

33 A Deep-water Amalgamated Sheet System, Punta Barrosa Formation, Marina's Cliff, Chile

Andrea Fildani^{1,2}, Michael R. Shultz^{1,2}, Stephan A. Graham², and Andrew Leier³

¹Chevron, ETC, San Ramon, California, USA ²Department of Geological and Environmental Sciences, Stanford University, Stanford, California, USA ³Department of Geology, University of Arizona, Tucson, Arizona, USA

Executive Summary

The outcrops of Marina's Cliff are part of the Punta Barrosa Formation along the eastern margin of the Andean fold-thrust belt in southernmost Chile (Figure 1). This formation was deposited during the first deep-water, coarse-grained clastic depositional stage that characterized the Late Cretaceous of the Magallanes retro-arc foreland basin. Deep-water deposition initiated with the Punta Barrosa Formation, continued with the Cerro Toro Formation, and concluded with the shoaling-upward Tres Pasos Formation. Because of its proximity to the Andean belt, the Punta Barrosa Formation is pervasively thrust and folded. Nevertheless, outcrops of the Upper Punta Barrosa to the east of the fold-thrust belt are not as extensively affected by tectonism and display better lateral continuity and architecture. The ~1000-m (~3300-ft)-thick Punta Barrosa Formation consists of interbedded packets of sandstone and mudstone. The bedding attitude and depositional style is characterized by layered and sometimes amalgamated beds.

Marina's Cliff is a laterally continuous outcrop of well-preserved, multiple, discrete packets ranging from 10–15 m (33–50 ft) thick (Figure 2). The packets are composed of massive sandstones containing few debris-flow and slurry-flow deposits (sensu Lowe and Guy, 2000), alternating with packets of finer grained units of thin-bedded turbidites (Tb, Tc, and Td Bouma sequences), siltstones, and turbiditic shales. Packets and bounding surfaces are evident in Figures 2 and 3, which show close-up views of the photomosaic.

The cliff has a north-south orientation, and beds gently dip to the west. Paleocurrent direction, determined from abundant sole marks, was mainly toward the south. A small normal fault in the middle of the cliff, probably related to later reactivation, precludes correlation of beds across the entire exposure, but outcrops north and south of the fault show the same depositional style — massive sandstone beds and slurry-flow packets alternating with fine-grained, thin-bedded turbidites. The length of the overall outcrop is ~420 m (~1390 ft) (not all visible in the photomosaic), and the total thickness exposed by the cliff section is at least 60 m (190 ft). Each portion of the cliff offers a different view of the sedimentation styles typical of the Upper Punta Barrosa Formation. Based on composition, bedding style, and overall geometry, the Punta Barrosa Formation is interpreted to have been deposited as lobes in a weakly confined setting with local areas of amalgamation (probably related to higher channelization).

