward) polyhalite beds; vertically oriented zones of reddish-brown mudstone near top (possible pit fillings); unit cross-cut be 2.5' deep pit filled with m-c IV with trace gray clay and vertically displaced reddish-brown mudstone near the top of the pit, local brown clay on margin of pit; upper contact possible E/S marked by reddish-brown clay.

1471.2-1472.9: Above 1491.8: polyhalite, microcrystalline, intercalated with gray anhydrite that displays wispy microlaminae, polyhalite seems to occur as nodules or irregular zones displacing/deforming the anhydrite; upper contact irregular with 0.4' relief. Below 1471.8: halitic anhydrite and polyhalite, anhydrite dominates the matrix above 1472.5 and contains diffuse zones of polyhalite with f-m I-IIIb-c halite; mainly disrupted/slumped polyhalite below 1472.5; possible E/S marked with gray clay and gray clay-filled desiccation crack at 1472.7; upper contact gradational; lower 0.1' consists of gray clay.

1472.9-1479.5: Halite, f IV with vertically-oriented crystals with polyhalite crystal drapes in lower 0.2', grades upward to f-c IV at 1479.0. Above 1479.0, halite is m-c IV with vc IV in MPs and pits. Aboe 1474.0, halite is f-m IV with c IV cements. Orange halite occurs below 1477.0. Polyhalite occurs as crystal drapes near the base; local POS fabrics, blebs, solution lags, and disrupted laminae below 1477.5; and isolated blebs above 1477.5. Some polyhalite blebs show displace margins near the top; some polyhalite is translocated into pits; pit near base contains I-IIIa-b halite.

1479.5-1480.5: Polyhalite, microcrystalline, wavy micro-laminae to thin beds; no clay at lower contact; upper contact sharp.

1480.5-1481.7: Halite, m-c IV, orange, with trace polyhalite blebs and stringers in upper 0.5'. Middle 0.3': slightly argillaceous halite, f-m IV; vc IV cements in MP; stringers of gray clay. Lower 0.4': halite, f-m IV, c IV cements, orange; trace disseminated polyhalite.

1481.7-1486.5: Above 1482.0: halitic mudstone, f-m I-IIIc, reddish-brown. Between 1482.0-1484.0: halite, f-m IV; trace brown and gray clay stringers; trace disseminated polyhalite; bisected by large MP/pit filled with c-vc IV. Between 1484.0-1486.0: polyhalitic halite, m-c IV, orange; trace polyhalite as crystal drapes and subhorizontal to subvertical stringers; unit is cross-cut by large pit filled with clear c-vc IV; c-vc IV in local MPs. Below 1486.0: halite, f IV with c IV in MPs and cements, orange; upper contact sharp.

1486.5-1486.8: Halite, f-m IV, c IV in MP; trace brown and gray clay; upper contact E/S marked by brown and gray clay.

1486.8-1491.7: Above 1487.2: halitic mudstone, m I-IIIb-c. Between 1487.2-1488.0: halite, f-m IV in pods; trace polyhalite stringers and blebs near base; gray to brown clay stringers and blebs; upper contact E/S with brown clay. Below 1488.0: halite, m-c IV with c-vc IV as cements and in MP, orange; trace irregular, continuous to discontinuous subhorizontal stringers of polyhalite; upper contact gradational.

1491.7-1492.5: Halite, f-m IV, possible pods; gray clay stringers and blebs; upper contact dilated E/S with gray clay.

1492.5-1503.8: Above 1499.0: halite, f-m IV in pods, m-c IV in zones bounding pods; local zones of halitic mudstone with f-c Ia-b; trace to some clay as irregular stringers, blebs, and zones in solution features with vertically-translocated clay; clay is reddish-brown above 1497.4, gray below 1497.4; local dissolution of potassium minerals (?) in clay-rich zones; E/S's marked by brown clay; upper contact E/S marked by brown and gray clay. Between 1499.0-1501.2: halite, m-c IV; trace to some clay and polyhalite as blebs and discontinuous stringers, some show vertical fabrics; upper contact gradational. Below 1501.2: halite, m-c IV, c IV cement abundant; moderately abundant polyhalite blebs, vertically translocated, dilated fabric common, rare I-IIa-c in blebs, many blebs show displacive margins; trace gray clay stringers above 1502.0; upper contact E/S with gray clay.

1503.8-1510.9: Above 1504.7: halitic polyhalite, microcrystalline, halite concentration increases downwards, becomes anhydritic in lower 0.2', some f-m I-IIIb-c, upper contact sharp. Between 1504.7-1508.1: anhydrite,

microcrystalline, microlaminated to laminated, local dipping strata, some strata are slumped, gray clay is squeezed between deformed strata at 1507.1', local APAGS to 1 mm high, upper contact gradational. Between 1508.1-1509.5, polyhalite, microcrystalline, contorted laminae. Between 1509.5-1510.2: polyhalitic anhydrite, microcrystalline, contorted laminae; disrupted black clay beds at upper contact. Below 1510.2: anhydrite micronodules with gray clay (?), solution pit filled with gray clay(?) at lower contact.

1510.9-1519.6: Above 1512.0: halite m-c IV, abundant cements, has brown color, trace disseminated gray clay and polyhalite. Between 1512.0-1514.5: alternating zones of polyhalitic halite and argillaceous (gray) halite. Polyhalitic zones contain halite, f-m IV with some m-c IV cements; polyhalite is most abundant in areas of f-m IV as crystal drapes, blebs, and rare stringers. Argillaceous zones contain f-m IV halite with trace disseminated gray to brown (less common) clay. E/S with gray clay at 1512.4. Below 1514.5: halite, orange, f-m IV at base, with some bottom-growth halite and cumulates, grading to m-c IV above 1519.0, local MPs; 0.1'-0.3' thick beds alternate between m IV and c IV above 1519.0; trace to some polyhalite as crystal drapes, crystal linings, blebs, and subhorizontal stringers and solution lags; upper contact E/S with gray clay.

1519.6-1526.0: Above 1520.7: halite, f-m IV, some pods; trace to some gray clay as disseminated material, blebs, and irregular laminae; trace disseminated polyhalite near base; E/S with gray clay at 1520.3' and at top. Below 1520.7: halite, m-c IV, local f IV, c IV occurs mainly as cements, cements increase upward, some primary (?) halite near base, rare MPs filled with c-vc IV; divided into alternating zones of orange halite (trace polyhalite) and clear to gray halite (trace gray clay); argillaceous zones tend to have more cements, clay is disseminated and occurs as rare stringers on E/S; polyhalite occurs as isolated crystal drapes and blebs; upper contact E/S with gray clay.

1526.0-1538.0: Above 1526.3: halite, f-m IV; trace dark brown clay as stringers; upper contact E/S with dark brown clay. Between 1526.3-1527.8: halite, f-m IV in pods local MP with c IV; trace disseminated polyhalite; upper contact E/S with no clay. Between 1527.8-1528.0: argillaceous halite, f-m IV with local zones of f II-IIIb-c; gray clay stringers; upper contact E/S with gray clay. Between 1528.0-1529.9: halite, f-m IV in pods above 1528.7, m-c IV in lower part; small to large blebs and zones of brown mudstone are vertically oriented and large zones contain f-m I-IIIa-c; upper contact E/S with gray clay. Between 1529.9-1535.5: halite, f-m IV in pods, m-c IV as cements and in pits, pods and pits are abundant, rare MPs; trace-moderately abundant clay, mostly reddish-brown, some gray, occurs as large vertically-oriented blebs and stringers, large blebs and zones of clay contain f Ia-b and m-c II-IIIb-c; trace to some polyhalite as blebs, crystal linings, and solution lags; some pits show vertically translocated brown clay and polyhalite; upper contact E/S with brown mud and large vertically-oriented blebs of mud containing f-m I-IIIb-c halite. Below 1535.5: halite, m-c IV with some f IV, rare MP; orange, clear in lower 0.3'; trace polyhalite blebs and crystal linings; upper contact diffuse.

1538.0-1543.4: Above 1539.5: halite, f IV in pods, m-c IV cements, c-vc IV in MPs and pits, clear in upper 1.5', orange in lower part; trace polyhalite as irregular stringers; upper contact E/S no clay. Below 1539.5: halite, f-m IV at base grading up to m-c IV, c IV in pits and MP, orange; trace polyhalite crystal lings and small blebs; upper contact diffuse.

1543.4-1545.9: Halite, f-m IV, cements are common, rare c IV cements, local f IV efflorescent crust (?); trace reddish-brown and gray clay above 1545.0', moderate amounts of reddish-brown clay between 1544.0'-1544.5', some f Ia halite in clay stringers and blebs; trace to some polyhalite crystal linings and blebs; upper contact E/S with some brown clay.

1545.9-1553.0: Above 1546.1: argillaceous halite, gray to brown clay with f I-IIIa-b. Between 1546.1-1547.0: halite, m-c IV with blebs of reddish-brown to gray mud, f IV pods with disseminated clay and trace polyhalite. Between 1547.0-1549.0: halite, f IV in pods with trace disseminated polyhalite and brown to gray clay; m-c IV cements with reddish-brown clay and polyhalite stringers and blebs, cements most abundant below 1548.0. Between 1549.0-1553.0: halite, f-m IV with c-vc IV as cements and in MPs, some primary halite near the base and middle, cements moderately abundant, orange with clear band between 1549.9-1550.0; trace polyhalite as rare blebs and crystal linings; trace at lower contact, dilated in pit; upper contact E/S with no clay.

1553.0-1563.9: Above 1553.5: halite, m-c IV; moderately abundant reddish-brown mudstone, large blebs of mudstone show vertical translocation; upper contact E/S with reddish-brown mudstone, mudstone within pit at upper contact is dilated. Between 1553.5-1554.6: halite, f-m IV, some pods; some reddish-brown clay blebs; trace polyhalite blebs; upper contact E/S with brown clay. Between 1554.6-1559.2: halite, f IV in pods with disseminated polyhalite and reddish-brown to gray clay; pods bounded by f-c IV cements with local stringers and solution lags of clay and polyhalite; m-c IV cements in rare MPs; upper contact E/S with dilated reddish-brown to gray clay and polyhalite solution lag. Between 1559.2-1560.5: halite, m-c IV, trace f IV in local zones; trace to some reddish-brown to gray clay as blebs, crystal drapes and discontinuous stringers; trace polyhalite crystal drapes, upper contact gradational. Between 1560.5-1562.1: halite, f-m IV with rare c IV cements; trace reddish-brown clay and polyhalite as crystal linings; f IV efflorescent crust (?) at top; upper contact E/S with reddish-brown clay. Between 1561.7-1562.1: halite, f IV as efflorescent crust (?) or pods. Below 1562.1: halite, f-m IV, some c IV cement, local dissolution pipes; trace reddish-brown to gray clay and polyhalite as stringers and crystal drapes near the lower contact; upper contact gradational.

1563.9-1570.5: Above 1564.3: halite, f IV pods bounded by c-vc IV cements and MP; trace disseminated polyhalite; upper contact E/S with no clay. Between 1563.4-1567.5: halite, m-c IV with vc IV in MPs and as abundant cements, vertically-stacked, narrow dissolution pipes are abundant; discontinuous subhorizontal polyhalite solution lags, to 1/2" thick, are crosscut by vertically-translocated blebs of polyhalite 1/4"-1" wide forming a boxwork fabric; upper contact E/S with polyhalite solution lag and some gray clay. Between 1567.5-1570.5: halite, f-m IV with some c IV cements, orange, some primary halite, moderately abundant cement, local pit near base filled with f IV efflorescent crust (?) and polyhalite drapes; trace to some polyhalite as small to medium blebs, crystal drapes, and solution lags; some polyhalite is vertically translocated in pits; upper contact marked by a polyhalite solution lag.

