

DESCRIPTIONS FOR STRATIGRAPHIC SECTIONS OF LOWER-MIDDLE POINT LOOKOUT SANDSTONE AND GALLUP SANDSTONE NEAR CABEZON, NM

Grain sizes follow the Udden-Wentworth scale for clastic sediments (Udden, 1914; Wentworth, 1922) and are based on field estimates. Sand textures are abbreviated as follows: very fine-lower, vFL; very fine-upper, vfU; fine-lower, fL; fine-upper, fU; medium-lower, mL; medium-upper, mU; coarse-lower, cL; coarse-upper, cU; very coarse-lower, vcL; very coarse-upper, vcU. Pebble sizes are abbreviated as: very fine, vf; fine, f; medium, m; coarse, c; and very coarse, vc. The term “clast(s)” refers to the grain size fraction greater than 2 mm in diameter. Descriptions of bedding thickness follow Ingram (1954). “Micro-laminations” are 0.1-1 mm in thickness.

Bosque Grande stratigraphic section. This section consists of a progression from offshore facies to lower shoreface facies, encompassing the transition from the upper Satan Tongue to the Point Lookout Formation. Measured in SE1/4 of SE1/4 of Section 20, T17, R2W, Sandoval County, New Mexico. Measured and described by Dan Koning and Claire Koning on December 8, 2023, using an abney level, brunton compass, Jacob's staff, and hand-held GPS unit.

Unit	Description	Thick- ness (m)	Height (m)
Top of stratigraphic section, a few meters north of top-edge of cliff: 313490 m E, 3950957 m N.			
BG-19	CAPPING SANDSTONE: A single, very thick bed whose sand is 2.5Y-10YR 8/2-3 and fL-fU (mostly fU). Sand is mostly massive, with 5-10% horizontal to low-angle cross laminations (up to 1 cm thick), especially in upper 0.5 cm. Basal contact is scoured (20-30 cm of relief) and exhibits local loading structures and gutter forms (0-20 cm wide, up to 20 cm deep); gutters trend 020-200 degrees. On lower contact are bedding-parallel burrows. Most of unit probably bioturbated, and that is why it is massive.	2.5	36.1
BG-18	SANDSTONE WITH MINOR MUDSTONE: Sandstone is mostly fL and in medium to thick beds that are slightly tabular. Sandstone beds exhibit internal horizontal-planar laminations and local burrows (1-2 cm thick). Upper contact is a scour with 20-30 cm of relief. Upper 25-30 cm of unit is very thinly bedded to laminated and consists of mudstones and siltstones. Middle 20 cm: Sandstone that is bioturbated locally on bedding planes. The sand is mostly fL and internally horizontal-planar laminated or burrowed. Lower 15-20 cm of unit consists of fissile, gray clay.	0.6	33.6
BG-17	SANDSTONE-DOMINATED, WITH TOOLMARKS, CROSS-STRATIFICATION AND RIPPLEMARKS: Sandstone beds are lenticular to tabular and thick. Sand is 2.5Y 7/3=8/2. Near 313489 m E, 3950964 m N: Two thick sandstone beds that are lenticular to tabular, separated by 20-30 cm-thick sandstone with hummocky cross stratification. Upper bed fills a ~0.9 m deep paleochannel cut into the lower sandstone bed. It has fL-fU sandstone and swaly cross-laminations to low-angle cross-laminations extending over a few meters of horizontal distance (photo of these swaly laminations was taken in the last trip out here). Top of upper bed has discontinuous (over few dm), ~1 cm tall ripplemarks trending 110 degrees, overprinted by 3-D, lunate forms indicating 020 degree flow. The lunate scours are overlain by hardened clay films. Ripplemarks on fallen slabs (from this unit?) have symmetrical, linear ripplemarks. Lower bed (0.6 m thick) is vFL-fU (mostly fU) and exhibits low-angle cross-laminations to horizontal-planar cross-laminations; it thickens to 1.5 m towards SE. Base of bed is sharp and slightly wavy (with few cm of relief). Base exhibits tool marks aligned 340-350 degrees; oblique to the shoreline.	1.4	33.0

Several meters to west, a lower, thick bed representing a channel fill increases the thickness of R2 at the expense of R2a. This occurs below the horizontal-projecting, overhanging ledge of unit R2d (see photo IMG 1396).

