Datashare 216

Shale facies in the Mesoproterozoic Beetaloo Sub-basin, Northern Australia—Experiment-based assessment of depositional conditions for the world's oldest gas shale

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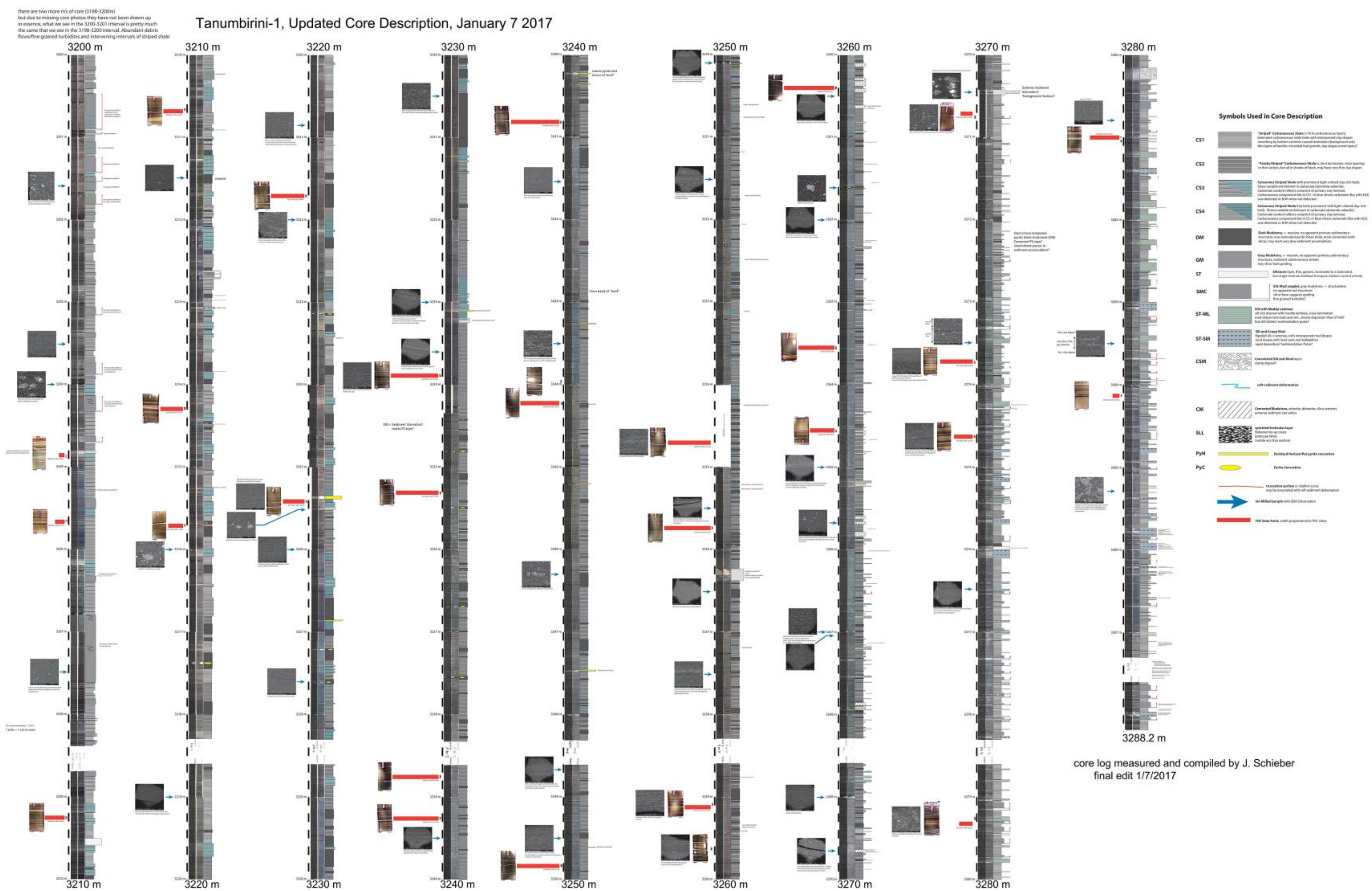
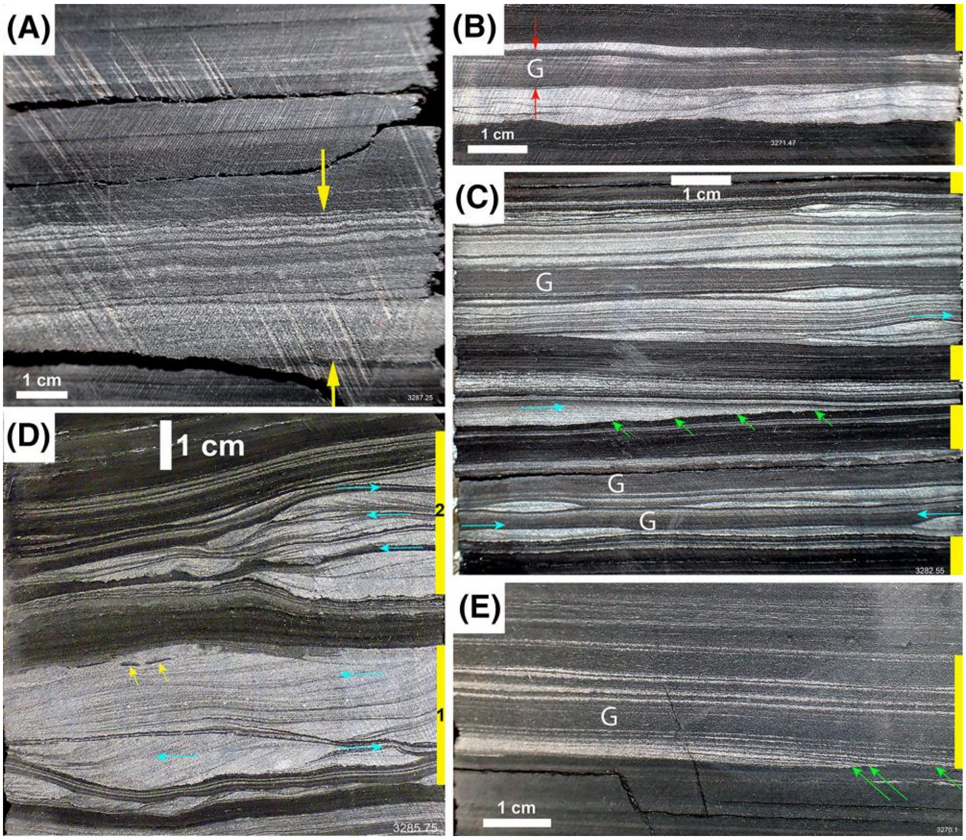
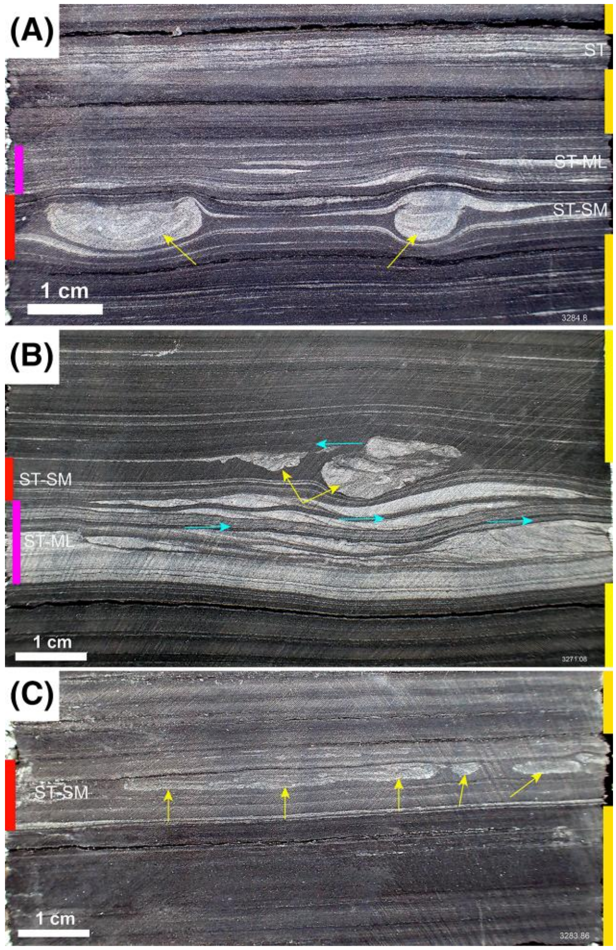
ONLINE SUPPLEMENTS