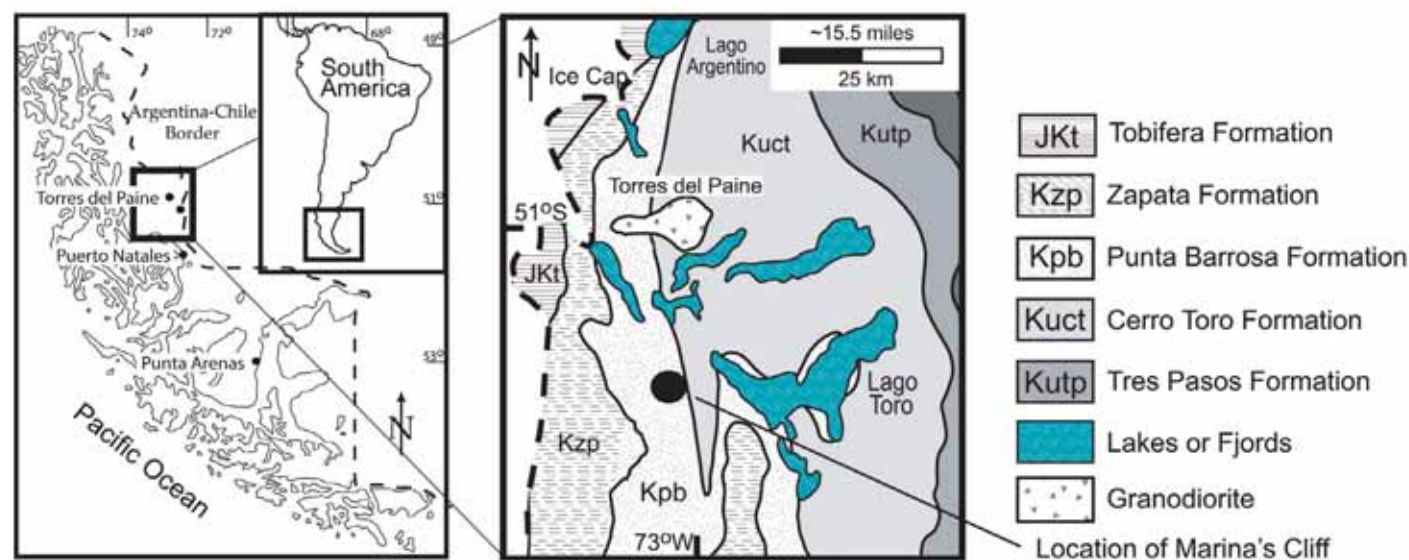


Figure 1. Location map for the Punta Barrosa Formation outcrops and main stratigraphic units of the Magallanes basin.

Outcrop Summary

Marina's Cliff		
Location	Specifics	Marina's Cliff (51° 16'S; 72° 57'W)
	Region/province/state	Ultima Esperanza District (Magallanes Region)
	Country	Chile
Formation		Punta Barrosa Formation
Age		Late Cretaceous (Turonian–Santonian)
Basin Setting		Juvenile, retro-arc foreland basin (Magallanes basin) related to the rising of the Andean cordillera
Basin Size		Magallanes basin: modern estimate >6,000 km ² (>3,750 mi ²)
General Outcrop Description and Stacking Pattern		Mixed sediment source, but more sand-rich. Sheet sands are layered and amalgamated. Higher net-to-gross sandstone packages are separated by low net-to-gross packets. The sand-rich intervals are characterized by the presence of debris-flow and slurry-flow deposits.
Depositional Setting Interpretation		The probable setting is one of lobes or distal fan depositional areas. The overall Punta Barrosa Formation is interpreted to be a lobe depositional setting with areas of more amalgamated (channelized?) systems.
Overall Outcrop Dimensions in Panel	Length	>420 m (>1378 ft)
	Thickness	>60 m (>197 ft)
	Average Net-to-gross	50–60% (presence of slurry beds complicate this estimate)
	Grain-size range of sand elements	Very fine- to very coarse-grained sandstone
Other		Minor faulting in the middle of the outcrop does not allow correlation between the two portions. The faulting does allow a more complete overview of a thicker sheeted sequence.
		Architectural Elements Number on Outcrop Photo or Interpretation
Sheetform Architectural Elements		S1-S9
	Length	Visible on the picture: >400 m (>1310 ft)
	Thickness	6–11 m (20–36 ft)
	Net-to-gross	80% (in sandstone packets)
	Outcrop orientation for this element	East-southeast facing cliff-face (dipping ~20° to the west)
	Average paleocurrent	170–190°
	Typical facies succession	Alternating third-order packets of coarser grained sandstone (with sharp base) and thin-bedded, fine-grained sandstone with silt and mud.
Sand-bed Architecture		
	Bed-length range	>200 m (>660 ft)
	Bed-length average	>200 m (>660 ft)
	Bed-thickness range	0.2–1.3 m (0.7–4.3 ft)
	Bed-thickness average	0.6–0.7 m (~2 ft)
	Texture — grain-size range; average; sorting	Fine- to coarse-grained sand; average medium-grained sand; very poor sorting (because of presence of debris-flow and slurry-flow deposits)
Shale/fine sand-bed Architecture		
	Bed-length range	>200 m (>660 ft)
	Bed-length average	>200 m (>660 ft)
	Bed-thickness range	0.02–0.4 m (0.08–1.3 ft)
	Bed-thickness average	0.3 m (~1 ft)