1570.5-1584.5: Above 1571.3: halite, f-m IV pods, local c-vc IV in MPs and cements; trace polyhalite and clay; upper contact E/S with gray and brown clay. Between 1571.3-1572.5: halite, f-m IV, possible pods or efflorescent crust, some pits with m IV; trace polyhalite stringers and blebs; trace brown to gray clay. Between 1572.5-1573.2: halitic mudstone, brown, with f-m I-IIIa-b halite; pod of f IV. Between 1573.2-1573.5: halite, f IV, possible efflorescent crust at top; trace polyhalite and brown clay; upper contact E/S with brown clay. Between 1573.5-1580.0: halite, m-c IV with abundant cements, vc IV becomes more abundant upward, crystal size decreases above 1574.5, zone of f IV pods/efflorescent crust cross-cut by pit at 1575.8; trace to some polyhalite and brown to gray clay, crystal drapes and blebs, blebs show vertical translocation and displacive boundaries; unit is cross-cut by a large dissolution pipe containing large (up to 1" diameter) polyhalite blebs, blebs are vertically translocated and contain m-c I-IIIa-c halite, trace gray clay and polyhalite blebs occur above pipe; upper contact

gradational. Below 1580.0: halite, f-c IV, mostly c IV, trace primary halite, local MPs; trace to some anhydrite blebs to 1"×1/2" showing displacive boundaries, some blebs contain f-m I-IIIa-c, blebs are aligned vertically; possible pits 1'-2' deep; upper contact gradational.

1584.5-1591.8: Above 1584.7: anhydrite, microcrystalline, halitic and polyhalitic, contorted microlaminae, contains f-m I-IIIb-c halite, upper contact irregular. Between 1584.7-1584.9: halite, m-c IV, clear, abundant cements, upper contact sharp. Below 1584.9: Polyhalite interbedded with anhydrite, microcrystalline, locally halitic; local parallel wavy to contorted thin laminae to very thin beds, some massive beds; local APAGS to 1/4"; irregular zones of finely crystalline halite above 1586.1 and between 1588.0-1590.5, local HPAG sand grains (?); upper contact sharp.

1591.8-1598.5: Halite, f-m IV, rare c IV in MP, orange, moderately abundant primary halite, trace cement; trace polyhalite as disseminated blebs; local subhorizontal polyhalite (some anhydrite) stringers, laminae, and medium beds, most are continuous, often completely dilated or dilated at margins by f Ia-c halite, upper contact sharp, irregular.

1598.5-1605.9: Anhydrite, microcrystalline; thinly laminated to very thinly bedded, strata mimic the lower contact and are wavy at the base, flattening upward, some wavy above 1904.9 with low-angle cross-cutting relationships; some irregular zones of halite between 1601.5-1602.3; large HPAGS above 1601.0, some to 2" high; polyhalite grading upward to anhydrite, thinly laminated to laminated, porous, possible halite cement between 1605.0-1605.9; upper contact sharp, irregular.

1605.9-1607.8: Gray mudstone with polyhalite nodules; microlaminated to thinly laminated mudstone in upper 0.2'; mudstone content increases upward above 1606.8; collapsed nodules between 1606.8-1607.4; mudstone with polyhalite nodules and breccia below 1607.4; probable collapse at lower contact; upper contact gradational.

1607.8-1612.3: Halite, m-cIV, orange, local f IV in lower half, trace to some cement, local MPs; trace polyhalite as small blebs, crystal drapes, and discontinuous stringers (some dilated); upper contact irregular with 2" deep dissolution pits filled with translocated polyhalite blebs with f-m I-IIIb-c; lower contact overlain by 1/2"-1" thick bed of f IV with disseminated polyhalite.

1612.3-1620.5: Halite, m-c IV, zones of c-vc IV cement, gray above 1614.4, orange below 1614.4, vc IV cement between 1613.1-1613.7; trace polyhalite as rare mm-scale blebs and crystal drapes; trace gray clay above 1613.1; trace langbeinite as isolated blebs to 1/4" and rare crystal linings, no langbeinite above 1614.4; E/S at 1613.1, no clay; E/S at 1619.5, no clay, underlain be f IV (efflorescent crust?) with disseminated polyhalite, disseminated langbeinite to 1619.7'; upper contact E/S with gray clay.

1620.5-1621.5: Above 1620.8: halite, m IV; trace disseminated gray clay; upper contact E/S, no clay. Below 1620.8: halite, f-m IV in beds 0.05'-0.1' thick; disseminated gray clay and sylvite (?); possible efflorescent crust; upper contact E/S with gray clay, dilated.

1621.5-1627.4: Above 1621.6: Mudstone, reddish-brown, contains vertically-oriented fibrous halite-filled fractures (desiccation cracks?); upper contact sharp. Between 1621.6-1623.5: halite, m-c IV at base, f-m IV at top, possible efflorescent crust at top, yellowish-orange between 1622.2-1623.3, clear to gray below 1623.3; possible sylvite; contains stringers of brown clay and polyhalite in upper 0.4'; upper contact sharp. Between 1623.5-1627.4: halite, m IV at base, grading upward to m-c IV, c-vc IV in MPs and cements, pit at upper contact contains c IV, f IV (efflorescent crust?) at top; cements rare at base and become common at top; some primary halite near base; trace polyhalite as blebs, crystal drapes, discontinuous stringers, and thin laminae; zone of polyhalite blebs with possible

sylvite in irregular zones with f-m I-IIIb-c halite between 1625.2-1625.7; irregular zones of sylvite (?) below 1627.0; vertically-oriented polyhalite blebs near upper contact; upper contact E/S with polyhalite stringer/solution lag.

1627.4-1630.3: Above 1627.9: argillaceous halite, f-m IV, f IV in pods containing trace disseminated polyhalite and brown clay; pods bounded by zones of brown halitic mudstone containing f-m I-IIIb-c halite and possible sylvite; upper contact sharp, E/S with brown clay and polyhalite solution lag. Below 1627.9: halite, f-c IV, some vc IV in MPs, some primary, cements become more abundant upward; orange at base, grading to yellow at top; trace to some polyhalite as irregular stringers, blebs, and rare crystal drapes, some polyhalite is vertically displaced in to 1"-2" deep pits; upper contact E/S, marked by brown clay that is displaced into a 0.2' deep pit.

1630.3-1643.0: Above 1633.3: halite, m-c IV, c-vc IV in MPs and as cements; trace to some polyhalite blebs, crystal drapes, and stringers; trace disseminated gray to brown clay; moderately abundant langbeinite, some euhedral crystals with dissolved (sylvite?) rims, some blebs; some dissolved sylvite; f IV halite in pods near base with some langbeinite and sylvite (?); upper contact undulatory over 0.2', sharp, E/S with brown clay and polyhalite solution lag. Between 1633.3-1636.8: halite, m-c IV, some vc IV as cements and MP and pit fillings; yellowish-orange below 1637.3, gray to brown above 1637.3; trace to some gray to brown clay as blebs and stringers; trace polyhalite blebs and stringers; locally abundant langbeinite blebs and stringers; sylvite possible locally; upper contact gradational. Between 1636.8-1638.0: halite, m-c IV, some c IV cements; trace to some polyhalite blebs and crystal drapes; langbeinite as possible alteration of polyhalite blebs and crystal drapes; gray in upper 0.5', remainder orange; trace gray clay in upper part; upper contact gradational, possible dilated E/S. Between 1638.0-1643.0: halite; f IV efflorescent crust with trace gray clay above 1638.1; gray m-c IV between 1638.1-1638.9; yellow m-c IV with local f-m IV and moderate cements between 1638.9-1641.0; orange f-m IV with few cements and some possible primary halite below 1641.0; trace polyhalite as disseminated blebs, crystal drapes, and local subhorizontal discontinuous-continuous stringers; some langbeinite crystal linings and blebs (some to 1"×2"), often showing vertical alignment in pits, possible replacements of other sulfates, local f-m I-IIIa-c halite within langbeinite blebs; upper contact E/S with trace polyhalite as a stringer/solution lag.

1643.0-1651.5: Above 1643.6: halite, m-c IV, abundant cements; trace to some gray clay as stringers and blebs; abundant langbeinite with sylvite (?) linings, some euhedral langbeinite; some dissolved sylvite (?); upper contact E/S with no clay or solution lag. Between 1643.6-1649.3: halite, f-m IV at base grading upward to m-c IV, trace to some primary, cements become more abundant upward, local MPs and zones of cement with c-vc IV, orange below 1645.0, gray to clear above 1645.0; trace polyhalite as small to medium blebs (some vertically translocated), crystal drapes, stringers, and rare solution lags with dilation; langbeinite locally abundant as blebs (possible replacement of polyhalite), some translocated into pits; E/S with no clay at 1645.0; upper contact E/S with trace gray clay. Between 1649.3-1651.5: halite, f-m IV, local c-vc IV in MPs and cements, lower 0.2' cement; color bands 0.2'-0.4' thick of clear, orange, yellow, and gray halite; trace polyhalite as small blebs, crystal drapes, and stringers; trace gray clay in upper 0.2'; some langbeinite in upper 0.5' and lower 0.7'; upper contact E/S with trace gray clay.

1651.5-1665.8: Above 1652.7: bloedite, microcrystalline (?), disseminated halite, tan-brown-gray, shows irregular margins; upper contact sharp to gradational. Between 1652.7-1655.9: halite, f IV in pods, pods bounded by argillaceous halite (m IV) and halitic mudstone (m I-IIIa-b); gray clay above 1553.2, brown clay below 1553.2; disseminated polyhalite. Between 1655.9-1657.9: halite, f-c IV, clear, unit cross-cut by pits, pits penetrate upper and lower contacts;

trace brown clay as blebs and crystal linings, some clay translocated into pit (?); trace polyhalite in upper 0.3' as blebs and stringers; upper contact E/S with brown clay, cross-cut by pit originating in overlying unit. Between 1657.9-1660.0: halite, m-c IV, orange, some MPs; no sense of bedding; moderately abundant polyhalite as blebs and stringers showing vertical translocation cross-cut subhorizontal stringers of polyhalite (incipient boxwork fabric); trace gray clay stringers; upper contact E/S, gradational, dilated, cross-cut by 1' deep pit. Between 1660.0-1665.8: halite, f-c IV some vertically-elongate crystals capped by fine crystals (probable bottom growth halite with preserved cumulates), cements moderately abundant and become more common upward, local zones of f IV; generally bedded (0.2'-0.5' thick), beds separated by irregular stringers of polyhalite and/or gray clay; polyhalite also occurs as crystal drapes and irregular blebs (some with possible vertical translocation); orange except between 1662.5-1664.5, where trace brown and gray clay occurs as stringers and brown clay occurs within halite crystals; upper contact gradational, marked by change in character.

1665.8-1680.3: Above 1666.7: mudstone, reddish-brown; no visible stratification; upper 0.3' cemented with halite, no visible crystals; lower part contains argillaceous halite (f IV in pods?) and zones with rare f-m I-IIIa halite; upper contact E/S with trace polyhalite and gray clay as a solution lag. Between 1666.7-1676.2: zones of podular halite (f IV with disseminated brown to gray clay and polyhalite) alternate with zones of halite (m-c IV) and halite cement (vc IV); trace to some brown mudstone as blebs, discontinuous stringers, and thin laminae that show displacive margins with halite; trace gray clay and polyhalite as stringers and small blebs; podular fabrics absent below ~1674; upper contact E/S with solution pit and abundant translocated brown mudstone. Below 1676.2: halite, m-c IV, local f IV (efflorescent crust) in 0.1'-0.2' thick beds in the lower 0.5', abundant cement, trace primary halite near base, mostly clear; trace polyhalite as stringers, blebs, and disseminated material in f IV halite; upper contact gradational, dilated.