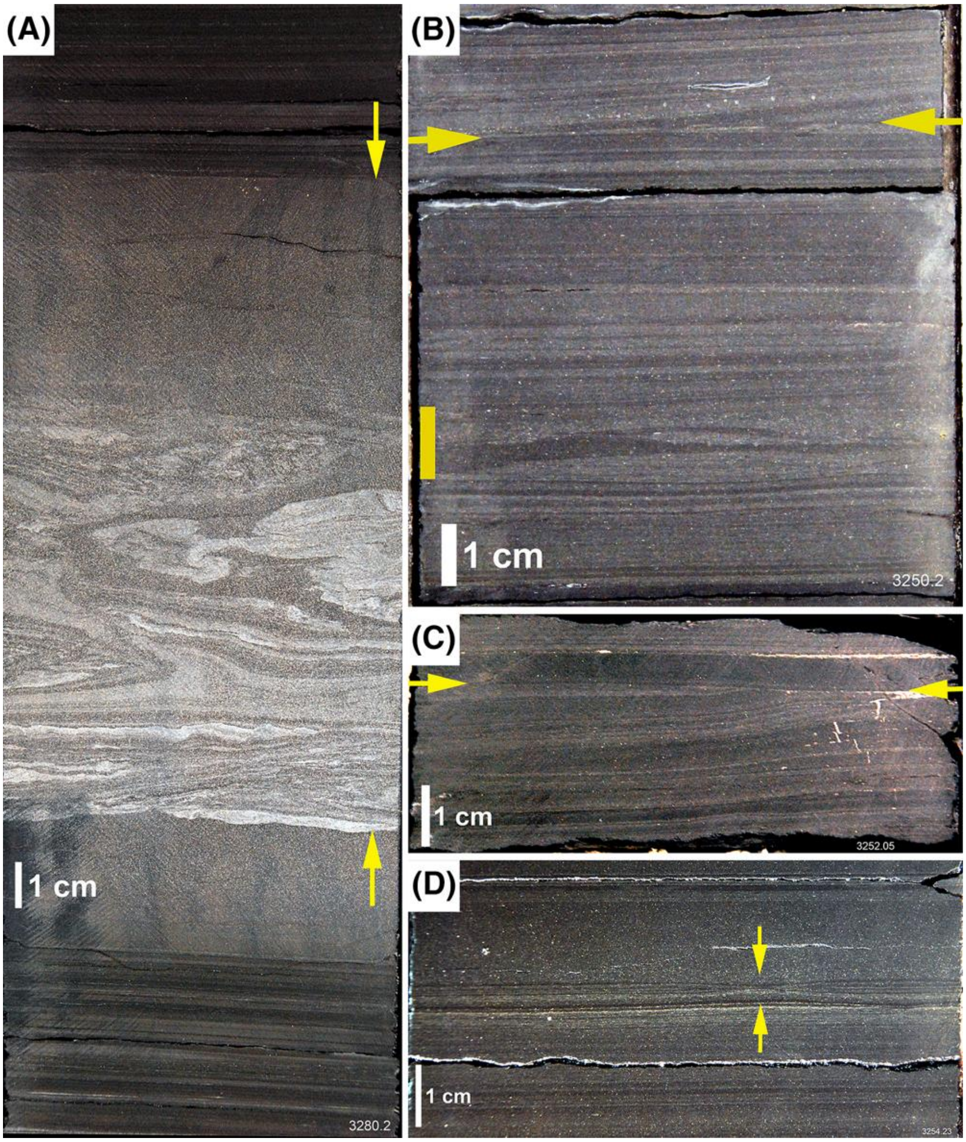
Online Supplement 1. Detailed petrographic-sedimentological log of Tanumbirini-1 core.