BG-16	<p>INTERBEDDED MUDSTONE AND SANDSTONE: Beds are tabular to lenticular over a few meters horizontal distance. Mudstone vs sandstone are subequal (to north-northwest) or $\frac{1}{4}$ vs $\frac{3}{4}$ (to south-southeast). Mudstone consists of interbedded, light gray, silt and clay and is in well-defined, 10-20 cm thick beds. Sandstone beds are up to 40 cm thick. Sandstone is vFL-fU and 2.5Y-10YR 7-8/3. The thick sandstone beds are internally massive and vFU-FL (mostly FL). Bases and tops of sandstone beds are sharp and have 1-2 cm of relief. Sandstone proportion increases to $\frac{3}{4}$ of sediment to east and southeast, where beds are commonly ~30 cm thick.</p> <p>@30.7-31.0 m: 30 cm-thick sandstone bed that is laterally extensive. Base of this bed has 2-3 cm of scour relief, locally up to ~20 cm deep paleochannels at base that trend 020 degrees.</p> <p>@30.5-30.7 m: Relatively bioturbated. To NNW, this zone is thicker and heavily burrowed by orphiomorpha.</p> <p>@29.6-30.1 m: 45 cm thick sandstone bed that is laterally extensive. Base has toolmark groves orientated 020 - 200 degrees.</p>	2.0	31.6
BG-15	<p>CLAYSTONE AND MUDSTONE: Well-bedded, 0.5-1 cm thick, local up to 2 cm thick.. Mostly grayish, silty mudstone (2.5 hue). Beds are locally finely laminated. No sign of bioturbation. Overall color is 2.5Y 6/1-7/3; 5% gray beds that are N6\ to N7\. Sandstone-siltstone interbeds increase in upper few dm, as seen to the west in photo IMG_1453.jpg.</p>	0.9	29.6
BG-14	<p>CLAY, SILTY CLAY, AND 30% SANDSTONE-SILTSTONE: Very thinly bedded. Proportion of sandstone-siltstone beds decreases up-section. Sandstone and siltstone are 2.5Y 7-8/2. Claystone is 2.5Y 5-6/2; it is commonly silty and organic detritus is 1-10 % (seems less common than below).</p>	2.6	28.7
BG-13	<p>THICK SANDSTONE BEDS WITH SUBORDINATE CLAY BEDS:</p> <p>North exposure: Subequal clay beds vs. vFL-FL sand beds; both are ~0.5-3.0 cm and tabular, but some beds are lenticular over ~1 meter. Sandstone is 2.5Y 7/3, 8/2-3; beds have sharp bases and tops. Clay is locally silty (also non-silty) and grayish (10YR-7.5YR 5/1 and N\5, @25.5-26.0: The uppermost sandstone bed is 0.6 m thick (25.5-26.1 m). Internally, this bed is massive to horizontal-planar laminated, but its topmost 0.1m exhibits well-defined, horizontal-planar laminations. The sand is 2.5Y 7/3, vFU-FL (mostly FL).</p> <p>South exposure of unit: two thick beds: @21.9-22.3 m (bottom) and 23.9-24.6 m (top).</p> <p>@23.9-24.6 m: Upper sandstone bed. It has a scoured basal contact (20 cm of relief); internally well-defined laminations suggestive of gentle swaly to hummocky forms (low-angle cross-stratified; foreset height of 20 cm). Lamination contacts have organic detritus (sub-millimeter length to 2 mm long. Sand is 2.5Y 7/3, vFL-FL, The bed pinches out rapidly within 2 m of where Kevin Hobbs was in photo in previous trip, but exposure is inadequate to clearly define bed geometry at "pinch out."</p> <p>@22.3-23.9 m: Very thin, tabular beds of sand; 1/3 beds of grayish clay. Sand is mostly vFU-FL and sandstone beds are internally massive.</p> <p>@21.9-22.3 m: Lower sandstone bed is internally massive, but locally horizontally planar laminated; its upper contact is sharp (5-10 cm of wavy relief); the top 10 cm of the bed has well-defined hummocky to swaly laminations; sand is 2.5Y 7/3-4 and vFU-FL.</p>	4.1	26.1