1680.3-1689.7: Above 1888.0: halite, f IV in rare to common pods with stringers and blebs of polyhalite and gray to reddish-brown clay; pods are bounded by pits, zones of cement, and possible deep pipes containing m-c IV halite; blebs and stringers of clay and polyhalite occur in zones of halite cement, some show possible vertical displacement; vc halite with crystals 2-3" across occurs between 1682.1-1682.5; upper contact E/S with reddish-brown to gray clay. Below 1688: halite, 0.1'-0.2' thick beds of m-c IV overlain by f IV; trace brown to gray clay stringers and crystal drapes; some MPs with m-c IV; trace to some polyhalite blebs and dilated solution lags; upper contact gradational.

1689.7-1699.0: Above 1693.0: halite, f-m IV in pods; pods contain disseminated reddish-brown clay and polyhalite and stringers and blebs; pods are bounded by halitic mudstone with m-c I-IIIa-c halite above 1691.0; pods are bounded by clear m-c IV cements (trace primary halite) with irregular blebs of polyhalite and clay (reddish-brown to gray) below 1691.0; upper contact sharp. Below 1693.0: halite, m-vc IV, mostly cement, local horizontal zones of f IV near base; trace polyhalite blebs in matrix; polyhalite blebs more abundant in pits, show vertical translocation; large pit widens into a MP at the base; upper contact gradational.

1699.0-1700.5: Above 1699.5: polyhalite, microcrystalline, some nodular fabrics; dilated by f-c I-IIIb-c, trace I-IIIa; upper contact irregular. Between 1699.5-1700.0: Polyhalite, microcrystalline, nodular with dipping strata; locally halitic, poikilotopic halite fills voids; trace gray clay locally; upper contact irregular. Below 1700.0: nodular polyhalite with gray clay, zones of argillaceous nodular polyhalite are bounded by irregular zones of coalesced polyhalite nodules; appears collapsed; upper contact irregular; lower contact a solution surface with ~0.2' of relief.

1700.5-1701.0: Halite, f-m IV, crystal size decreases upward, orange; trace polyhalite blebs and stringers; upper contact solution surface with collapse of overlying unit.

1701.0-1706.2: Above 1702.0: halite, f IV in pods; trace disseminated polyhalite and reddish-brown clay; unit cross-cut by pits filled with m-c IV halite; upper contact E/S with brown clay. Below 1702.0: halite, f-c IV, vc IV locally, local pits; 0.1' thick beds in lower 0.3'; trace disseminated polyhalite blebs; upper contact gradational.

1706.2-1720.9: Three types of halite: 1) f IV in pods with brown clay and polyhalite as disseminated material and local stringers. 2) m-c IV, clear; blebs of clay and polyhalite, some showing vertical translocation over short distances, local polyhalite solution lags, some irregular polyhalite and clay stringers. 3) c-vc IV in pits, pipes, and MPs; trace brown clay and polyhalite blebs. Large MP at the base. Upper contact E/S with brown clay.

1720.9-1722.3: Halite, c-vc IV, mostly cements and MPs; trace to some (at base) polyhalite blebs, stringers, and crystal linings in vc IV; trace gray clay blebs and stringers above 1721.5; upper contact overlain by large MP.

1722.3-1725.5: Above 1722.5: irregular polyhalite bed, microcrystalline, with c IIIc halite. From 1722.5-1722.8: halite, m-c IV, with polyhalite stringers, MP filled with vc IV halite. Below 1722.8: polyhalite, microcrystalline, halitic, appears granular with halite cements, some microcrystalline halite appears displacive; strata appear to follow the upper surface of an irregular zone of m-vc IV halite, halite zone appears dissolved on margins (possible relict of partially-dissolved halite bed); ~1" gray clay at base; upper contact gradational/partially dilated.

1725.5-1734.0: Above 1726.0: halite, f-c IV, f at base, c at top; disseminated gray clay stringers, blebs, and material infiltrated downward from upper contact; upper contact solution boundary, marked by gray clay. Below 1726.0: halite, f-m IV, m-c IV locally, local MPs, orange, crystal size increases upward and c IV cements become more common above 1728.4, beds 0.1'-0.2' thick below 1728.4; beds often display discontinuous stringers of polyhalite; disseminated polyhalite as blebs and randomly-oriented stringers, some vertically-translocated polyhalite blebs form a boxwork fabric locally; upper contact gradational.

1734.0-1737.2: Above 1734.2: polyhalite, halitic, irregular upper contact. Between 1734.2-1735.5: halite, f-m IV, c IV at the top, orange, local MP, possible bottom-growth halite with polyhalite crystal drapes; subhorizontal polyhalite stringers, laminae, and thin beds; upper contact sharp, undulatory. Between 1735.5-1736.2: halitic polyhalite, microcrystalline, subhorizontal laminae to thin beds; local beds 1/4"-1" thick of bottom-growth halite with polyhalite crystal drapes; possible HPAG sand; upper contact sharp, slightly undulatory. Between 1736.2-1736.5: halite, f-m IV, orange, some vertically-elongate crystals (possible bottom-growth halite); upper contact sharp, irregular. Below 1736.5: polyhalite, microcrystalline; hints of subhorizontal strata; local PPAGS to 1/8" high near top; possible HPAGS to 1" high at 1737.0; strata in lower 0.2' slumped and contorted with irregular zones of gray clay; lower contact solution surface, marked by gray clay.

1737.2-1741.7: Above 1739.5: halite, f-m IV, in beds 0.1'-0.5' thick, possible primary halite, orange; trace polyhalite stringers and crystal drapes, local polyhalite solution lag; upper contact sharp, marked by concentration of polyhalite blebs and infiltrated gray clay (solution surface). Between 1739.5-1740.1: halite, m-c IV, equant, gray; trace gray clay; upper contact sharp, E/S with no clay. Below: 1740.1: halite, f-m IV, some c-vc IV, orange, some cement; trace polyhalite crystal drapes and stringers; upper contact sharp.

1741.7-1743.6: Above 1742.2: halite, f IV, gray, possibly hygroscopically altered; disseminated gray clay; upper contact E/S with gray clay and solution pits filled with gray clay. Below 1742.2:

halite, f-m IV, some vertically-elongate crystals; orange except near top; beds 0.1-0.2' thick; trace polyhalite as blebs and subhorizontal stringers; gradational upper contact, no clay.

1743.6-1746.9: Above 1744.9: halite, m-c IV at base, f IV at top, hygroscopically altered; gray and brown clay blebs, stringers, and irregular laminae; upper contact E/S with gray clay stringers. Between 1744.9-1745.7: halite, f IV at top, c IV at base; dark gray clay blebs and stringers; trace polyhalite; upper contact E/S with brown/black clay. Below 1745.7: halite, m-c IV, f IV at top, vc IV in MP, abundant cements, orange to clear; trace subvertical polyhalite stringers, blebs, and crystal linings; upper contact E/S with gray clay.

1746.9-1748.9: Halite, m-c IV, abundant cements; disseminated gray and brown clay as blebs and stringers; brown clay as pipe fillings and large blebs with f-m I-IIIa-b; local polyhalite blebs and POS; stringers; upper contact sharp, irregular.

1748.9-1753.7: Above 1749.5: halitic mudstone, f-m I-IIIab, local pod of f IV; upper contact undulatory. Between 1749.5-1751.6: halite, f-m IV, beds 0.1'-0.2' thick, possible hygroscopic alteration at the tops of some beds; beds locally separated by irregular laminae to very thin beds of reddish-brown mudstone, local blebs of mudstone, mudstone contains f-m I-IIIa-c halite; trace to some polyhalite blebs and POS; upper contact E/S with brown mudstone. Below 1751.6: halite, f-c IV, average crystal size decreases upward, abundant cements, local MPs irregular zones of brown and orange; disseminated polyhalite in zones of f IV; abundant stringers and blebs of polyhalite, some show vertical translocation, some polyhalite POS; local brown clay blebs and stringers, some show vertical translocation; upper contact marked by brown clay separation.

1753.7-1761.2: Above 1755.4: halite, f IV in pods with abundant disseminated reddish-brown clay; trace disseminated polyhalite, some polyhalite POS; pods bounded by brown halitic mudstone with f I-IIIa-c; upper contact E/S with brown clay. Between 1755.4-1757.1: halite, f-m IV, orange, rare c IV cements, weak beds 0.1'-0.3' thick; trace polyhalite blebs; upper contact E/S, undulatory over 0.1'. Between 1757.1-1754.9: halite, c-vc IV, clear, possible large pit/MP filling. Below 1754.9: halite, f-m IV, orange, some c IV cement, some vertically-elongate crystals, grades to m-c IV at top where cements are more abundant, local MPs, beds 0.1'-0.2' thick; trace polyhalite blebs, some large blebs with displacive margins near top, abundant polyhalite blebs near base with f I-II a-b halite.

1761.2-1763.2: Polyhalite, microcrystalline; bottom-growth halite separated by thin laminae to laminae of polyhalite in upper 0.3', halite shows polyhalite crystal drapes and linings; remainder of unit is laminated to medium bedded, strata are wavy to locally contorted, some possible nodules, some strata separated by gray clay; 1/2" gray clay at base.

1763.2-1773.9: Above 1764.2: argillaceous halite and halitic mudstone, reddish-brown; dilated thin beds of f-m IIIc halite bounded by halitic mudstone containing f I-IIIa-c halite; upper contact sharp, marked by gray clay. Between 1764.2-1764.9: halite, f-m IV in pods; trace to locally abundant polyhalite and brown clay as disseminated material, stringers, and laminae; local solution pits; upper contact irregular. Between 1764.9-1765.9: halite m-c IV at base, f IV in upper 0.3', local pits and MPs, c IV in MPs; trace reddish-brown clay and polyhalite blebs, content increases near top; upper contact E/S with brown clay. Between 1765.9-1766.4: halite, f-m IV in pods with disseminated brown clay (some) and polyhalite (trace); pods bounded by pit containing clear m-vc IV halite with trace brown to gray clay; upper contact E/S with no clay. Between 1766.4-1767.3: halite, m-c IV with vc IV cements in MPs and pits; abundant dark brown to orange polyhalite blebs in pit with displacive margins and local I-IIIa-b in some blebs; trace polyhalite and brown clay as stringers and laminae outside of pit. Between 1767.3-1770.8: halite, f-c IV, vc IV in MP, trace primary halite, abundant

cements, orange; trace polyhalite blebs and stringers; trace gray clay near top; upper contact solution pipe 2.1' deep, no solution lag. Below 1770.8: halite, f-m IV, some c-vc IV in cements and MPs, orange, occurs in beds 0.1'-0.3' thick; irregular subhorizontal stringers of polyhalite separate some beds, trace polyhalite as crystal drapes and linings, irregular bed of polyhalite (possible coalesced solution lags) containing f-m I-IIIa-c halite occurs between 1773.1-1773.2; a 0.1' thick polyhalite bed occurs at the lower contact, the bed has slightly deformed laminae and overlies a gray clay laminae; upper contact gradational, marked by dilated solution lag.

1773.9-1775.2: Halite, f-m IV at top, m-c IV at base, orange; trace polyhalite stringers and crystal linings; trace gray clay; upper contact sharp, solution surface.

1775.2-1776.1: Halite, f-m IV at base, m-c IV at top, abundant cements; trace gray clay blebs and stringers; upper contact missing.

1776.1-1782.9: Above 1778.5: halite, f-m IV with clear c IV cements between 1776.5-1777.0; local irregular, blebby thin laminae of polyhalite; trace polyhalite stringers; f IV in upper 0.2', with disseminated polyhalite; upper contact E/S, with ~1" relief, no clay. Between 1778.5-1779.9: halite, f-m IV; clear, c IV cements occur between 1778.6-1779.0; orange below 1779.0; locally abundant polyhalite blebs, some with vertical fabrics; trace polyhalite stringers; trace gray clay stringers and crystal linings; upper contact E/S with trace gray clay. Below 1779.0: halite, f-m IV with c-vc IV in MPs, orange at base, clear at top, possible primary halite near base; trace polyhalite stringers, small blebs, and crystal linings; bedded (0.1'-0.2' thick) below 1782.0; upper contact E/S with trace polyhalite as a solution lag.

