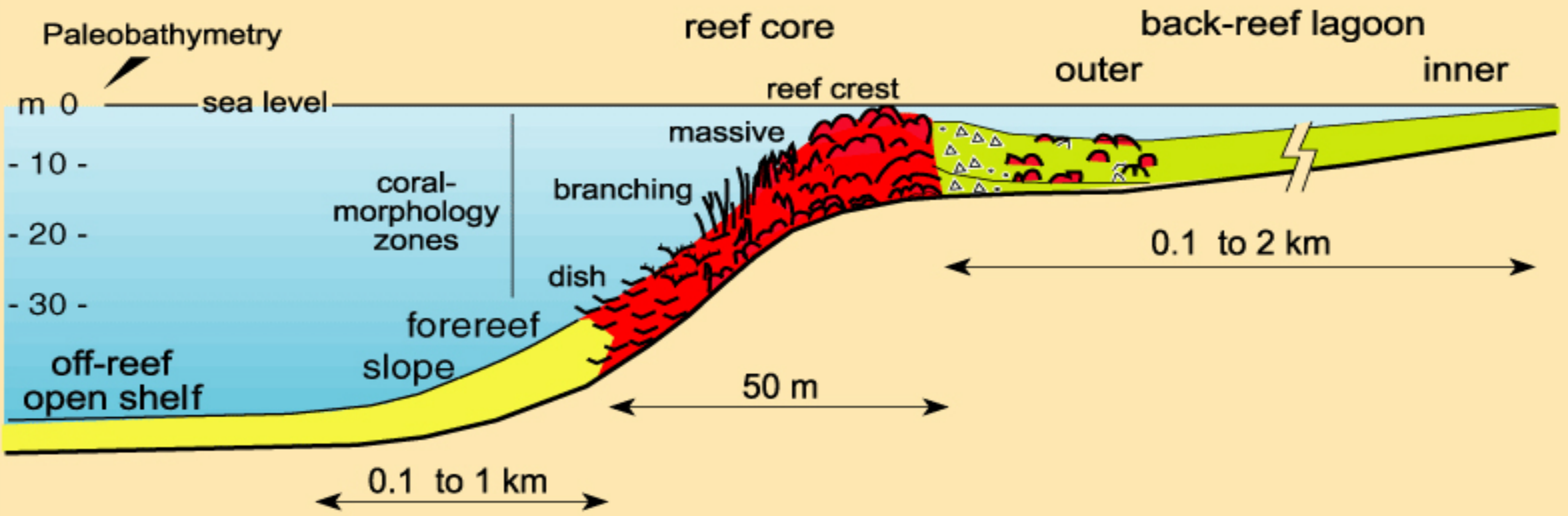
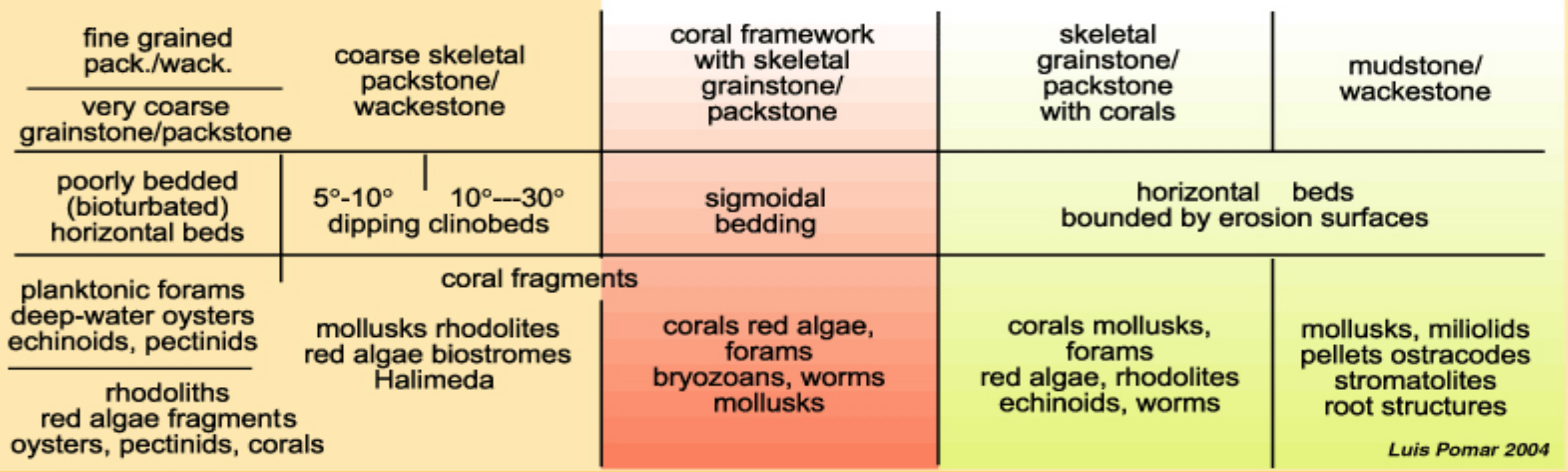
Reefs

Modern Reef Structure





fine grained pack./wack. very coarse grainstone/packstone	coarse skeletal packstone/ wackestone	coral framework with skeletal grainstone/ packstone	skeletal grainstone/ packstone with corals	mudstone/ wackestone
poorly bedded (bioturbated) horizontal beds	5°-10° | 10°---30° dipping clinobeds	sigmoidal bedding	horizontal beds bounded by erosion surfaces	
planktonic forams deep-water oysters echinoids, pectinids rhodoliths red algae fragments oysters, pectinids, corals	coral fragments mollusks rhodolites red algae biostromes Halimeda	corals red algae, forams bryozoans, worms mollusks	corals mollusks, forams red algae, rhodolites echinoids, worms	mollusks, miliolids pellets ostracodes stromatolites root structures