@24.6 m: Transfer horizontally along 350 degrees from the bed I previously took a photo of (with Kevin on left side) to main cliff face to the NW. South coordinates: 313473 m E, 3950944 m N. North coordinates: 313475 m E, 3950965 m N.			
BG-13	SANDSTONE AND MUDSTONE, INTERCALATED: Strata are mostly in thin to very thin, tabular beds. Sandstone proportion increases up-section.		
	@19.0-19.3 m: Interval with cm-scale horizontally elliptical, ball-and-pillow shaped sandstone -- indicative of soft sediment deformation in my view but Kevin Hobbs thinks it may reflect selective scouring.		
	@18.5: Top of thick sandstone bed. Upper 0-20 cm has well-defined, hummocky laminations.		
BG-12	SANDSTONE INTERBEDDED WITH SUBORDINATE SILTY CLAYSTONE: 60% SAND AND 40% CLAY-SILTY CLAY. Beds are very thin to thin and tabular to lenticular (lenticular over a few horizontal meters). Internal bedding: laminated and horizontal-planar to slightly hummocky-swaly; no notable of bioturbation. 1-50% organic detritus seen on bedding planes (1-50%). Beds have sharp bases and sharp tops. Sand is vFL-FL. Unit has a sharp, broadly wavy upper contact (up to 5 cm of relief over 2-3 m horizontal distance).	1.9	21.9
BG-11	BED OF SILTY FINE SANDSTONE: Relatively continuous bed of silty vFL-FL sandstone (mostly FL sand); 2.5 Y 7/2. Bed is locally low-angle cross-laminated (up to 10 cm tall and facing SE). Upper and lower contacts are sharp.	0.3	20.0
BG-10	SANDSTONE INTERBEDDED WITH MUDSTONE: Unit marks transition to overlying, sand-dominated sediment. Beds are relatively tabular. Sandstone beds are 1-15 cm thick and their relative proportion increases up-section. Internal bedding of sandstone is horizontal-planar to slightly wavy laminated; also massive. Sand is 2.5Y 7/3 and vFL-FL. Clay is 2.5Y 5-6\1-2, relatively fissile and laminated to 2 cm thick.	2.1	19.7
BG-9	INTERBEDDED MUDSTONE AND SANDSTONE. Mainly very thin and tabular bedded. Mudstone beds are 2.5Y 5-6/2 and consist of internally disrupted silty clay. About 5-10% beds of very thin, tabular sandstone; sandstone is 2.5Y 7/3-8/2 and vFL-vFU.	2.3	17.6
BG-8	SUBEQUAL SANDSTONE, SILTSTONE, AND CLAY: Siltstone and sandstone is 2.5Y 8/2-7/3 and are in well-defined, laminated to very thin and tabular beds. Clay is grayish. Tops and bases of beds are sharp. About 10% of beds are 3-15 cm thick, siltstone-very fine sandstone beds that are lenticular to broadly lenticular; these are internally massive to laminated-very thin and horizontal-planar to slightly hummocky.	2.0	15.3
	Photo of internal hummocky bedding in R1d		
BG-7	SANDSTONE: 2.5Y 7/3, vFL-FL sandstone that is horizontal-planar laminated to slightly hummocky laminated. 10-20 cm thick.	0.2	13.3
	Unit R1c lies at base of cliff. From here we follow rising base of cliff to NW, directly measuring strata with Jacob staff.		
BG-6	SANDSTONE AND SILTSTONE: Thin beds of silt and very fine sandstone. 10% dark gray lamina that define bedding. Silt and very fine sand are in thin beds.	3.5	13.1
	@12-13.1 m: Very thin to medium beds of 2.5Y 7/3, vFL-FL sandstone. 10% gray clay lamina that are discontinuous and up to 1.5 cm thick. Sandstone is silty to slightly silty. Beds are internally massive.		
BG-5	SANDSTONE: Hummocky to swaly cross-laminated. Sand is mostly vFU-FL.	0.2	9.5
	Subequal sand, silt, and clay.		
	UTM coordinates: 313476 m E and 3950918 m N		
	Uppermost Satan Tongue of Mancos Shale: Upper Offshore facies.		
BG-4	INTERBEDDED CLAY AND VERY FINE SAND: Poorly exposed.		9.3
	@8-9 m: Subequal dark gray clay and pale brown (2.5Y 6/3) very-fine grained sand. Strata are horizontal-planar laminated to slightly wavy laminated		