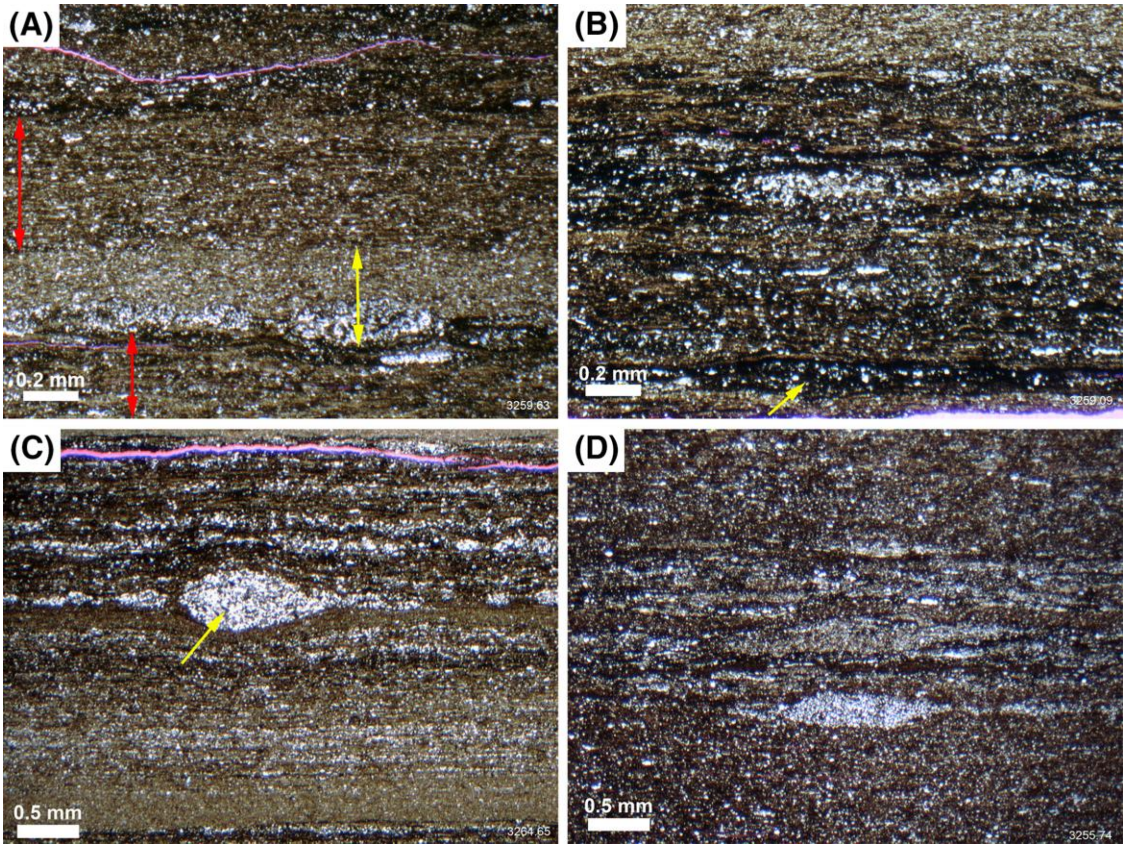
Online Supplement 2. Types of silt layers in the Amungee Member. (A) Generic silt layer (ST, between yellow arrows) with internal laminae that are separated by thin mud drapes and show lateral thinning and thickening. (B) An example of silt with muddy laminae (ST-ML), sandwiched between striped shale (yellow bars in right edge). Red arrows mark a gray mudstone dominated layer "G" separating lenticular/rippled silt layers. (C) A succession of multiple ST-ML layers interspersed with striped shale (yellow bars at right). "G" marks gray mudstone separations between silt dominated layers. Note common formation of silt lenses (ripples), some of which show internal cross-lamination and indicate flow directions of depositing currents (blue arrows). Green arrows mark base terminations (downlap) of low-angle inclined laminae. (D) Two intervals of silt layers (ST-ML; marked by yellow bar on right) that show lenticular buildup and are separated by striped shale. Several silt lenses show cross-lamination, blue arrows mark flow directions of depositing currents. Note that in (C) and (D), packages of silt laminae suggest alternating current flow internally (blue arrows). In (D), yellow arrows point to mud rip-up clasts in ST-ML interval 1. (E) Bundle of parallel silt laminae with gray mudstone "G" interlayers. At right, downlapping low-angle inclined laminae are marked with green arrows.