Luis Pomar 2004

Factor	Fore Reef	Reef Core	Back Reef
Energy of Water	Low especially in deeper parts, except for storms, turbidity currents	High energy where waves break	Low to medium
Temperature	Cool water, relatively constant	Warm water, variable	High, variable
Oxygen Level	Moderate, constant	Lots of photosynthesis, lots of breaking waves – higher O, stable	Depends – could be high if photosynthesis, could be low if decomp
Salinity	Moderate, constant	Variable within bounds	Variable: high if evaporation, lower if storms
Substrate (what is the bottom like)	Some mud, some sandy, sometimes unstable	Hardground, sandy channels	Sandy if higher energy, muddy if low energy

Zone	Advantages	Challenges	Adaptations
Forereef	Constant environment	Less sun, colder, debris flows	Righting orgs, weedy orgs., filter feeders
Reef core	Lots of oxygen, light, incoming food particles. Stable bottom,	High energy, somewhat variable	Clamping down orgs., robust skeletons, dome-shaped orgs
Back reef	Lots of sunlight, possibly lots of oxygen, warm, lower energy	Could be low oxygen, interacts with terrestrial env., variable temp & salinity	Smaller, more delicate orgs., photosynthesizing, adapted to changing conditions

Now let's look at a Permian reef

Guadalupe Reef, Permian Basin, Texas

All images from Scholle, Goldstein & Ulmer-Scholle, 2007, Open File Report 504, New Mexico Bureau of Geology and Mineral Resources

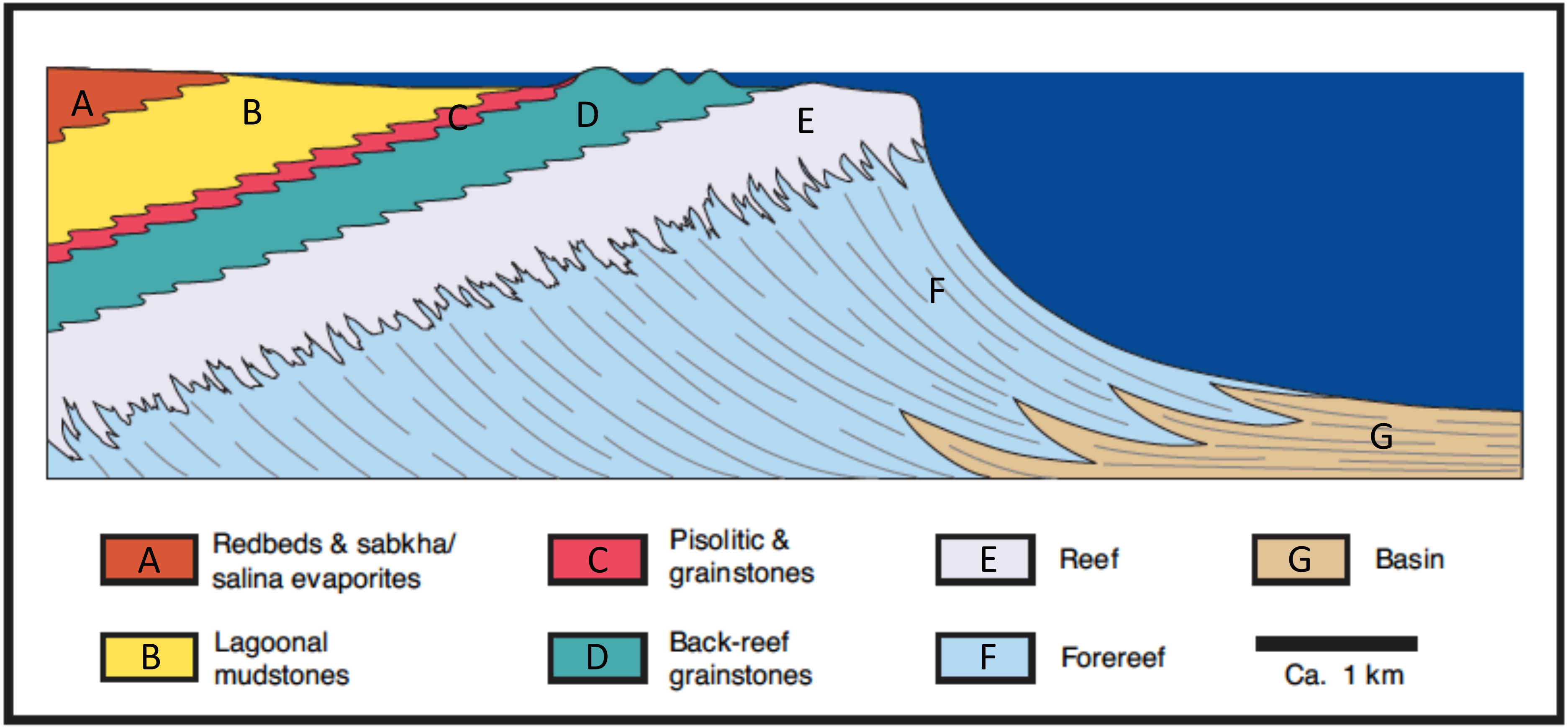


Figure 18. Shelf-to-basin spectrum of microfacies and interpreted depositional environments for the Capitan and Capitan-equivalent strata of the Guadalupe Mountains. Vertical axis is approximately 0.5 km.

A: Redbeds and Evaporites

What do redbeds and evaporites tell us about environment?

Redbeds: terrestrial deposition; Evaporites: restricted circulation (reef is blocking incoming ocean water)