BG-3	SAND WITH MINOR CLAY INTERBEDS: 2.5Y 6/3. Vague to well defined, very thin to thin beds of very fine-grained sandstone. One clay bed is dark-colored and 5-10 cm thick, but most beds are laminations. Upper contact is sharp and slightly wavy, with 1-2 cm of relief. Lower beds are disrupted (wavy or brecciated).	0.5	7.2
BG-2	CLAY: 2.5Y 3-4/1. It is poorly bedded but locally wavy-laminated, especially in upper 5-10 cm. Upper contact is a scour with 1-2 cm of relief.	0.2	6.7
BG-1	SILTY CLAY: Mostly clay and silty clay, with subordinate vfl-fl sand and clayey-silty vfl-fl sand. Color of clayey sediment is 2.5Y 3/1-2 and color of sandy beds include 2.5Y 5/4, 2.5-5Y 8/2-3, 2.5Y 7/3, and 10YR 6/4). Strata are in horizontal-planar to slightly wavy laminations to very thin beds; bedding is well-defined. Locally, lamina exhibit soft deformation (i.e., look "swirly."). Poor exposure and shallow holes (few dm deep) need to be dug to ascertain unit's characteristics. @4.7-5.0: Mostly gray clay and vfl-vfU sand is subordinate. Clay is 10YR 4/1 and very fine sand is 2.5Y 6/3. Both are laminated but laminations are disturbed and mixed-up.	6.5	6.5
BASE OF SECTION: 313,472 m E, 3,950,905 m N, ± 3 m; zone 13, NAD83. Stake placed at base of section near base of slope. 3D attitude of 350°\1.5°SW. Measured roughly along strike (010° bearing) using 0° apparent dip			

Guadalupe Mesa stratigraphic section. This section consists of a progression from offshore facies to lower shoreface facies, encompassing the transition from the upper Satan Tongue to the Point Lookout Formation. Measured in SW1/4 of SW1/4 of Section 14, T15N, R3W, Sandoval County, New Mexico. Measured and described by Dan Koning and on January 19, 2024, using an abney level, brunton compass, Jacob's staff, and hand-held GPS unit.