1782.9-1791.5: Above 1785.4: halite and argillaceous halite, f IV in pods with trace disseminated brown (base) and gray (top) clay and polyhalite; pods bounded by argillaceous halite, m-c IV with abundant cements, contains irregular zones and blebs of brown mud with f-M I-IIIa-b; E/S with brown clay at 1784.4; upper contact E/S with gray clay. Below 1785.4: halite, m-c IV with local horizontal zones of f IV near base, c IV in MPs, orange; trace polyhalite as blebs, crystal linings, and disseminated material; weakly horizontally bedded, beds 0.1' thick occur between 1790.5-1790.9 with possible bottom-growth halite; upper 0.5' consists of c IV with large polyhalite blebs and stringers, some with displacive boundaries; a dissolution pipe occurs between 1785.4-1787.6 and is filled with clear, equant c IV with a of trace polyhalite and clay; halite on the margin of the pipe is f-m IV with some polyhalite blebs; margin of pipe is irregular; the base of the pipe is marked by polyhalite blebs and crystal linings with displacive margins; 0.1' thick polyhalite bed occurs at 1790.0 and contains f-m I-IIIc halite; upper contact gradational.

1791.5-1802.6: Above 1791.7: halite, f-m IV; disseminated gray clay; upper contact E/S, no clay. Between 1791.7-1793.0: halite, m-c IV, clear, equant; trace polyhalite; trace gray clay, content increases upward; upper contact gradational. Between 1793.0-1795.3: halite, m-c IV, mostly equant, abundant cements, possible m IV pod; moderately abundant blebs, stringers, and irregular zones of reddish-brown mud, some with displacive margins; trace brown polyhalite blebs; upper contact gradational. Between 1795.3-1801.4: halite, c-vc IV at base, m-vc IV at top, clear, equant, large fluid inclusions, possibly recrystallized; minute quantities of clay and polyhalite, insoluble content gradually increases above 1797.4 reaching trace clay (blebs) at top. Between 1801.4-1802.0: halite, m-c IV, clear, equant, possibly recrystallized; trace brown clay on upper surface. Below 1802.0: halite, f-m IV, abundant cement; moderately abundant polyhalite blebs, some blebs show vertical translocation in a pipe; upper contact gradational.

1802.6-1810.5: Above 1805.5: halite, f-m IV in pods bounded by zones of m-c IV cement; pods contain trace to some disseminated polyhalite and gray (above 1803) and brown (below 1803) clay; zones of cement contain blebs, irregular stringers,

and discontinuous laminae of brown mud, some zones and blebs are vertically oriented; E/S with brown clay at 1804.4; upper contact E/S with brown clay. Between 1805.5-1806.5: halite, m-c IV, equant, clear, fills pipe at lower contact; trace clay and polyhalite as small blebs; upper contact gradational. Below 1806.5: halite, f-c IV, m-c IV above 1808.0, some cement, orange, local MPs; trace polyhalite crystal linings and subhorizontal stringers; trace polyhalite blebs above 1808.8; discontinuous polyhalite solution lag at 1810.1; upper contact dissolution pipe ~1.5' deep.

1810.5-1814.1: Above 1811.5: halite f-c IV, brown clay crystal linings, blebs, and stringers; f IV in pods with disseminated brown clay in upper 0.2'; local zones of f IV, possible hygroscopic alteration; upper contact E/S with brown clay. Between 1811.5-1813.0: halite, m-c IV, clear, trace brown clay crystal linings; upper contact gradational. Below 1813.0: halite, m-c IV, orange, local MP; polyhalite blebs and discontinuous stringers at top and bottom; upper contact E/S with polyhalite solution lag.

1814.1-1822.5: Above 1815.5: halite, f IV in pods with disseminated polyhalite and disseminated gray clay in upper 0.1'; pods underlain and bounded by m-c IV cement with trace polyhalite blebs and stringers, some blebs show vertical translocation; local solution pits; upper contact E/S with gray clay. Between 1815.5-1817.3: halite, f-m IV at base, m-c IV at top, clear, equant, possible solution pipe filling; trace polyhalite blebs; upper contact gradational. Between 1817.3-1818.0: halite, f IV in pods; disseminated polyhalite; disseminated gray clay in upper 0.1'. Between 1818.0-1819.0: halite, m-c IV, clear, equant; trace polyhalite blebs; unit is possibly pipe filling halite, fills pipe at base; upper contact irregular and gradational. between 1819.0-1821.5: halite, f-m IV, equant, orange, local MPs; trace polyhalite as blebs showing vertical translocation; local pods near top with disseminated polyhalite; upper contact solution pipe. Between 1821.5-1822.1: polyhalite, microcrystalline, hints of disrupted strata; contains irregular zones of f-m IV halite; upper contact sharp, irregular. Below 1822.1: halite, f-m IV, orange; trace to some polyhalite blebs.

1822.5-1827.7: Above 1825.6: halite, f IV in pods; pods bounded by argillaceous halite; clay is reddish brown at base grading to brown/gray in the upper 0.1' and occurs as crystal lining, blebs, and discontinuous stringers; rare f-m I-IIIa-c; E/S with brown clay at 1823.4; upper contact E/S with trace brown clay. Below 1825.6: halite, f-c IV, mostly m IV, abundant cements, crystal size decreases upward; moderately abundant polyhalite crystal linings, blebs, and discontinuous stringers; trace clay locally; upper contact gradational.

1827.7-1832.3: Above 1830.9: halite, f IV pods with disseminated polyhalite and brown clay; locally bounded by irregular, discontinuous laminae of brown mudstone near the top; possible saucers near top; pods also bounded by f-c IV containing blebs of reddish-brown clay; rare blebs of polyhalite near the base; upper part of unit crosscut by 2.3' deep pit, pit margins marked by clay and polyhalite, f IV halite (efflorescent crust?) occurs on margin of pit; upper contact E/S with brown clay solution lag. Below 1825.6: halite, m-c IV at base, f-m IV at top, equant, orange, abundant cements; trace polyhalite as rare blebs; upper contact undulatory and gradational.

1832.2-1840.9: Above 1833.0: halite, m-c IV, mostly cement; some dark gray and brown clay blebs; upper contact sharp, E/S with 0.7' deep pipe, no solution lag. Below 1833.0: halite, f-m IV, abundant primary halite, some c IV cements, orange, local vertically elongate crystals, weak beds 0.2'-0.4' thick above 1838.4; polyhalite occurs as blebs and discontinuous to continuous stringers and laminae above 1035; locally abundant polyhalite crystal drapes and linings below 1836; polyhalite blebs and crystal linings show displacive margins below 1840.5; upper contact E/S with gray clay.

1840.9-1841.9: Polyhalite, microcrystalline; wavy to locally contorted micro-laminae to thin beds,

slumped at lower contact; irregular halite bed near top contains f-m IV with polyhalite crystal drapes (possible bottom-growth halite); gray clay at base; upper contact wavy, irregular.

1841.6-1851.6: Above 1841.8: Clay, gray, contains f-m I-IIIa-c, upper contact undulatory and sharp. Between 1841.8-1843.5: argillaceous halite, f-m IV, c IV in local cements and in MPs; brown clay occurs as irregular laminae and disseminated blebs, local a-c boundaries with halite; E/S with brown clay at 1842.5; upper contact sharp, irregular. Between 1843.5-1846.5: halite, f-m IV in pods, m-c IV cements; pods contain disseminated polyhalite and gray to reddish-brown clay; irregular zones of cement contain reddish-brown clay and polyhalite blebs and stringers of varying orientation; local polyhalite POS textures; upper contact gradational. Below 1846.5: halite, f-m IV, some vertically-elongate crystals, some c IV in cements and MPs, abundant primary halite, orange, occurs in beds 0.1'-0.4' thick; trace to some polyhalite stringers and blebs; 0.1' thick polyhalite bed at 1849.8 shows slumping at base; halite below 1849.9 shows trace polyhalite crystal drapes and linings; polyhalite lag over basal contact; upper contact E/S, marked by solution lag of polyhalite and trace gray clay.

1851.6-1857.3: Above 1854.0: halite, f-m IV in possible pods above E/S marked by brown clay at 1852.2, m-c IV elsewhere; gray clay as disseminated material, blebs and discontinuous stringers above 1852.2; trace to some gray to brown clay blebs (some large) and stringers below 1852.2; trace polyhalite POS textures below 1853.0; upper contact E/S with gray clay solution lag. Below 1854.0: halite, mostly m-c IV, some f IV locally, c-vc IV as cements and in MPs, orange; trace polyhalite as blebs and rare stringers; crude beds 0.1'-0.4' thick alternate between orange and clear; local polyhalite POS textures; upper contact E/S marked by brown clay.

1857.3-1859.5: Above 1859.0: halite, f-c IV, f IV at top (hygroscopically altered bed?), abundant cements; blebs and laminae (near top) of brown mud; some disseminated brown clay; some stringers of gray clay and local polyhalite POS textures near base; upper contact E/S with no lag. Below 1859.0: halite, f-m IV, orange; trace polyhalite POS textures, blebs, and subhorizontal stringers; upper contact sharp to gradational.

1859.5-1860.0: Halite, f-m IV, possible hygroscopically-altered beds; disseminated polyhalite POS textures; trace gray clay at top; trace brown clay at base in stringers and irregular zones; upper contact E/S marked by polyhalite POS textures.

1860.0-1868.2: Above 1865.5: halite, local pods of f-m IV with disseminated polyhalite and reddish-brown clay; some horizontal to subhorizontal zones of f IV may be large pods or hygroscopically-altered beds; pods are bounded by f-m IV with abundant cements, trace brown clay and polyhalite crystal linings; upper 0.1' consists of brown halitic mudstone with f-m I-IIb-c; E/S with reddish-brown clay occurs at 1862.3; polyhalite blebs become abundant toward the base and in the solution pipe at the lower contact; upper contact E/S with brown clay. Dissolution pipe originating at 1865.5 contains: halite, c-vc IV at base, m-c IV at top; translocated reddish-brown (top) to gray (bottom) clay; irregular masses of polyhalite; large (2"×2") irregular zone of reddish-brown mud containing f-m Ia-b halite. Below 1865.5: halite, m-c IV, some primary halite, abundant cements; trace polyhalite blebs, some with vertical orientation; upper contact marked by solution pit.

1868.2-1872.8: Above 1870.0: halite; f IV in pod near upper contact with some reddish-brown clay and small dissolution pits; remainder consists of f-m IV with c IV cements, gray to brown above 1869.0, orange below 1869.0, trace polyhalite blebs; upper contact E/S with reddish-brown clay and polyhalite solution lag. Between 1870.0-1872.0: halite, f-vc IV, equant; rare polyhalite blebs; upper contact gradational to diffuse. Below 1872.0: halite, f-m IV, some vertically-elongate

crystals, some c IV cements; abundant polyhalite crystal drapes, crystal linings, and stringers; upper contact sharp to gradational.

1872.8-1873.7: Polyhalite, microcrystalline; hints of slumped strata at the base; local zones with PPAG growing into halite-filled voids; HPAGS to 1/8" high near top; lower contact shows slumping/collapse with gray clay and nodular polyhalite; upper contact sharp, slightly irregular.

1873.7-1874.7: Halite, m IV, some f IV, orange; some polyhalite crystal linings and blebs near base, content decreases upward; gray halite with gray clay in pit originating at upper contact; upper contact dissolution surface with ~0.3' relief.