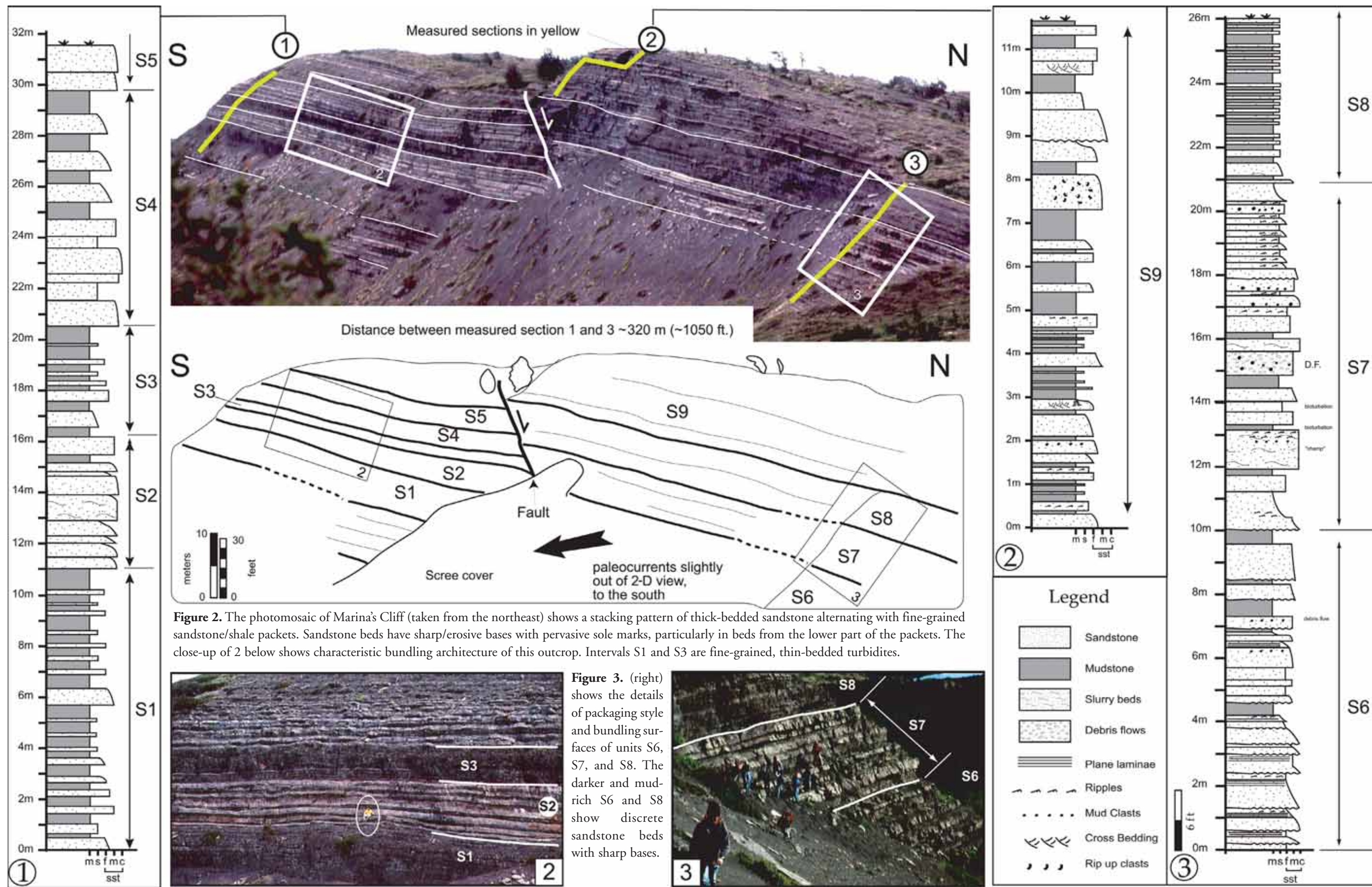


Figure 2. The photomosaic of Marina's Cliff (taken from the northeast) shows a stacking pattern of thick-bedded sandstone alternating with fine-grained sandstone/shale packets. Sandstone beds have sharp/erosive bases with pervasive sole marks, particularly in beds from the lower part of the packets. The close-up of 2 below shows characteristic bundling architecture of this outcrop. Intervals S1 and S3 are fine-grained, thin-bedded turbidites.