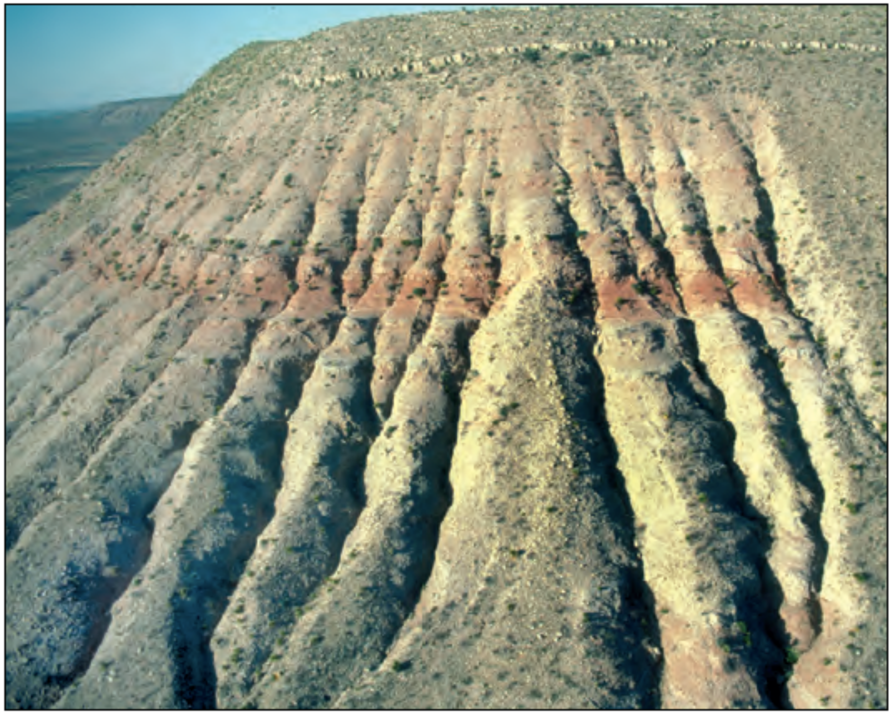


Figure 19. Seven Rivers embayment on New Mexico Highway 137 about 10 km north of the intersection with Dark Canyon road. Approximately 100-m-thick section of interstratified red siltstone and gray, massive, bedded evaporite of the Seven Rivers Formation. Note extensive gullying of the soluble evaporite and presence of capping layer of dolomicrite (Azotea Dolomite) which has preserved this outcrop from erosion.

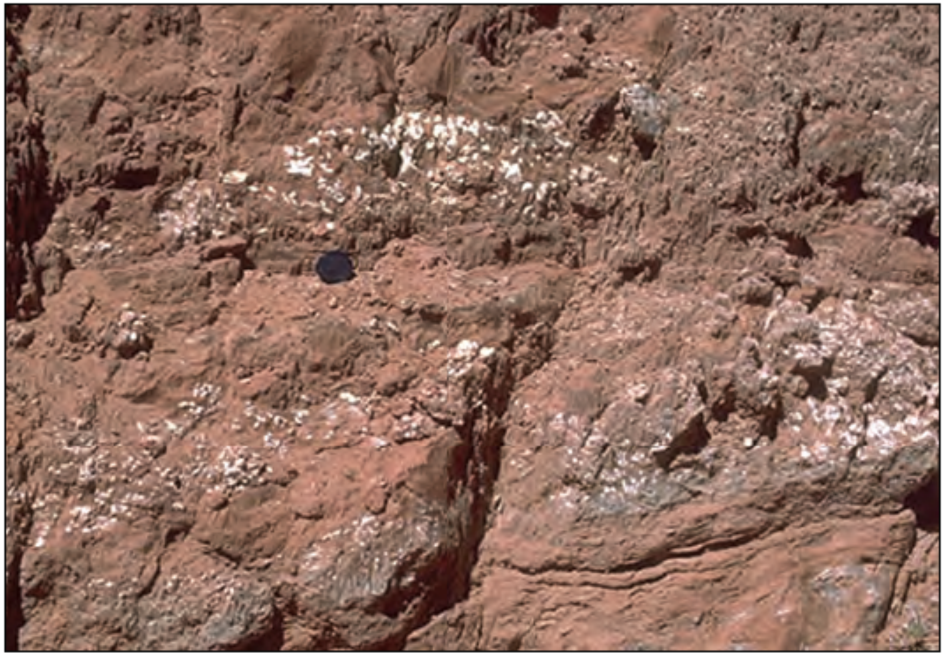
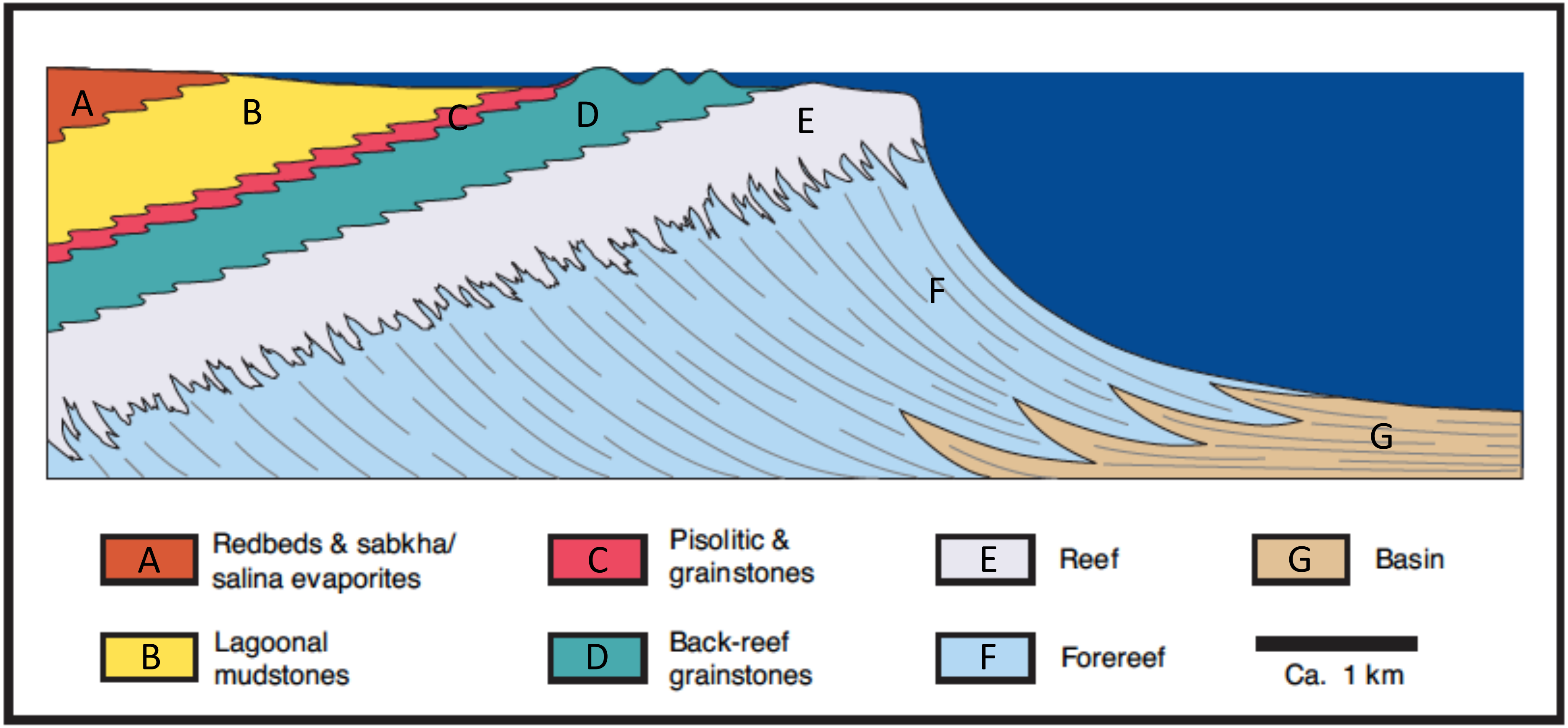