1874.7-1893.7: Above 1877.9: halite, f-m IV in pods bounded by f-m IV cements; trace to some polyhalite as disseminated material and blebs; trace to some gray clay as discontinuous stringers and laminae; upper contact irregular with ~1" relief. Between 1877.9-1882.2: halite, f-m IV, some c IV cements, hints of beds 0.2'-0.3' thick; trace polyhalite as disseminated blebs; upper contact E/S, no clay, dilated. Between 1882.2-1884.0: halite, f-m IV, some c-vc IV cement, clear with orange interbeds 0.1'-0.2' thick; polyhalite as disseminated crystal linings; upper contact gradational. Between 1884.0-1886.1: halite, f-m IV, some bottom-growth halite, some primary halite, orange; trace disseminated polyhalite crystal linings; some polyhalite crystal drapes near base, concentration decreases upward; beds 0.2'-0.5' thick separated by wavy and slightly slumped laminae to very thin beds of polyhalite; polyhalite bed with irregular zones of halite between 1889.0-1889.2; upper contact sharp, marked by irregular and discontinuous polyhalite laminae. Between 1890.8-1891.6: polyhalite, microcrystalline, halitic; contains irregular stringers and zones of anhydrite; possible HPAG sand; upper contact sharp, slightly undulatory. Between 1891.6-1892.2: halite, f-m IV, orange, polyhalitic; trace to some polyhalite crystal drapes and linings; upper contact irregular, possibly dilated. Between 1892.2-1893.3: polyhalite, microcrystalline; thinly laminated with gray clay in lower part with polyhalite PAGS 2 mm-1.5 cm high; hints of disrupted strata in upper part; upper contact sharp, slightly irregular. Below 1893.3: clay, dark gray, with polyhalite nodules 1 mm to 5 mm in diameter; upper contact gradational.

1893.7-1896.2: Halite, f-m IV; alternating gray and orange, gray zones have gray clay stringers and blebs, orange zones have trace polyhalite blebs; clear m-c IV in lower 0.3'; polyhalite accumulation at E/S at 1894.7, E/S underlain by discontinuous bed of f IV (hygroscopically altered bed); upper contact sharp, irregular, dissolution surface.

1896.2-1920.5: Above 1899.5: halite, f-m IV at base, f IV at above 1897.7, local hygroscopically-altered bed near top, gray; trace dark gray clay blebs and local discontinuous and irregular stringers; trace disseminated polyhalite in upper 0.5'; upper contact E/S with some gray and brown clay. Between 1899.5-1901.3: halite, f-c IV, abundant cement, polyhalitic, orange; trace polyhalite; upper contact E/S with dissolution pit, no solution lag. Between 1901.3-1904.0: halite, f-c IV, clear, abundant cement, fills pit below 1902.5; pit cross-cuts polyhalitic halite, f-m IV, orange with trace polyhalite blebs; upper contact gradational, dilated (?). Between 1904.0-1909.5: halite, m-vc IV above 1906.5, f-m IV between 1906.5-1909.2, c IV below 1909.2, mostly equant, abundant cements; trace to some gray clay as blebs and discontinuous and irregular stringers; upper contact marked by dissolution pipe. Between 1909.5-1918.5: halite, m-c IV, some vc IV cements, local zones of f IV as hygroscopically-altered beds beneath local E/S, local dissolution pits, orange from 1915.5-1918.5, alternating zones of gray (trace gray clay) and orange above 1915.5, no apparent primary halite; moderately abundant, irregular and discontinuous polyhalite stringers and laminae, many showing vertical displacement; trace to some thick polyhalite crystal linings; polyhalite content decreases upward; unit show apparent slumping of insoluble materials (possibly due to

long-term vadose zone alteration); upper contact undulatory, gradational, no solution lag, possible E/S. Below 1918.5: anhydrite, microcrystalline, gray; upper 0.1' consists of polyhalite; HPAGS to 1" tall in upper part; microlaminated to thinly laminated, wavy, some low angle cross-cutting relationships, 0.1' gray clay at base; upper contact sharp, undulatory, moderately irregular.

1920.5-1926.4: Above 1924.0: halite, f IV in local pods, pods bounded by gray m-c IV with some vc IV cement, pit at lower contact filled with clear m-c IV; trace to some gray clay as stringers and disseminated material; local blebs of gray clay with f I-IIIa-b halite; trace polyhalite blebs; trace polyhalite as lag along the lower dissolution pipe boundary; upper contact sharp, dissolution surface. Below 1924.0: halite, f-m IV, rare c IV cement, some primary halite, orange, hints of beds 0.2'-0.4' thick; trace polyhalite as blebs and intercrystalline material; upper contact marked by dissolution pipe.

1926.4-1930.0: Above 1927.4: halite, f IV in pods bounded by f-m IV cement, local c IV in MPs and dissolution pits; trace gray clay; trace disseminated polyhalite and gray clay in pods; upper contact irregular E/S with gray clay, overlain by deformed polyhalite laminae (solution lag?). Below 1927.8: halite, f-m IV, abundant cements, orange; trace polyhalite blebs; trace gray clay near middle of unit; undulatory E/S at 1928.9 is dilated and marked by gray clay; possible discontinuous hygroscopically-altered beds in lower 1'; upper contact E/S no clay, marked by dissolution pipe.

1930.0-1936.1: Above 1932.8: halite, f IV in pods and possible hygroscopically-altered beds (above 1932.8), pods bounded by clear m-c IV as cement and dissolution pipe filling; pods contain trace disseminated gray clay and polyhalite; local polyhalite blebs, local gray clay stringers and blebs; pipes and cements contain rare gray clay and polyhalite blebs; upper contact E/S with gray clay, E/S cross-cuts pit in upper part of unit. Below 1932.8: halite, c-vc IV in lower part with abundant cements, m-c IV above 1933.5 (may fine upward), hints of beds near middle part of unit 0.1'-0.2' thick; trace polyhalite as blebs, some with displacive margins; upper contact marked by dissolution pipe.

1936.1-1947.8: Above 1946.9: anhydrite, microcrystalline, gray; strata occurs in zones bounding HPAGS, thin laminae to laminae are flat to wavy, locally contorted and disrupted, some cross-cutting relationships; HPAGS range from 1/4"- 4" tall, local HPAGS mounds; upper contact sharp. Between 1946.9-1947.3: anhydrite, microcrystalline, gray; microlaminated at base grading to thin laminae at top, strata parallel and follow lower contact. Below 1947.3: gray clay, hints of microlaminae that parallel undulatory lower contact, contains subhorizontal fibrous halite-filled fracture to 1/2" thick.

1947.8-1952.6: Above 1950.5: halite, m-c IV with some pods of f IV, abundant cement, gray; trace gray clay as crystal linings and blebs; trace disseminated gray clay in pods; upper contact sharp, irregular, dissolution surface. Below 1950.5: halite, m-c IV, equant, abundant cement, gray; trace anhydrite crystal linings; trace gray clay at top.

1952.6-1952.8: Anhydrite, microcrystalline, gray; microlaminated to thinly laminated, wavy to contorted, mimic lower boundary; unit contains relict zones of halite; upper contact sharp, irregular.

1952.8-1957.1: Above 1955.5: halite, f IV in upper ~1.5', some f IV in pods, some m-c IV in zones bounding pods and as cements; trace disseminated anhydrite and gray clay; upper contact sharp, irregular. Between 1955.5-1957.1: halite, m-c IV at base, f-m IV at top, clear, abundant cement; trace anhydrite; upper contact gradational.

1957.1-1959.5: Above 1958.0: halite, f IV, in pods or hygroscopically-altered beds; trace to some disseminated polyhalite and polyhalite POS textures; trace disseminated gray clay; upper contact gradational, possibly dilated. Below

1958.0: halite, f-m IV, gray; trace anhydrite crystal linings and disseminated gray clay; upper contact diffuse.

1959.5-1963.7: Above 1961.5: halite, f-m IV at base, f IV at top; trace disseminated polyhalite and gray clay; upper contact gradational. Between 1961.5-1962.0: clay, gray; contains m-c I-IIa-b halite, possible cave filling; unit thins dramatically across diameter of core; upper contact sharp, irregular. Below 1962.0: halite, c-vc IV; equant, gray, large MP filled with clear halite near top; moderately abundant, discontinuous anhydrite laminae show vertical translocation; large irregular mass of anhydrite near base shows vertical translocation; some translocated gray clay; upper contact sharp, irregular.

1963.7-1965.0: Anhydrite, microcrystalline; microlaminated to thinly laminated, strata are wavy to contorted; local irregular zones of halite; HPAGS to 2" high; gray clay at lower contact; upper contact sharp, slightly irregular and undulatory.

1965.0-1975.2: Above 1971.2: halite, f IV in pods and hygroscopically-altered beds, pods and hygroscopically-altered beds are bounded by f-m IV; gray clay and polyhalite as disseminated material, some blebs, and some stringers; E/S (?) with gray clay at 1964.4; upper contact sharp, dissolution surface marked by gray clay. Between 1971.2-1974.0: halite, f-c IV, mostly m IV, equant, brown to gray; trace polyhalite blebs; local blebs and discontinuous stringers of brown clay; upper contact gradational. Below 1974.0: halite, f-c IV, abundant cements, orange, brown in upper 0.2'; trace disseminated polyhalite blebs and crystal linings, blebs concentrated in upper 0.3'; upper contact gradational.

1975.2-1984.5: Above 1981.9: halite; abundant f IV pods; m-vc IV in MPs, dissolution pipes, and zones of cement; pods contain irregular stringers and blebs of polyhalite and brown clay; zones of cement contain abundant blebs and stringers of reddish-brown clay at top; trace brown clay and polyhalite at base; E/S at 1976.6 marked by brown clay containing f-m I-IIIa halite, clay shows displacive "a" boundaries with IV halite; E/S with brown clay at 1979.9; upper contact gradational, dilated E/S. Below 1981.9: halite, f-m IV, beds ~0.3' thick, MP at base; orange; brown between 1982.5-1983.0, zone contains brown clay stringers and blebs; trace polyhalite crystal linings, blebs, and stringers; upper contact gradational.

1984.5-1986.7: Above 1986.0: argillaceous halite, f-m IV with c IV in MPs and cements; reddish-brown clay stringers and blebs show displacive boundaries with IV halite and contains f IIa halite; trace polyhalite blebs and stringers; E/S with brown clay at 1984.7; upper contact undulatory E/S with no solution lag. Below 1986.0: halite, m-c IV, clear, abundant cements; trace polyhalite; upper contact gradational.

1986.7-1991.8: Above 1990.4: argillaceous halite; f IV in pods with disseminated reddish-brown clay and polyhalite, some gray clay, irregular discontinuous laminae and zones of reddish-brown clay with some Ia halite and displacive boundaries with IV halite; zones bounding pods, cements, MPs, and dissolution pits contain m-c IV halite with disseminated reddish-brown clay blebs and discontinuous stringers and laminae; trace polyhalite blebs; upper contact E/S with reddish-brown clay and polyhalite solution lag. Below 1990.4: halite, f-m IV, with c IV cement and MP filling, orange, trace polyhalite as disseminated crystal drapes, blebs, and discontinuous subhorizontal stringers; upper contact gradational.

1991.8-1995.5: Above 1993.0: halite, f IV in pods with disseminated polyhalite and brown clay, some stringers of brown clay; unit cross-cut by dissolution pipe filled with equant m-vc IV halite; pipe contains translocated polyhalite and reddish-brown clay blebs with displacive boundaries (IIIa); upper contact E/S with reddish-brown clay and polyhalite solution lag. Below 1993.0: halite, m-vc, orange, cross-cut be dissolution pipe filled with clear m-vc IV; trace polyhalite blebs with displacive boundaries;

trace reddish-brown clay in pit; upper contact gradational.