Unit	Description	Thick-ness (m)	Height (m)
Top of stratigraphic section: 307139 m E, 3932598 m N (±3 m; zone 13, NAD83). Top of section corresponds to the top of the highest sandstone bed exposed along trail. This bed is overlain by basalt-rich, sandy gravel of a Quaternary terrace deposit.			
LOWER-MIDDLE GALLUPS SANDSTONE: LOWER SHOREFACE			
10	SANDSTONE: Tan sandstone in thick, tabular beds. Beds exhibit bioturbation and local distinct burrows (~1 cm in width). Sand is fl-mL (mostly fu). Upper 30 cm of unit is fu-mL. Forms capping unit.	2.2	31.1
9	SANDSTONE: Thin, tabular beds of sandstone. There is much bioturbation and sand is mostly fu (minor fl and mL). Slightly finer-grained than Unit 8. Golden-yellow color.	3.3	28.9
8	SANDSTONE: Tan color. Thick, tabular beds that are internally bioturbated (fl-mL, mostly fu).	4.9	25.6
7	POOR EXPOSURE. 17.7 m corresponds to top of upper sandstone bed along the trail at the topographic saddle on Guadalupe Ruin mesa. To south: Sandstone beds seem similar to that of Unit 8.	3	20.7
6	SANDSTONE: Well-bedded sandstone with distinctive horizontal-planar lamination occurring within very thin to medium (mostly thin), tabular beds. Some beds are internally massive. Grains size is fu-mL (mostly fu).	1.8	17.7
5	SANDSTONE: Tabular, very thin to thin (mostly thin) beds of sandstone that are heavily bioturbated and commonly reduced. Grain size: vfU-fu (mostly fl). Uppermost 0.6 m is a gradation with the distinctly bedded strata of Unit 6.	1.9	15.9
4	SANDSTONE INTERBEDDED WITH SUBORDINATE MUDSTONE: Sandstone interbedded with minor mudstone. Sand is mostly vfU-fl. The proportion of sandstone increases up-section, as does the sandstone bedding thickness. There is ~50-60% sandstone and bed thicknesses are ~3-4 cm in lower part. There are 80-90% sandstone and associated bed thicknesses are 5-10 cm near upper part. Still ~10% bulbous forms inferred to be related to burrowing and bioturbation, but distinct burrows not seen.	0.8	14.0

Photo IMG_5836: My hand is at base of unit.

LOWER TONGUE OF MANCOS SHALE, UPPERMOST STRATA: Offshore to offshore-lower shoreface transition.			
3e	INTERBEDDED MUDSTONE, SILTSTONE, AND MINOR SANDSTONE: 20-25% very thin (some thin), tabular beds of sandstone within siltstone-mudstone lamina-very thin beds. 10%, ~1 cm-wide, reddish oxidation occupying bulbous forms that are probably burrows.	2.1	13.2
3d	INTERBEDDED MUSTONE, SILTSTONE, AND MINOR VERY FINE SANDSTONE: Similar to unit 3a, but 20-30% very thin to thin, tabular beds of vfU-fL sandstone (minor fU grains). Clay-mud lamina can be seen within sandstone beds.	1.2	11.1
3c	INTERBEDDED MUSTONE, SILTSTONE, AND MINOR VERY FINE SANDSTONE: Similar to unit 3a, but has slightly more (~10-20%) ledge-forming, very fine sandstone beds.	1.9	9.9
3b	SANDSTONE BED: Thin, tabular, laterally continuous bed of vfU-fL sandstone.	0.1	8.0
3a	INTERBEDDED MUSTONE, SILTSTONE, AND MINOR VERY FINE SANDSTONE: Laminated to very thin, tabular beds of mudstone, siltstone, and very fine sandstone. Sandstone beds have sharp bases and tops. There are ~10% very fine sandstones that form ledges.	5.2	7.9
@5.7 m: 5 cm thick, tabular, fL sandstone bed that is laterally extensive.			
Base of stratigraphic section along trail: 307075 m E, 3932504 m N (± 3 m; zone 13, NAD83),			
2	Poorly exposed mudstone-siltstone: Probably similar to unit 3.	2.5	2.7
1	SANDSTONE: Tan sandstone that is vfU-fU (mostly fL). Well-defined laminations that are gently hummocky cross-stratified.	0.2	0.2
BASE OF SECTION: 307086 m E, 3932505 m N, ± 3 m; zone 13, NAD83. Base is near where the walking trail meets the exposed cliff face. Basal ledge is to right of the trail (3-5 m).			