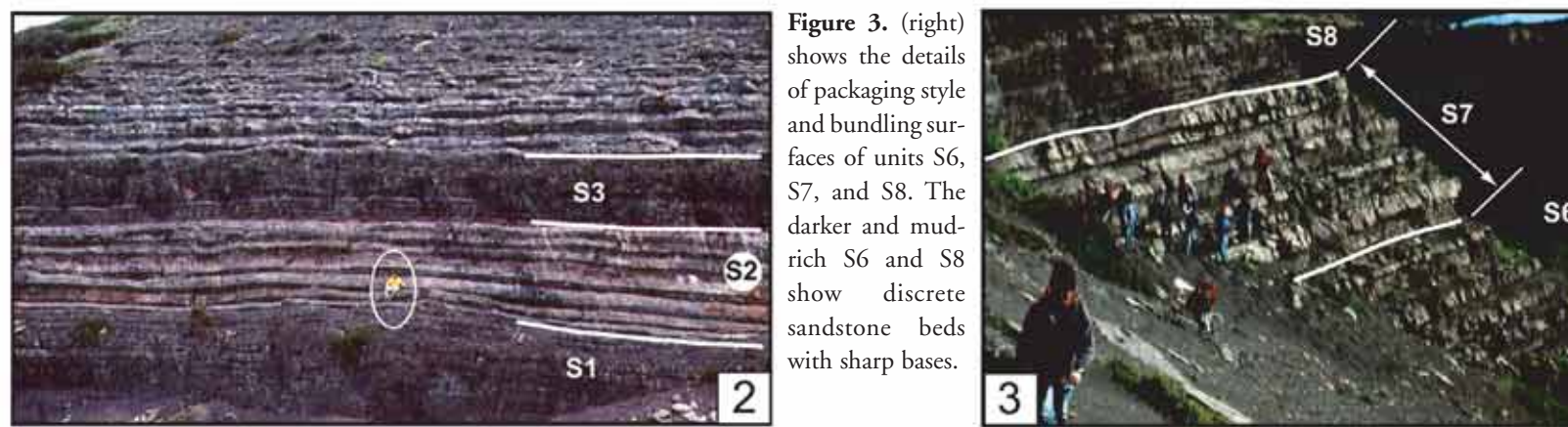


Figure 3. (right) shows the details of packaging style and bundling surfaces of units S6, S7, and S8. The darker and mud-rich S6 and S8 show discrete sandstone beds with sharp bases.