1995.5-2006.8: Above 1998.1: halite, f IV in pods, m-c IV as cements and in small MP; brown clay as disseminated material, as stringers and in irregular zones; irregular zone of brown mudstone near upper contact contains f Ib-c halite; upper contact E/S with reddish-brown solution lag. Between 1998.1-2002.1: halite, f-c IV, c IV occurs mainly as cements, some pods of f IV with disseminated polyhalite, color alternates between orange and gray (clay); some polyhalite crystal linings and blebs; upper contact gradational. Below 2002.1: halite, f-c IV, f IV in pods above 2002.5; moderately abundant polyhalite crystal linings and solution lags of crystal linings above 2005.5; abundant polyhalite crystal linings to 1 mm thick below 2005.5, many with displacive "a" boundaries, local solution lags of linings with m-c I-IIa-b halite; polyhalite blebs moderately abundant above 2004.0, some with displacive boundaries; solution lag of polyhalite crystal linings in lower 0.3', some f-m I-IIa-c halite; 2.7' deep solution pipe originates near upper contact, filled with mostly clear halite; upper contact gradational.

2006.8-2016.4: Anhydrite, polyhalitic below 2008.2, microcrystalline, gray to grayish orange; thinly laminated to laminated above 2008.2, wavy, dips following upper contact, some low angle cross-cutting relationships; mix of anhydrite and polyhalite between 2008.2-2015.5, HPAGS with some PPAGS to 4" high, polyhalite content ranges from 10% at top to 60% at base; anhydrite below 2015.5, microlaminated to thinly laminated, APAGS to 2 mm high; halitic gray clay between 2016.0-2016.2; anhydrite in lower 0.2'; no clay at lower contact; upper contact sharp, undulatory.

2016.4-2018.2: Halite, f-m IV, clear, some primary halite (?); beds to 0.5' thick delineated by dilated, flat polyhalite laminae; anhydrite bed 0.1' thick at base, microcrystalline, gray, wavy to disrupted thin laminae to laminae, overlies dissolution surface with 0.1' relief, gray clay mixed with halite underlies anhydrite bed; upper contact sharp, dissolution surface marked by dilated polyhalite solution lag.

2018.2-2032.8: Above 2028.0: halite, gray f-m IV above 2024.9, gray f IV between 2024.9-2027.0, clear m-c IV below 2027, local f IV in pods near the top and in zones of hygroscopically-altered beds; disseminated gray clay, brown clay, and anhydrite, locally concentrated in pods and hygroscopically-altered beds; polyhalite POS textures in some hygroscopically-altered beds near base; upper contact E/S with trace to some gray clay. Below 2028.0: halite, f-m IV above 2031.0, m-c IV below 2031.0; 0.1' thick anhydrite bed with irregular, deformed, thin laminae at 2022.0; orange with trace polyhalite blebs and irregular laminae below 2032.0; discontinuous, irregular, 0.5' thick zone of dipping (~45) polyhalite laminae above 2032.0; clear transitioning to yellow at top; discontinuous polyhalite and anhydrite stringers and laminae above 2031.0, crude beds 0.3'-0.5' thick; upper contact marked by brown clay stringer.

2032.8-2035.0: Halite; gray f-m IV with trace disseminated polyhalite and gray clay above 2034.0, possible pods; clear to orange, equant m-c IV with trace polyhalite blebs; gray halite in pit; upper contact irregular, possibly dilated.

2035.0-2037.5: Above 2036.0: halite; f IV in pods with trace polyhalite and gray clay at top; clear, equant f-m IV with trace brown clay blebs and stringers at base; upper contact E/S. Below 2036.0: halite, f-m IV, gray; disseminated gray and brown clay; trace polyhalite; upper contact E/S with trace gray clay.

2037.5-2045.5: Above 2040.5: halite, m-c IV, mostly dissolution pipe filling, clear; local f IV on margin of pipe; trace polyhalite blebs on margin of pipe; upper contact E/S with trace brown clay. Between 2040.5-2042.0: halite, f IV in pods or hygroscopically-altered beds cross-cut by a dissolution pipe filled with clear, equant m-c IV; trace disseminated gray clay and polyhalite in pods or hygroscopically-altered beds; rare

polyhalite and brown clay blebs in pipe; upper contact gradational. Below 2042.0: halite, m-c IV, clear, equant; trace polyhalite, anhydrite, and brown clay blebs; upper contact diffuse.

2045.5-2054.5: Above 2050.5: halite, f IV in pods, pods contain trace disseminated polyhalite and reddish-brown to gray (at top) clay; pods bounded by equant f-m IV cement with trace reddish-brown clay blebs; entire unit cross-cut by dissolution pipe. Pipe is filled with equant m-c IV; trace to some polyhalite blebs, some show displacive boundaries; trace reddish-brown clay blebs; local reddish-brown clay laminae crosses pipe but doesn't enter adjacent pods at 2047.0; pipe is likely continuous with overlying unit. Below 2050.5: halite, m-c IV with some f IV and vc IV, clear to brown above 2052.0, orange below 2052.0; moderately abundant polyhalite as large blebs, some with displacive "a" boundaries, many appear vertically translocated, polyhalite content decreases upward; some gray and brown clay blebs and stringers above 2053; trace brown clay stringers and blebs above 2052.0; most of unit likely pipe filling; upper contact diffuse.

2054.5-2057.8: Halite; c-vc IV in lower 1'; m-c IV in most of unit, fines upward; f IV in a pod near upper contact contains disseminated polyhalite and reddish-brown clay; cobble size anhydrite clasts near upper contact, possibly deformed while soft; irregular zone of reddish-brown mudstone near top contains f-m Ia halite; irregular zones of vertically translocated mudstone in lower 1', contains c-vc I-IIIa-b halite; abundant vertically translocated polyhalite blebs, some with displacive boundaries; upper contact E/S, no clay, possible dissolution pipe.

2057.8-2062.8: Halite, m-c IV, pod of f IV with disseminated polyhalite in upper 0.5', vc IV in MPs near base, orange between 2059.3-2060.7; unit cross-cut by dissolution pipes filled with reddish-brown and some gray mud; trace polyhalite blebs and irregular zones in pipe filling; abundant large blebs and zones of polyhalite with displacive boundaries and some II-IIIa halite between 2059.3-2060.7; zones of reddish-brown mud near base contains f-m I-IIIa-b halite; some gray clay and anhydrite crystal linings and stringers between 2060.6-2061.8; upper contact E/S with reddish-brown mud filled pipe.

2062.8-2068.9: Above 2066.4: halite; f IV in pods with trace disseminated polyhalite and reddish-brown clay, polyhalite and clay content increases below 2064.7 as irregular discontinuous zones and laminae surrounding pods; pods bounded by pipes filled with clear, m-c IV with equant crystals, pipes contain trace clay blebs below 2066.0; upper contact E/S with brown mud. Below 2066.4: halite; m-c IV above 2067.5, trace anhydrite and reddish-brown clay as crystal linings, blebs and stringers; equant, clear c-vc IV below 2067.5, rare polyhalite blebs, local f IV; upper contact E/S with reddish-brown clay.

2068.9-2076.7: Above 2072.0: halite; f IV in pods with disseminated polyhalite and reddish-brown clay near top, pods locally bounded by stringers of reddish-brown clay, cross-cut by dissolution pipes filled with c IV halite and translocated reddish-brown clay blebs and stringers; clear f-c IV in lower part, rare disseminated anhydrite crystal linings, rare reddish-brown crystal linings and blebs; upper contact E/S, dissolution pipe, no clay. Below 2072.0: halite, f-m IV, clear, abundant primary, hints of beds 0.2'- 0.5' thick; trace polyhalite blebs; rare anhydrite blebs and discontinuous stringers/laminae below 2075.0; upper contact gradational.

2076.7-2077.2: Anhydrite, microcrystalline, gray, microlaminated to thinly laminated, strata show some low-angle cross-cutting relationships; no gray clay at base, overlies reddish-brown mudstone; upper contact sharp, undulatory.

2077.2-2084.5: Above 2082.2: halite; f IV in pods with trace disseminated brown clay, pods bounded irregular discontinuous laminae of reddish-brown clay; f-m IV in pipes, MPs, and cements; cements contain trace reddish-brown clay blebs and discontinuous stringers; upper contact E/S with reddish-brown mudstone. Below

2082.2: halite, f-m IV, local c IV, clear, mostly equant, some primary halite; some stringers of reddish-brown clay in lower 0.2'; upper contact gradational.

2084.5-2090.9: Above 2085.9: halite, f-m IV; trace to some reddish-brown clay as stringers and blebs; trace gray clay and anhydrite near the base; pods of f IV above 2085.2, trace disseminated polyhalite, pods bounded by irregular zones of brown clay; upper contact E/S with no clay. Below 2085.9: halite, f-m IV with some c IV cements, clear, some primary, beds 0.1'-0.5' thick below 2088.5; trace discontinuous anhydrite stringers, stringers and blebby laminae of anhydrite become more abundant below 2089.0; 0.1' thick bed of anhydrite and anhydritic gray clay occurs at 2090.3, exhibits wavy to contorted microlaminae, contains f-m I-IIIa-c; a hygroscopically-altered bed consisting of f IV underlies upper contact; upper contact marked by dissolution pit.

2090.9-2099.7: Above 2095.5: halite; f IV in pods and hygroscopically-altered beds, pods contain trace disseminated reddish-brown clay; pods bounded by irregular, discontinuous stringers of reddish-brown clay; halite bounding pods consists of equant, clear f-c IV with discontinuous stringers of anhydrite and a trace of polyhalite; E/S with reddish-brown clay at 2093.4 underlain by a hygroscopically-altered bed; local MP; upper contact sharp, undulatory. Below 2095.5: halite, f-m IV, some c IV near base, beds 0.1'-0.4' thick below 2097.0; orange above 2096.0, brownish yellow between 2096.0-2097.0, orange below 2097.0; trace polyhalite disseminated in crystals; trace gray clay at 2096.2; trace anhydrite crystal linings and stringers; E/S with anhydrite solution lag at 2098.8; 0.4' thick zone of dilated, discontinuous, irregular stringers and laminae of anhydrite occurs below E/S; upper contact E/S (?), no clay.

2099.7-2100.6: Anhydrite, microcrystalline, gray, halitic; microlaminated to laminated, wavy to contorted; HPAGS to 2 mm high; overlies brown clay on E/S; upper contact sharp.

2100.6—2107.3: Above 2101.8: halite; f IV in hygroscopically-altered beds with trace disseminated clay and rare polyhalite; beds bounded by irregular, discontinuous, subhorizontal stringers of brown clay; remaining halite consists of equant, clear, f-m IV with trace amounts of anhydrite; upper contact E/S with brown clay. Between 2101.8-2107.0: halite, f-m IV, clear with a yellow hue, possible primary halite, hints of beds 0.2'-0/5' thick; local discontinuous anhydrite laminae; upper contact gradational. Below 2107.0: anhydrite, microcrystalline, gray; discontinuous, disrupted microlaminae to laminae; discontinuous zones of f-m IV halite with polyhalite POS textures; underlain by gray clay; upper contact sharp, slightly irregular.

2107.3-2115.0: Above 2110.5: halite; f IV in pods with trace disseminated brown clay and trace irregular and discontinuous brown to gray clay stringers, rare polyhalite; pods bounded by f-m IV with brown to gray clay stringers and blebs, rare anhydrite blebs; equant, f IV with trace disseminated brown clay in lower 1.5'; possible hygroscopically-altered bed at base; upper contact dissolution surface with gray clay. Between 2110.5-2112.8: halite, f-m IV, equant, local c IV, abundant cement; trace brown clay blebs; rare polyhalite blebs; upper contact gradational. Below 2112.8: halite, f-c IV, c-vc IV in pipes and MPs; trace polyhalite as intracrystalline blebs; dissolution pipe filled with clear m-c IV penetrates lower contact; upper contact gradational.

2215.0-2116.0: Halite, m-c IV, equant; trace disseminated brown clay; brown clay blebs near top; unit cut by pit originating in overlying unit; upper contact sharp to gradational.