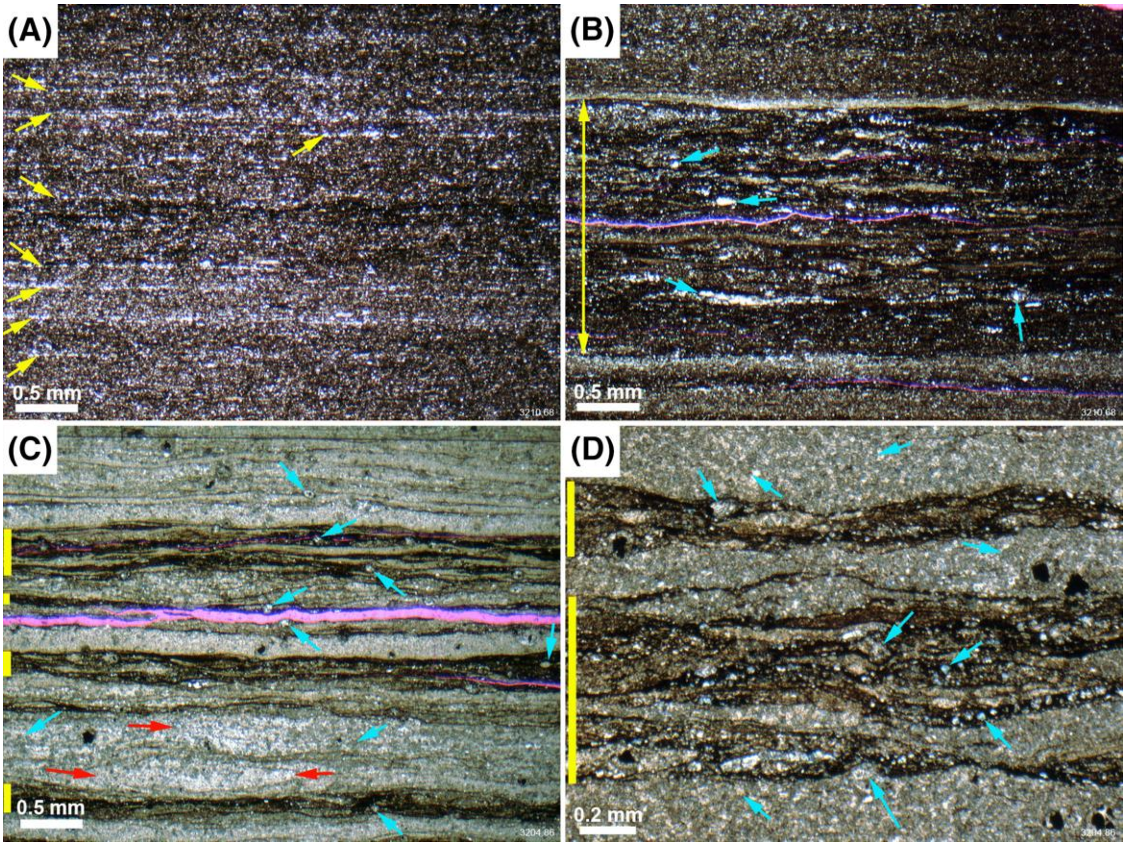
Online Supplement 3. Examples of “silt and soupy mud” (ST-SM) intervals (marked with red bar at left). (A) ST-SM interval that is overlain by silt with muddy laminae (ST-ML) interval (purple bar at left). Yellow arrows point to well-developed load casts (pillows). Differential compaction suggests an initial water content of approximately 80 vol. % for the mud layers. (B) ST-SM interval that overlies ST-ML interval (purple bar at left). Yellow arrows point to “sunk in” or “load-casted” ripples. Multiple silt lenses show internal cross-lamination as well as opposing flow directions (blue arrows) of depositing currents. (C) shows a mud dominated ST-SM interval. What is notable here is that the little silt that did arrive still caused fabric collapse and pillow formation (yellow arrows), suggestive of high initial water content and soupy consistency of underlying mud. Yellow bars at right indicate layers of carbonaceous (striped) shale.