Figure 20. Red siltstone and nodular gypsum from the Seven Rivers Formation. Siltstone shows vague horizontal lamination, largely disrupted by growth of evaporite minerals. Outcrop in Seven Rivers embayment on New Mexico Highway 137, about 10 km north of the intersection with Dark Canyon road.



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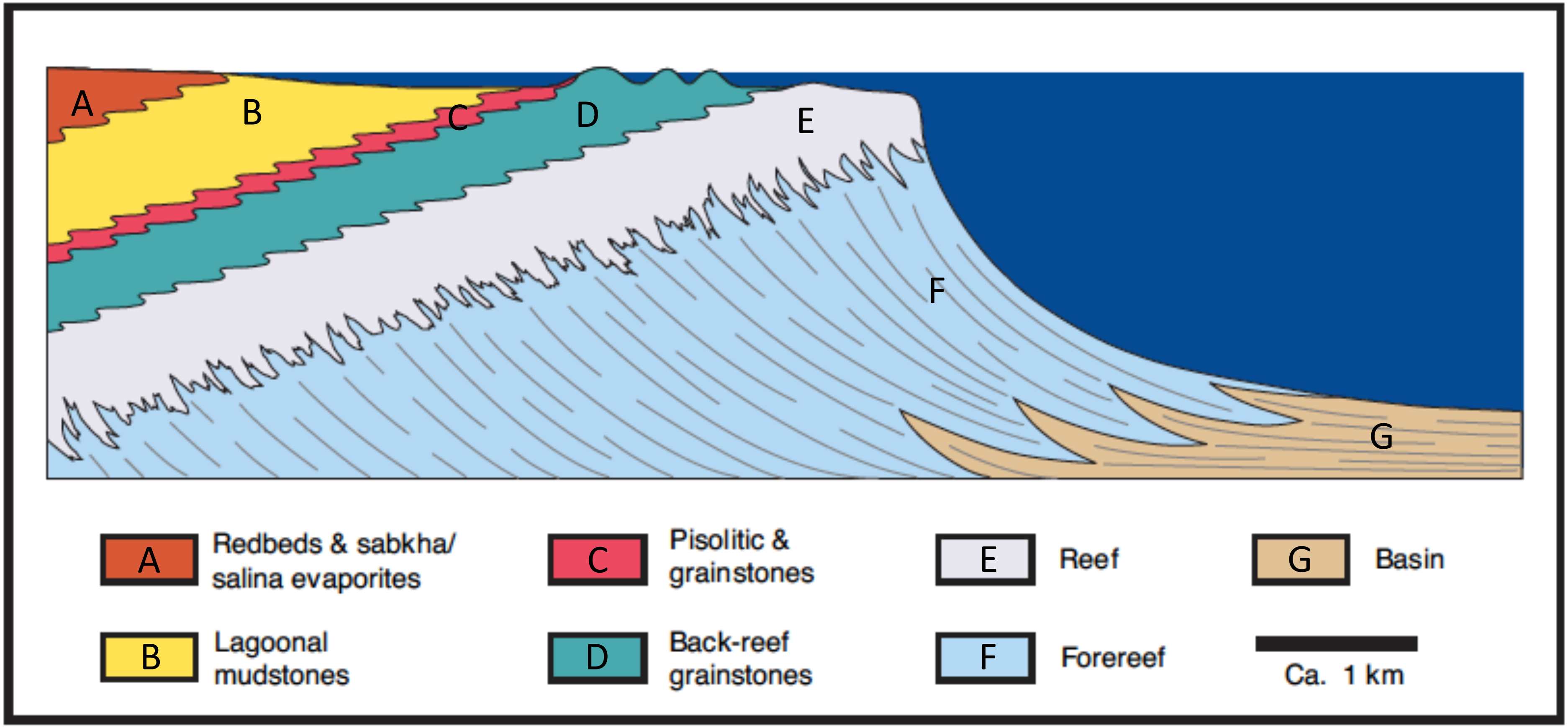
B: Lagoonal Mudstones

Figure 23. Polished slab of a laminated, fenestral, very fine-grained dolomite from the back-reef "lagoonal" facies of the Seven Rivers Formation. This fabric was most likely produced by intertidal blue-green algal stromatolites; some of the larger voids are the result of dissolution of synsedimentary evaporite crystals.

What does the presence of stromatolites tell us about the environment?

Stromatolites mean nobody is eating the algae, not even snails. So unusual water chemistry (probably too saline, and that is confirmed by the dolomite and evaporites)



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C&D: Pisolites & Grainstones

Figure 29. Low angle, seaward-dipping cross-beds in the upper Tansill Formation. These skeletal grainstones of probable beach origin overlie subtidal and lower intertidal grainstones and packstones (below base of photograph) and, in turn, are overlain by pisolitic strata. Thus, they are part of one of the many shallowing-upward sequences in this part of the section, probably associated with small barrier islands in the very near-back-reef zone. These barriers are thought to have restricted the flow of marine water from the basin onto the shelf.