2116.0-2118.0: Halite; m-c IV with disseminated reddish brown clay above 2116.5, mostly cement; f IV in pods with disseminated brown clay between 2116.5-2117.3, pods bounded by irregular and discontinuous stringers of brown clay; equant f-m IV with trace disseminated brown clay below

2117.3; E/S with brown clay containing I-IIIa-b halite at 2116.5; upper contact gradational.

2118.0-2121.0: Above 2018.5: halite, f IV in pods with disseminated polyhalite and gray clay; upper contact gradational. Between 2018.5-2019.2: halite, m-c IV, equant; trace brown clay and polyhalite blebs showing vertical translocation; upper contact gradational. Below 2019.2: halite, m-c IV at base, grading to f-m IV at top; trace to some polyhalite crystal linings and blebs show vertical translocation, fewer blebs near base; upper part of unit cross-cut by dissolution pipe, pipe filling similar to rest of unit with fewer blebs; upper contact gradational.

2121.0-2130.4: Above 2123.5: halite; f IV in pods with trace disseminated brown clay and polyhalite, edges of pods show irregular and discontinuous stringers (solution lags) of brown clay; pods bounded by dissolution pipes and cements consisting of equant f-m IV with blebs (some suggesting vertical translocation) and discontinuous stringers of brown clay; upper contact E/S, marked by solution lag of polyhalite and gray and brown clay. Between 2123.5-2129.9: halite, m-c IV, clear, equant, locally contains zones of f-m IV and c-vc IV; contains rare blebs of brown clay above 2128.7, some showing vertical translocation in a dissolution pit (?); gray clay crystal linings below 2128.7; rare polyhalite blebs below 2129.0; unit may be mostly dissolution pipe filling; upper contact gradational. Below 2129.9: polyhalitic halite, m-c IV, equant; abundant polyhalite as 1 mm thick crystal linings and large blebs (to 2"), some blebs show displacive "a" margins; upper contact sharp to gradational.

2130.4-2134.5: Polyhalite, microcrystalline, orange; tipped, collapsed, and dissolved HPAGS and irregular zones (relicts of halite beds?) of vc IV halite above 2132.0; polyhalite contains nodules (?) of anhydrite below 2132.0, some with disseminated polyhalite, anhydrite content increases downward; anhydrite nodules coalesced into beds (?) below 2133.5; consists of microcrystalline, gray, anhydrite below 2134.2, anhydrite exhibits wavy to contorted, slumped and disrupted laminae to very thin beds; bedded nodular anhydrite overlies microlaminated to thinly laminated anhydrite at base; 1/2" thick bed of gray clay at base; upper contact sharp, irregular and undulatory.

2134.5-2142.4: Above 2139.0: halite; f IV in pods with trace disseminated gray clay and polyhalite, local discontinuous stringers and laminae of gray clay on edges of pods; halite bounding pods consists of equant, clear to gray, f-m IV with discontinuous stringers and laminae of gray clay, rare blebs of gray clay and polyhalite; upper contact dissolution surface marked by gray clay. Below 2139.0: halite, m-c IV below 2141.0, f-m IV above 2141.0, polyhalitic, orange; contains abundant small-large blebs of polyhalite, some with "a" margins, some blebs contain f Ib-c halite; local polyhalite crystal linings and subhorizontal stringers; unit has sense of vertical translocation; blebby solution lag of polyhalite in lower 0.1', partly dilated, underlain by gray clay; upper contact gradational.

2142.4-2147.7: Above 2144.7: halite; f IV pods with trace disseminated polyhalite and reddish-brown and gray clay; bounded by dissolution pipe and MPs with clear m IV with reddish-brown clay crystal linings and blebs; local zones of f-m IV cements; upper contact dissolution surface, marked by gray clay (solution lag ?). Below 2144.7: halite, f-m IV, rare c IV in MPs, coarsens upward; moderate polyhalite as crystal linings, vertically-displaced blebs, and 2" thick zones of solution lags; polyhalite solution lags contain f-m I-IIIa-c halite; upper contact E/S, no lag.

2147.7-2150.4: Zones of f IV in pods and hygroscopically-altered beds alternate with gray to orange, equant, m-c IV cements; pods contain disseminated polyhalite and gray clay; cements contain large zones of polyhalite solution lags with f I-IIb-c, trace subhorizontal stringers of gray clay; upper contact marked by hygroscopically-altered beds, gradational.

2150.4-2159.2: Above 2154.2: halite, f IV in pods, m-c IV cements, m-vc IV in dissolution pipes; pods contain trace disseminated polyhalite and reddish-brown clay, disseminated brown and gray clay in upper 0.7'; cements contain rare, disseminated polyhalite blebs; dissolution pipes contain vertically-displaced small to large blebs of polyhalite and brown mud (some with displacive "a" boundaries); dissolution pipe in lower 0.5' contains infiltrated brown mud with m I-IIa-b halite; upper contact E/S with dilated polyhalite and gray clay solution lag. Below 2154.2: halite, f-c IV, c-vc IV in MP, f-m IV in upper 1' and lower 0.7', orange; trace to some polyhalite as crystal linings, discontinuous and irregular laminae, and vertically displaced blebs; 0.1' thick irregular bed of polyhalite at 2159.0; upper contact gradational.

2159.2-2159.5: Anhydrite, microcrystalline, gray; HPAGS to 3 mm high near top; local zones of halite bounded by collapsed (?) anhydrite; wavy microlaminae to thin laminae near at top; gray clay at base; upper contact sharp.

2159.5-2166.2: Above 2163.0: halite; f-m IV above 2060.2, E/S marked by gray clay is cross-cut by solution surface at upper contact; the middle of the unit contains f IV in pods with trace disseminated polyhalite and brown clay; pods are cross-cut by a dissolution pipe containing clear, equant f-c IV with blebs of brown clay (some containing f Ia halite); the lower part of the unit consists of clear f-m IV with trace crystal linings of polyhalite and gray (more common upward) and brown; E/S marked by gray clay at 2060.2; upper contact dissolution surface, sharp. Below 2163.0: halite, m IV at base grading to f IV at top, equant, orange, in beds 0.2'-0.5'; trace disseminated polyhalite as intracrystalline blebs; upper contact marked by solution pit, gradational, dilated.

2166.2-2175.4: Above 2170.2: halite, f IV in pods and hygroscopically-altered beds with trace disseminated brown clay and polyhalite (rare); hygroscopically-altered beds contain subhorizontal, irregular, discontinuous brown clay laminae; pods and hygroscopically-altered beds bounded by zones of cement and dissolution pipes with clear, f-m IV with reddish-brown clay blebs. Below 2170.2: halite, f-m IV below 2174.0, m-c IV between 2172.0-2174.0, f-m IV above 2172.0, clear; trace gray clay between 2170.6-2171.0 and at upper contact; f IV remnant of a hygroscopically-altered bed near top; halite contains rare intracrystalline blebs of polyhalite and gray clay; upper contact E/S marked by gray clay solution lag.

2175.4-2178.8: Above 2177.2: halite; f IV in pods with disseminated gray clay; pods locally cross-cut by dissolution pits; pods bounded by f-m IV with trace to some vertically displaced blebby laminae and blebs (some contain I-IIIa-c halite); dissolution pits filled with equant f-m IV; upper contact E/S with pit and local gray clay solution lag (above a f IV pod). Below 2177.2: halite, m-f IV, orange; trace polyhalite as disseminated crystal linings and discontinuous stringers; upper contact E/S, no lag.

2178.8-2186.9: Above 2180.0: halite; f-m IV with some c IV, gray to orange, cross-cuts pods or hygroscopically-altered beds of f IV with disseminated polyhalite; moderately abundant anhydrite blebs, discontinuous stringers, and crystal drapes; upper contact sharp to gradational. Below 2180.0: halite, f-m IV, possible primary halite, some c IV in MPs, orange, occurs in beds 0.1'-0.5' thick, beds become less distinct upwards; trace polyhalite as discontinuous to continuous, subhorizontal stringers and laminae; some polyhalite crystal linings and drapes; dilated anhydrite bed at 2186.5; upper contact gradational.

2186.9-2200.0: Above 2197.2: anhydrite, microcrystalline, gray, locally polyhalitic between 2191.5-2096.5; halitic anhydrite and polyhalite above 2188.0 with HPAGS to 5 mm tall and local f-m I-IIIa-b; upper 0.3' shows dilated laminae separated by halite; locally laminated to thinly bedded, mostly wavy to contorted

with HPAGS to 4" high; possible crushed-prism texture between 2192-2095; upper contact sharp, marked by anhydrite laminae. Between 2197.2-2197.6: anhydritic siltstone, gray; hints of flat strata; possible anhydrite nodules (?) near top; thin laminae of anhydrite near base; upper contact sharp. Between 2197.6-2199.5: anhydrite, microcrystalline, gray; microlaminated to thinly laminated, flat with some low-angle cross-cutting relationships; upper contact sharp, erosional. Below 2199.5: Sandy siltstone, halitic, gray; local f I-IIIa-b halite; upper contact sharp.

2200.2-2204.6: Halite, f-m IV, orange, occurs in beds 0.1'-0.5' thick; trace subhorizontal polyhalite and rare anhydrite stringers; some disseminated, intracrystalline polyhalite; dissolution pit at top filled with m-c IV and trace gray clay; ~0.1' thick dilated bed of anhydrite occurs at base of unit, bed contains f-m IV and some IIIa halite and overlies 1/2" thick gray clay bed; upper contact sharp, dissolution surface.

2204.6-2210.2: Above 2208.5: halite; f IV in pods with disseminated polyhalite and gray (near top) and reddish-brown (near base) clay; pods bounded by irregular zones of f-m IV cement containing trace brown clay blebs; large blebs occur in dissolution pipe with m-c IV, pipe contains some vertically translocated polyhalite blebs; upper contact sharp, dissolution surface marked by gray clay. Below 2208.5: halite, f-m IV, c IV in MPs, orange; trace to some polyhalite blebs and crystal linings; upper contact gradational.

2210.2-2211.2: Halite, f-m IV, c IV in MP and dissolution pipe at base, clear, f IV in pod at top; moderately abundant polyhalite and reddish-brown clay blebs showing vertical translocation; E/S at 2210.6 marked by brown clay and polyhalite solution lag; upper contact E/S, marked by brown mud solution lag with f Ia halite.

2211.2-2215.7: Above 2013.6: halite; f IV in pods with disseminated brown clay and polyhalite (near top); margins of pods marked by stringers and irregular zones of brown clay; unit cross-cut by dissolution pipe; pipe filling and cements bounding pods consist of equant m-c IV with some f IV, trace brown clay blebs and crystal linings; upper contact marked by dissolution pipe. Below 2013.6: halite, f-m IV, some c IV, orange; some polyhalite crystal linings and blebs (some with I-IIIc); some gray clay near 2015.1; pit penetrates gradational upper contact.

2215.7-2218.0: Above 2216.7: halite; f IV in pods with disseminated polyhalite, brown clay laminae and zones on edges of pods; pods bounded by equant m IV cement with trace brown clay; upper contact E/S marked by a brown clay and polyhalite solution lag. Below 2216.7: halite, f-m IV, mostly clear, trace polyhalite; some discontinuous hygroscopically-altered beds of f IV containing trace disseminated polyhalite, beds 0.2'-0.5' thick; upper contact gradational.

2218.0-2224.2: Above 2221.7: halite; m-c IV at base, equant, clear; grades upward to equant f IV with local f IV hygroscopically-altered beds; trace brown clay as blebs and subhorizontal stringers; rare polyhalite blebs; upper contact E/S (?), no lag. Below 2221.7: halite, f-c IV at base, f-m IV at top, f IV hygroscopically-altered beds (?) near top, orange in lower 0.5', remainder clear; trace polyhalite blebs; trace reddish-brown and gray clay; polyhalitic anhydrite bed in lower 0.2' displays irregular and discontinuous thin laminae and is dilated by f-m I-IIIa-b, underlain by gray clay; upper contact E/S with small dissolution pit.