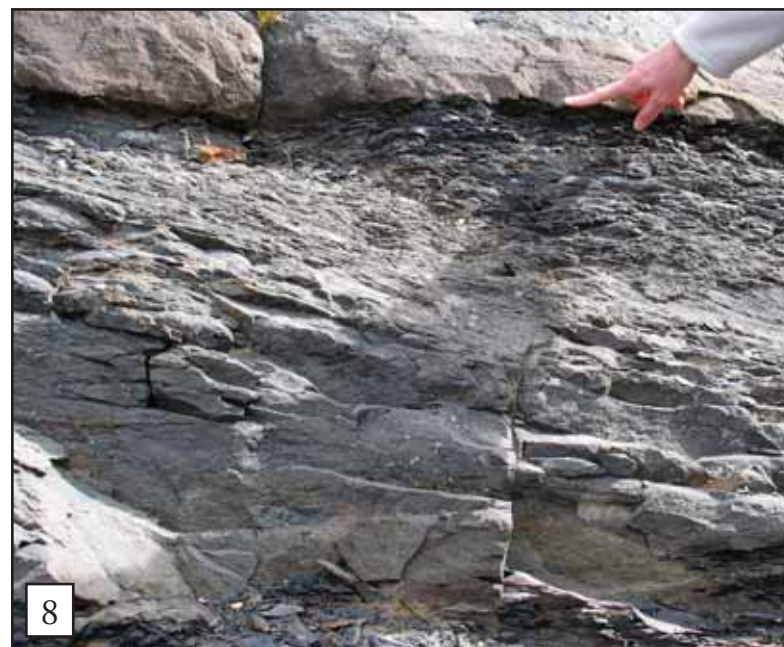
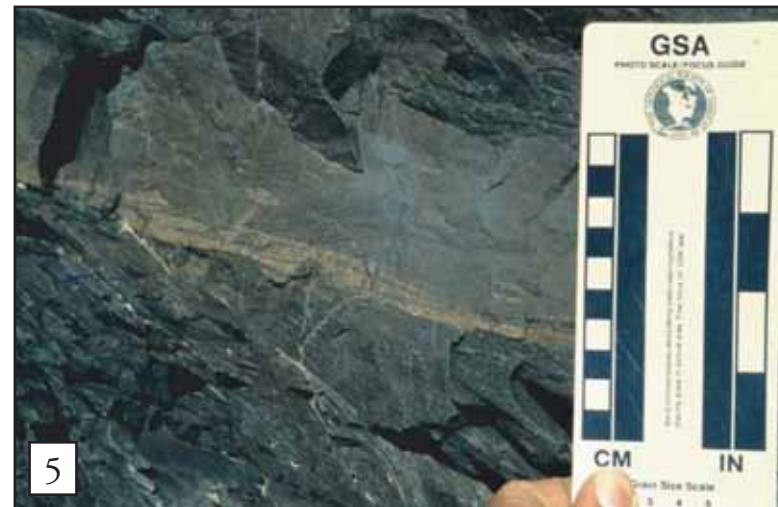
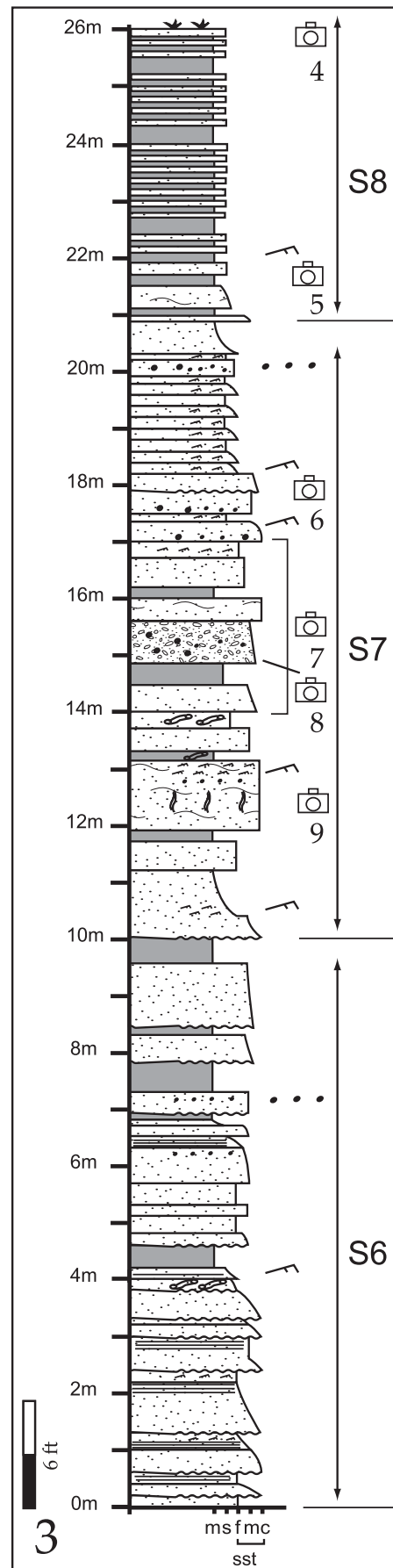


Figure 4. Erosive base of the basal sandstone of Unit S9 over the thin beds of Unit S8, which are largely composed of mud and thin beds of fine-grained sandstone and siltstone. Tool marks and flutes indicate an approximately southerly flow direction (Fildani and Hessler, 2005).

Figure 5. Ripple-laminated, fine-grained sandstone interval in the thinly bedded, mud-rich Unit S8. Ripples are common in the finer-grained and thinner units throughout the Punta Barrosa Formation.

Figure 6. Flame structures at the base of a coarse-grained sandstone bed in Unit S7. Flame structures and soft-sediment deformation are very common, especially at sand-mud contacts. Loading features have been interpreted in the Punta Barrosa as indicators of relatively high depositional rates.

Figure 7. Overview looking north of the Marina's Cliff. The sandstone beds are from Unit S7 (Professor Graham for scale). Some of the sandstone beds with related mud caps have been recognized in the field as slurry-bed deposits (sensu Lowe and Guy, 2000).

Figure 8. Detail of the debris-flow deposits highlighted from S7. This picture clearly shows the plastic behavior of this unit during deposition as well as the muddy matrix and uneven weathering pattern.

Figure 9. Massive sandstone bed, normally graded with muddy matrix and distinctive vertical water-escape features (pipes). This bed has a high mud content (>20%) and it has been interpreted as a slurry bed.

Acknowledgments

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