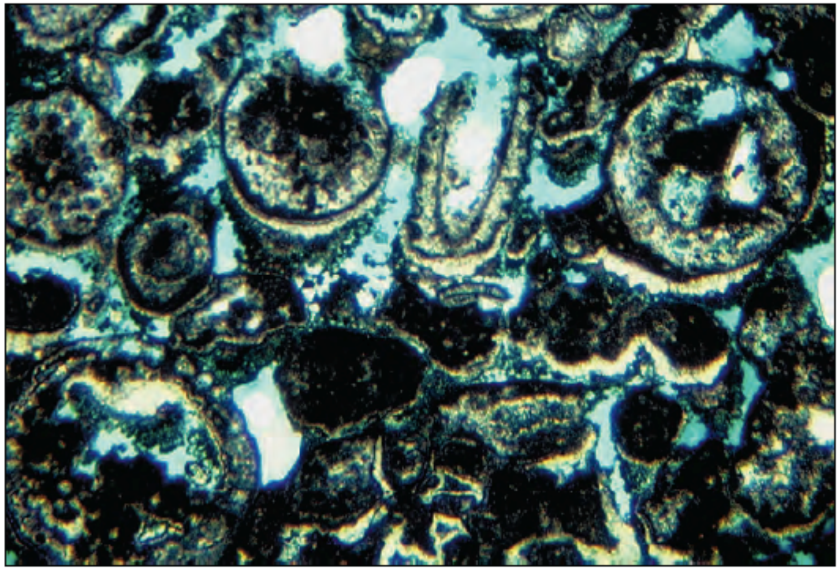


Figure 28. Thin-section photomicrograph (plane-polarized light) of a near-back-reef grainstone in the Tansill Formation. The predominant grains are *Mizzia* green algae and, in this example, the primary porosity was partially filled with an early diagenetic cement produced in the vadose zone — note slight corrosion of tops of grains and pendants or microstalactites of calcite cement below the grains. Subaerial exposure may have occurred on small islands during sedimentation or in association with a major (early Ochoan) hiatus that follows Tansill deposition. Walnut Canyon, less than 1 km west of canyon mouth, Carlsbad Caverns National Park, Eddy Co., New Mexico.

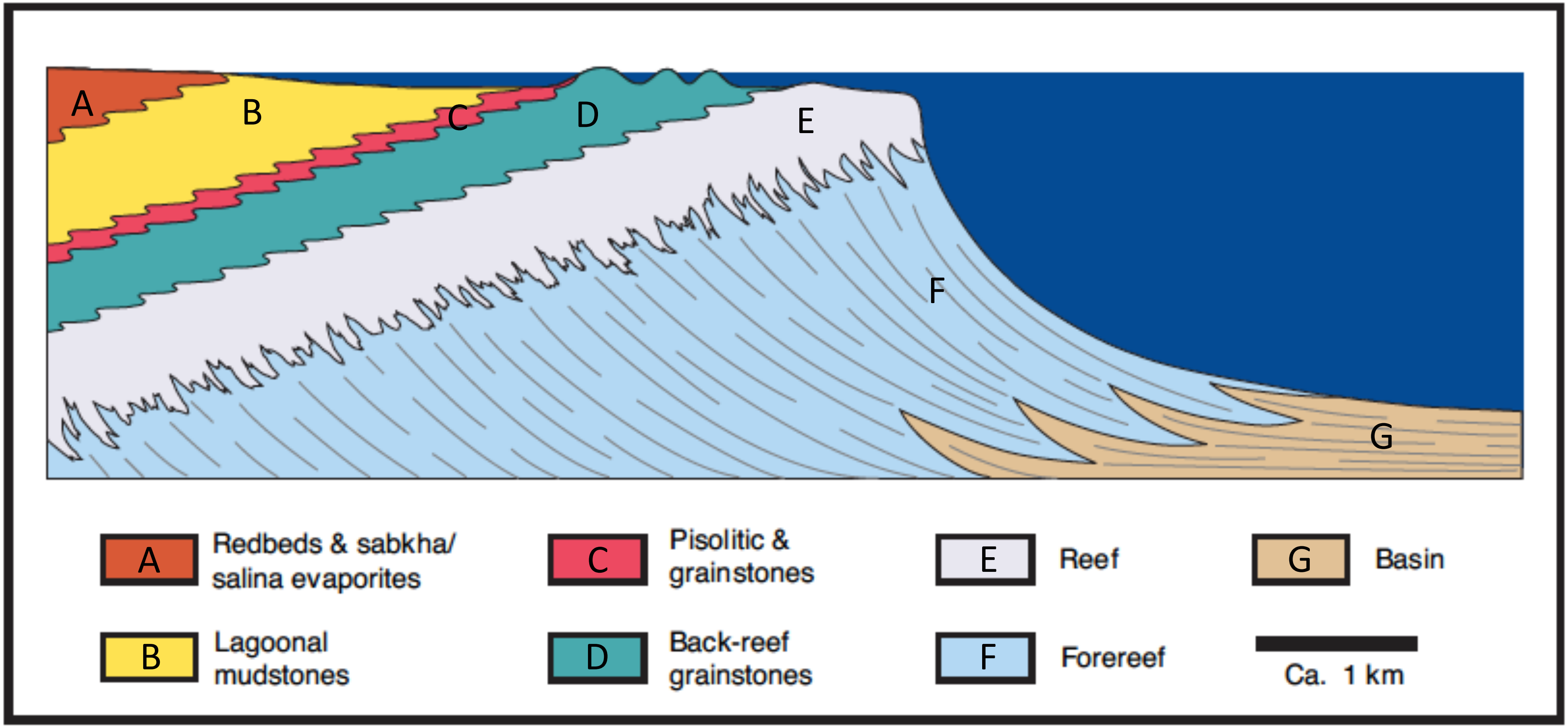
C&D: Pisolites & Grainstones (cont)

Figure 24. Polished slab of pisolitic dolomite from the uppermost Yates Formation. Note reverse grading of grains and "fitted fabric" in which grains have interlocked boundaries produced by compromise growth of outer coatings. Slab is 8.4 cm in height.

What do pisolites and cross-beds tell us about the environment?