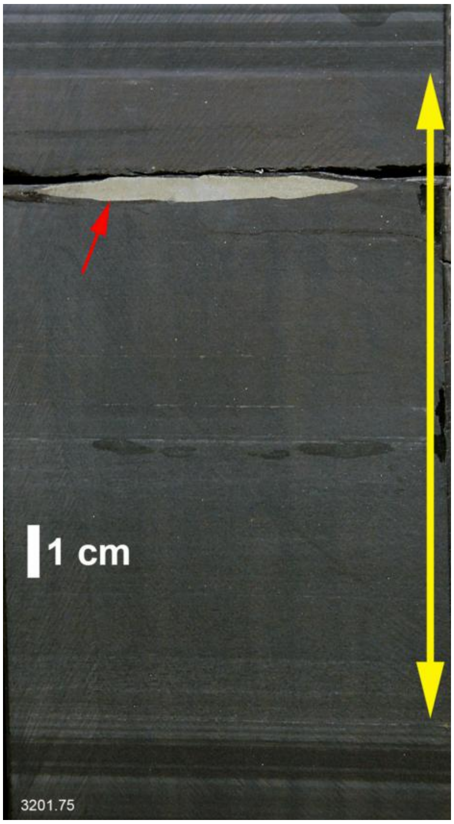
Online Supplement 4. (A) Convolute bedding in the lower half of an original silt-mud couplet (marked by yellow arrows). The complex folding and crumpling of original layering is consistent with convolute bedding (Reineck and Singh, 1980), a structure ascribed to fabric collapse of the initial sediment. (B–D) Substantially more subtle expressions of soft sediment deformation in the dominant striped shale facies types. (B) Striped shale with what appears to be an internal shear plane (marked with yellow arrows), and a thin interval with deformed layering (yellow bar on left). (C) A sharp truncation surface (yellow arrows). Note white mineral filled fractures near right arrow. (D) Constricted laminae between yellow arrows probably mark a loop structure as defined by Cole and Picard (1974).



Online Supplement 5. Photomicrographs of facies CS2 (faintly striped carbonaceous shale) (Tanumbirini-1). (A) Lighter layers (non-black with flattened lenticles (water-rich rip-ups) marked by red double arrows. Yellow double arrow marks a thin graded silt-mud couplet. Towards the top of the image organic matter-rich, interpreted microbial mat fragments increase in abundance (transition to homogenous-lenticular microfacies). (B) Lighter layer with rip-ups and interbedded lenses of silt. Yellow arrow points to continuous wavy-anastomosing carbonaceous layer near the bottom, a possible microbial mat deposit. (C) Sets of parallel silt laminae as in facies CS1 (striped carbonaceous shale). Note irregularity of laminae and formation of silt lenses (yellow arrow). (D) Compacted-flattened lenticles (rip-ups) that can exceed 1 mm in length, significantly larger than the more typical 0.1–0.3 mm lenticles in (B).



Online Supplement 6. Photomicrographs showing textural attributes associated with carbonaceous laminae in facies CS3 (striped calcareous carbonaceous shale) and CS4 (faintly striped calcareous carbonaceous shale). (A) Parallel-laminated carbonaceous laminae; thin, parallel silt laminae are marked with yellow arrows. (B) Homogenous-lenticular carbonaceous laminae (marked with yellow double arrow) where soft lenticles are mingled with organic-rich sediment. Blue arrows mark carbonate grains and lenses. (C) Wavy-anastomosing carbonaceous laminae (marked with yellow bars at left edge of image) that are separated by thin clay drapes and appear to be continuous. Blue arrows mark visible carbonate grains, red arrows mark large lenticles (soft rip-ups) that exceed 1 mm in length. (D) Close-up view of carbonaceous laminae in (C) (marked with yellow bars at left edge of image). These have good lateral continuity, and multiple laminae are continuous even without the "benefit" of separating sediment lenses. Iron carbonates (blue stain, blue arrows) are disseminated through the rock.



Online Supplement 7. A flat pyrite concretion (red arrow) near the top of a cemented DM (dark mudstone) layer (yellow double arrow).

REFERENCES CITED

Cole, R. D., and M. D. Picard, 1974, Primary and secondary sedimentary structures in fine-grained lacustrine rocks of Green River Formation (Eocene), Piceance Creek Basin, Colorado: AAPG Bulletin, v. 58, no. 5, p. 912–913.

Reineck, H. E., and I. B. Singh, 1980, Depositional sedimentary environments: New York, Springer, 551 p.