2224.2-2226.7: Halite, equant m-c IV at base, f IV (hygroscopically-altered bed?) at top, occurs in beds 0.5'-0.7' thick, upper surfaces of beds become more irregular upward above 2225.0; trace polyhalite crystal linings and blebs in coarser halite; trace disseminated polyhalite in finer halite; upper contact dissolution surface marked by gray clay.

2226.7-2238.5: Above 2228.5: halite, beds of equant m IV topped by f IV hygroscopically-altered beds, beds 0.2-0.5' thick; rare disseminated polyhalite and brown clay; beds overlain by slightly irregular brown clay laminae; some c IV in pits and as cements; upper contact E/S with brown clay lag.

Below 2228.5: halite, equant f IV above 2230.5, equant m IV with some c IV between 2230.5-2236.4, f IV hygroscopically-altered bed (trace disseminated polyhalite) between 2236.4-2236.5; equant m IV between 2236.5-2238.1, equant f IV below 2238.1; E/S with discontinuous brown clay lag at 2234.0; halite beds ~0.5' thick, appear more continuous below 2234.0 and discontinuous above 2234.0; trace brown clay crystal linings and blebs, some discontinuous subhorizontal stringers near the top of some beds below 2234.0; upper contact gradational.

2238.5-2245.2: Halite, f-m IV, equant, clear, c IV in pits and MPs (recrystallized); local zones of f IV hygroscopically-altered beds, some discontinuous subhorizontal stringers of brown clay, some with trace disseminated polyhalite; rare subhorizontal stringers of brown clay in remainder of unit; upper contact E/S marked by brown clay and polyhalite POS lag.

2245.2-2252.2: Halite, orange; f IV in pods and hygroscopically-altered beds with trace disseminated polyhalite (no clay); pods bounded by equant, clear m-c IV; vc IV in MPs and solution pits; trace to some polyhalite crystal linings; locally abundant large polyhalite blebs showing vertical translocation; upper contact E/S, dilated, no lag.

2252.2-2258.0: Above 2254.3: halite, f-m IV with some cIV, local f IV in pods (with disseminated gray clay and polyhalite); moderately abundant gray clay and polyhalite blebs and discontinuous stringers; upper contact E/S with polyhalite and gray clay solution lag. Between 2254.3-2256.9: halite, f-c IV in irregular zones of gray and orange; subhorizontal stringers of polyhalite dip to 20 locally; polyhalite and gray clay occur as crystal linings, blebs, local solution lags, and stringers; upper contact E/S marked by gray clay. Below 2256.9: halite, f-m IV, orange; abundant polyhalite crystal linings and vertically-displaced blebs; upper contact E/S marked by polyhalite solution lag.

2258.0-2266.8: Above 2061.1: Polyhalite solution lag (?); nodules and blebs appear to be pushed together while soft, becomes better packed toward base; irregular zones of halite occur throughout unit, ~ 50% halite at top. Between 2060.1-2062.0: anhydrite, microcrystalline, gray; PPAGS and HPAGS 1 mm to 1" high; upper contact sharp, erosional (?). Between 2062.0-2266.3: Polyhalite, microcrystalline, orange, with some anhydrite beds, anhydrite content increases upward; PPAGS and HPAGS to 3" tall; beds dip ~25 to ~30 between 2264.0-2265.0; upper contact gradational. Below 2266.3: sandy siltstone, gray, hint of flat strata.

2266.8-2269.9: Above 2268.1: halite, f-m IV at base, f IV at top, local f IV hygroscopically-altered bed disseminated polyhalite and gray clay at base, f IV pod with disseminated gray clay near top; disseminated polyhalite; abundant polyhalite solution lags near base; upper contact sharp, dissolution surface. Below 2268.1: halite, f-m IV, local c IV; abundant polyhalite blebs and solution lags, solution lags suggest bedding; upper contact E/S with gray clay.

2269.9-2281.8: Above 2278.0: halite, f-IV in pods and hygroscopically-altered beds with disseminated polyhalite and reddish-brown or gray clay; pods and hygroscopically-altered beds bounded by zones of equant f-m IV; solution lags of reddish-brown clay and polyhalite locally form laminae on subhorizontal E/S; zone of slumped mud with thin laminae near base; upper contact gradational. Below 2278.0: halite, f-m IV, clear to orange, abundant cements; moderately abundant polyhalite solution lags and blebs; upper contact gradational.

2281.8-2286.5: Halite, f-m IV, clear to orange to gray, local f IV in truncated pods (containing disseminated polyhalite and brown clay), abundant cements; abundant polyhalite solution lags; trace gray clay locally; abundant polyhalite solution lags and vertically translocated blebs; large accumulations of polyhalite solution lags locally; E/S with 0.1' thick polyhalite solution

lag at 2284.7; upper contact E/S with pit, dilated polyhalite solution lag, gradational.

2286.5-2293.0: Above 2290.5: halite, f-m IV, local clear to cloudy c IV in MPs, f IV in pods with disseminated polyhalite and brown clay; pods bounded by m IV with brown to gray clay blebs and irregular laminae; trace to some polyhalite crystal linings and solution lags; upper contact E/S with gray clay and polyhalite solution lag, dilated. Below 2290.5: halite, equant, m-c IV above 2292.5, m IV grading upward to f IV below 2292.5; irregular polyhalite beds consisting of solution lags with POS textures at 2291.4; abundant circular polyhalite and anhydrite (below 2292.5) rims surround ~1 mm halite cores; E/S at 2292.5 marked by gray clay, trace gray clay below 2292.5; upper contact gradational.

2293.0-2298.0: Halite, f-m IV, equant, some cloudy, orange at base grading to gray at top; irregular lags of anhydrite and polyhalite; local f IV in HABs and pods with trace disseminated gray clay and polyhalite above 2295.7; c IV in MPs with large fluid inclusions above 2295.7; upper contact gradational, solution pipe, dilated.

2298.0-2302.0: Halite, m-c IV in lower 1', f-m IV higher, c IV in MPs and dissolution pipes, f IV in discontinuous HABs and possible pod near top (disseminated polyhalite and gray clay); trace to some disseminated polyhalite blebs and circular polyhalite rims surrounding ~1 mm halite cores; trace light brown grading to gray clay at top; blebby solution lag of polyhalite (?) and gray accumulated in base of pipe above lower contact; upper contact sharp to gradational.

2302.0-2305.0: Halite, f-c IV, gray to light orange; local pods of f IV with disseminated gray clay and polyhalite; trace to some anhydrite blebs suggesting vertical translocation; local irregular masses of f IV with gray clay and anhydrite also suggest vertical movement; 0.2' thick irregular solution lag of anhydrite at 2304.5, displays granular (?) fabric and local POS textures, some APAG crystals appear to have grown into open voids; irregular microlaminae of anhydrite and anhydrite POS textures below 2304.6, locally dilated; upper contact E/S with dissolution pipe.

2305.0-2305.7: Halite bounding irregular mass of anhydrite; upper contact sharp, marked by anhydrite stringers. Halite, m-c IV, light orange to light gray, some vertically-oriented crystals near base and top, equant crystals near middle of unit; polyhalite crystal linings and POS textures common; subhorizontal stringers of anhydrite near top bound vertically oriented crystals; has irregular to ragged contact with anhydrite mass. Anhydrite mass is 0.7' high and appears to consist of amalgamated soft clasts of anhydrite surrounding a core of m-c IV halite; some clasts display crushed-prism textures and HPAGS, these features are often rotated more than 90 from vertical; separated from underlying unit by laminar gray anhydrite.

2307.5-2311.2: Anhydrite, microcrystalline, white to light gray to light brown; above 2307.4: wavy microlaminae to thin laminae showing some cross-cutting relationships, local bedded nodular textures, some nodules near top and 2307.0; below 2307.4: no apparent bedding, HPAGS to 4" at 2308.5, remnants of HPAGS occur above and below 2308.5; upper sharp, slightly undulatory.

APPENDIX H

GEOPHYSICAL LOG

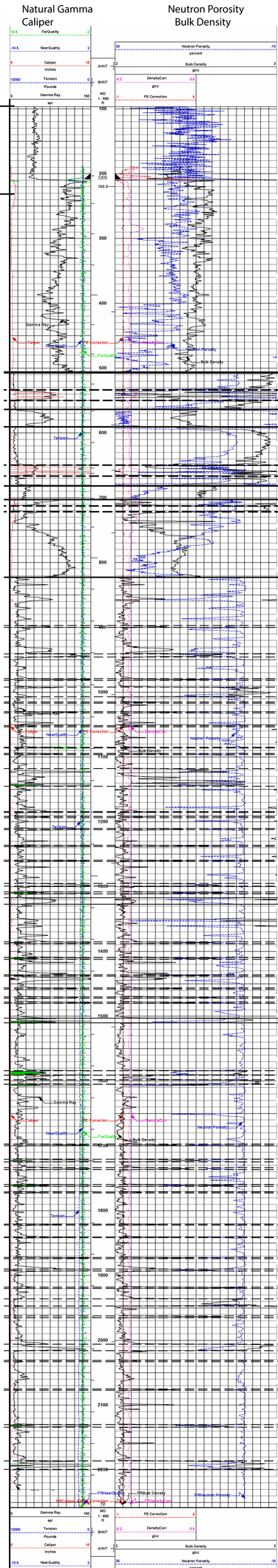
ANNOTATED FOR STRATIGRAPHIC MARKERS

(~200 FT TO ~2250 FT)

Partial Geophysical Log of C3977
Annotated for Stratigraphy

Reference Elevation: 3 ft above ground level
Ground Level Survey Elevation: 3402.84 ft amsl
Depths are interpreted visually to nearest 0.5 ft
Operator: Halliburton

Related Information:
Appendix X for files of geophysical logs
Appendix Y for Excel file comparing units in C3977 to AIS



Formation	Member	Informal Unit/ Marker Bed	Depth (Ft)
Dewey Lake			506.5
Rustler Formation	Forty-niner	*A-5*	*533.5*
		M-4/H-4	*549*
		A-4	563.5
	Magenta Dolomite		590.5
	Tamarisk	*A-3*	*649*
		M-3/H-3	*666.5*
		A-2	681.5
	Culebra Dolomite		702.5
		M-2/H-2	*712.5*
		A-1	*721.5*
	Los Medaños	*M-1/H-1*	822
Salado Formation		MB100	898-900
		MB101	940.5-945
		MB102	980-981
		MB103	992-1007
		MB104	1014.5-1015.5
		MB105	1030-1031
		MB1067	1051-1052
		MB107	1084-1085
		MB108	1094.5-1096
		MB109	1118-1144
		MB110	1184-1185
		MB111	1191-1193
		MB112	1210-1212
		MB113	1236-1238
		MB114	1259-1261
		MB115	1295-1299.
		MB116	1308-1311
	Vaca Triste Ss.		1317-1327
		MB117	1385-1388
		MB118	1409-1412
		MB119	1436-1438
		MB120	1456-1458
		MB121	1470-1472
		MB122	1478-1480
	Union Anhydrite		1504-1510
		MB123	1584-1606
		MB124	1597-1606
		MB126	1697-1699.5
		MB127	1720.5-1724.5
		MB128	1733.5-1737.5
		MB129	1759.5-1762
		MB130	1771-1772.5
		stray	
		MB131	1840.5-1841.5
		MB132	1872-1874
		MB133	1890-1893
		stray	
		MB134	1936-1947
		MB135	1962-1965
		MB136	2006-2016
		MB137	2031-2033
		MB138	2075-2077
		MB139	2130-2134
		MB140	2186-2199