Pisolites = shoaling (waves sloshing back and forth) or tidal motion causing sediment to roll.

Cross-beds = current



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E: Reef Core

Figure 34. Phylloid algal-*Archaeolithoporella*-marine cement facies in Capitan reef in Walnut Canyon. White, curved strips are oriented phylloid algae; white-gray patches are trapped micrite and darker encrustations consist mainly of *Archaeolithoporella* and marine cement.

There are no Permian corals that build big frameworks, so the reef is built from other organisms: here it's algae.

E: Reef Core

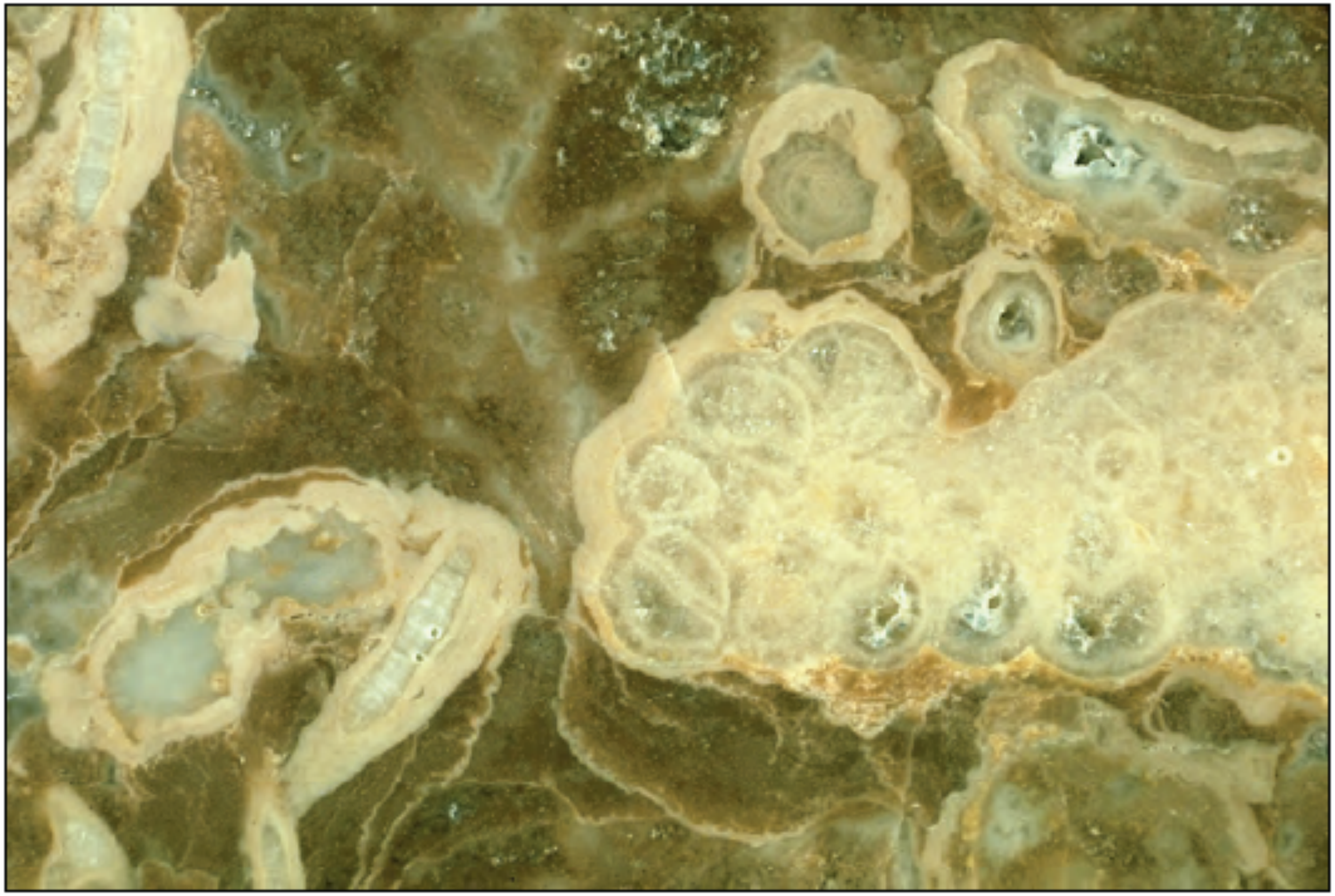


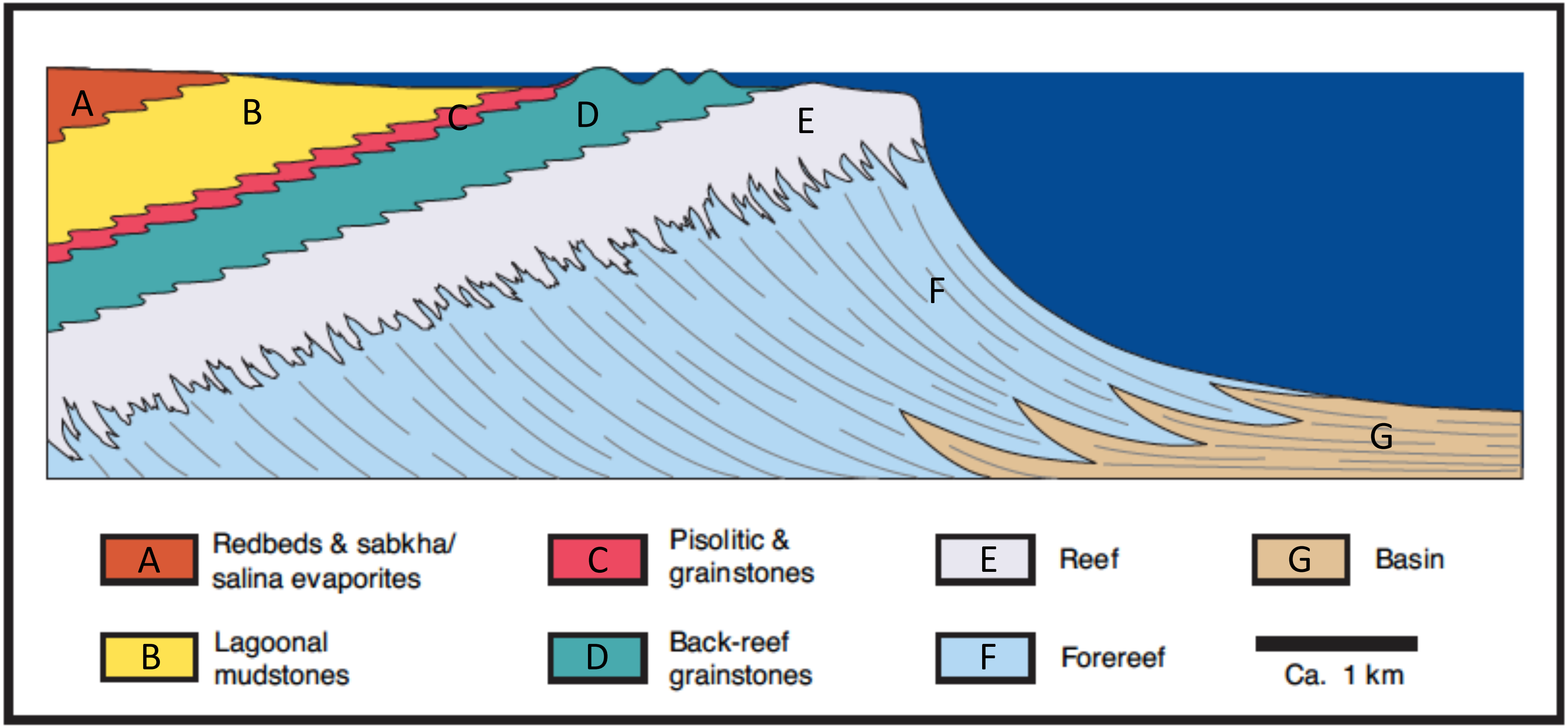
Figure 35. Polished slab with calcareous sponges, *Archaeolithoporella* encrustations, and dark brown marine cements from the sponge boundstone facies of Babcock (1977a) in Walnut Canyon.

These are cross-sections through the sponge framework of the reef.

Figure 31. A portion of the diorama of the Capitan reef produced by Terry L. Chase and displayed at the Permian Basin Petroleum Museum in Midland, Texas. This artist's conception emphasizes the framework sponges and the abundant encrusting fauna.

Reconstruction of reef core

Sponges, algae, corals and coral-like creatures, bryozoans, echinoderms (cystoids, crinoids)



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F: Upper Reef Slope

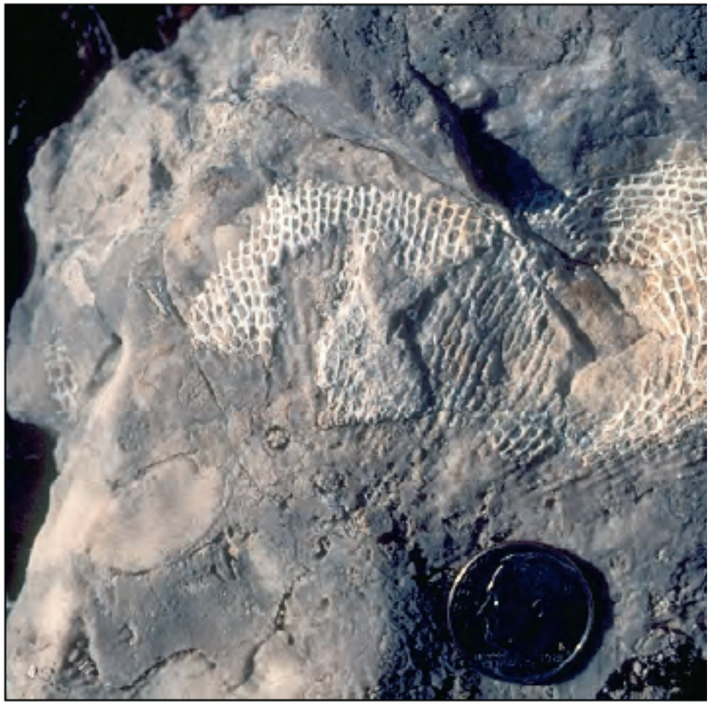


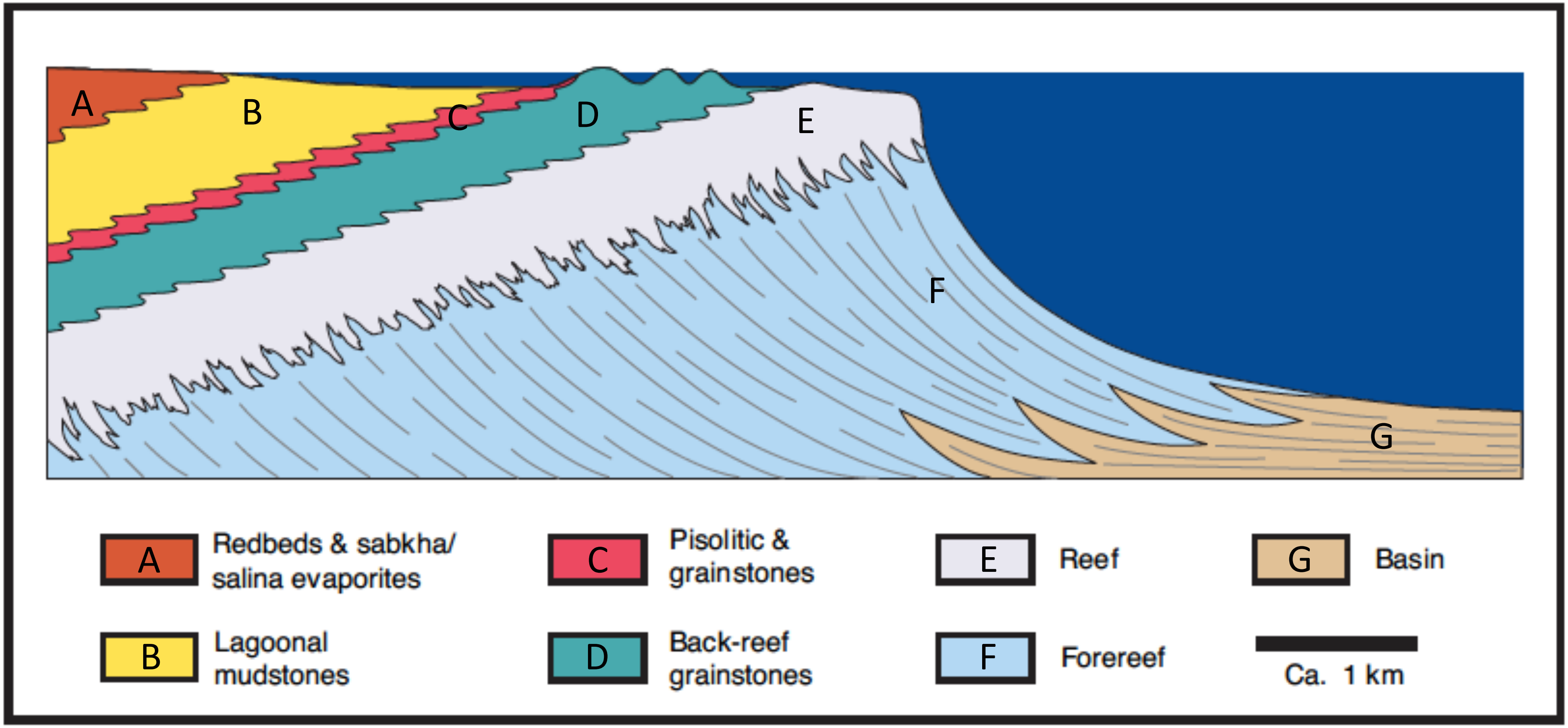
Fig. 38 A large fragment of a fenestrat
the more common organisms which col
fore-reef slope (north wall, McKittrick C

Figure 39. Small channel in Capitan fore-reef talus (south side of McKittrick Canyon). Floor of channel axis is lined with several thin flow units and then is plugged with a massive debris flow. Slope deposition was accomplished by a mix of rock falls, debris flows, density currents, and perhaps other processes. The middle slope, in particular, is dominated by debris flow deposits.

F: Lower Reef Slope

Figure 40. Graded turbidite of carbonate packstone t wackestone in the lower slope facies of the Capitan Formation (Permian Reef trail, north side of McKittrick Canyon) Constituent grains are mainly slope-dwelling organism (brachiopods, bryozoans, echinoderms), many of whic have been replaced by authigenic silica.

Figure 47. Large blocks of carbonate slope material in a debris flow (the Rader slide) within sandstones of the Bell Canyon Formation at Stop II-4. The largest clasts in this part of the flow (which lies approximately 7 km basinward from the shelf margin) exceed 3 m in diameter. The deposit represents an unusually large catastrophic failure of part of the Delaware Basin margin, and its occurrence at the transition between clastic and carbonate sedimentation phases in the basin may indicate that it was associated with a sea-level change.



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G: Basinal Deposits

Figure 44. View southeast from U.S. Highway 62-180 south of Guadalupe Pass showing face of the Delaware Mountain escarpment with a series of lenticular sand-filled submarine fan channels surrounded by finer-grained interchannel (overbank) sediments. Approximately 300 m of Brushy Canyon Formation strata are exposed below the Cherry Canyon Formation carbonate ledges that cap the ridge.

Turbidites cascaded down the reef slope into the basin. Coarse grained layers are channels; finer grained are the farther edges of a flow or the finer materials that spilled over the channel lip (overbank deposits).

G: Basinal Deposits

Turbidites at the bottom edge of the fans

Figure 41. Thin-bedded, dark colored, subtly graded, dis
turbidites (wackestone to mudstone) in lower part of
Capitan slope facies (north wall of McKittrick Canyo
Base of unit at level of acid bottle shows silicification
coarse basal material. Inter-turbidite sediment is fissile
slightly more clay-rich than associated turbidite sedimen

Very fine-grained limestone in the basin

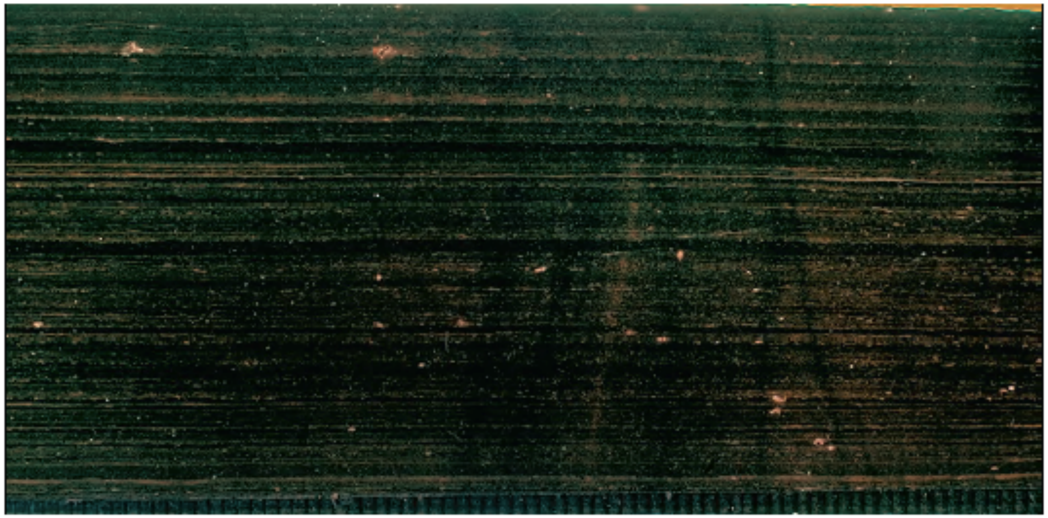

Figure 42. Polished slab of laminated, very dark colored, basinal Lamar Limestone (the uppermost member of the Bell Canyon Formation, roadside outcrop along U.S. Highway 62-180). Note excellent preservation of fine-scale lamination and lack of bioturbation in this sample from a locality about 7 km basinward from the age-equivalent Capitan reef margin.