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Straight-crested ripple marks in supratidal dolomite, Buffalo Springs Formation, near Morgantown, Pa. A Franklin and Marshall College student serves as scale (see article on page 3).

EDITORIAL

Where Do We Go From Here?

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Wow. I'm writing this in the second week of November 2016, so you all know what I mean. We have completed one long national odyssey, and are about to begin another. The resultant hopes and fears that each one of us feels are real, whether or not they seem to be rational or grounded in fact. The only way through is to address the fears without dashing the hopes. So be kind, be understanding, and listen, really listen. You might be surprised at what you hear.

We don't know what will happen over the next four years. However, based on things that have been said and names that have been floated for key positions, it looks like science may have a rough go. As scientists, then, how can we react? First, I would say, we continue to do our work and to report the results accurately and honestly. If we lose our credibility, we lose everything. Second, take every opportunity to talk and to educate. Most people get their "science" from less-than-knowledgeable sources. Make yourself the knowledgeable and accessible source. Talk to your friends, community groups, kids, and adults. Explain things in a way a nonscientist can understand. The scientific issues we face are complex, but no one has the time to sit through long, nuanced explanations. Perhaps it would behoove us all to mentally prepare a few "elevator speech" responses. Maybe we can't explain the whole process of hydrofracturing a shale well, but we can say quickly that the cracks are the width of a sand grain, or that the gas companies work very hard to keep the cracks within the shale layer because otherwise they risk losing the gas and the profits. This approach won't provide a full education, but it might put a few tears in the veil of ignorance. (As an aside, I wish we could educate people about risk, because we all worry about things that don't do us much harm, while the things that can really hurt us are right under our noses without raising alarm. But that's a discussion for another time.) Third, stick to observable facts. It's easy to argue about whether human-produced carbon dioxide is changing the climate. It is harder to argue about the fact that the Pentagon considers climate change a threat to national security. Or that coastal cities in Virginia and Florida are experiencing regular and worsening flooding, not from storm events but from normal high tides. Or that in September, a cruise ship took 1,000 tourists through the Northwest Passage; yes, the same Northwest Passage that had been blocked by ice since European exploration of the New World began.

Finally, we must look ahead. Politics is concerned with the short term. Certainly science works in the present, but it also looks to the future. The powers that be might not recognize the utility of good science, but that does not negate the fact that humanity needs science. As it has since the days of cracking stones to make tools and the discovery of fire, our survival depends on science. As scientists, we must continue to look ahead and ensure that we establish a base of knowledge to serve future needs.

Gale C. Blackmer

Semiarid Climate and Cyclic Carbonates—Deposition and Diagenesis of the Middle Cambrian Buffalo Springs Formation, Morgantown, Pennsylvania

Carol B. de Wet[1], Amy C. Moser[2], Katherine L. Oxman[1], and Erin K. Peck[3]

***Dedication**—This paper is dedicated to George E. W. Love to honor his contributions to the geology of Pennsylvania, including his Master's thesis work at Franklin and Marshall College on the Morgantown limestones (1969) and his service as the Director of the Pennsylvania Geological Survey and State Geologist (2010–15).*

Geologic Context, Age, and Stratigraphy

GEOLOGIC CONTEXT. Many Cambrian carbonate rocks in southeastern Pennsylvania are pervasively dolomitized, recrystallized, or metamorphosed to greenschist facies, making determination of their ages and depositional settings difficult. Considerable research has been done on age-equivalent strata in central Pennsylvania and Maryland, but modern sedimentological research on easterly areas of the Laurentian Cambrian-Ordovician platform known as the great American carbonate bank is scarce (Fritz and others, 2012). This paper helps fill that knowledge gap and is important in understanding the region's early Paleozoic geology. Considerable depositional and diagenetic information can be determined from carbonates that have experienced low-grade metamorphism and/or substantial tectonism by obtaining detailed petrography and geochemical data; therefore, sedimentary rocks that have been disregarded as "too altered to study" warrant a closer look.

A former lime quarry 0.75 mile northeast of Morgantown, Pa. (Figure 1), exposes cyclic Cambrian limestone and dolomite. First described by Love (1969), these rocks are typical of the Cambrian-Ordovician carbonates that accumulated on the Laurentian passive margin (Fritz and others, 2012). Morgantown carbonates were deposited in a shallow-water continental margin setting and exhibit preserved depositional and diagenetic mineralogy and primary sedimentary structures. Three lithofacies and their cyclic repetition are here delineated. We bring together disparate previous work on these carbonates with new petrographic and geochemical results, and we provide new interpretations of their diagenetic history and climatic setting.

AGE AND STRATIGRAPHY. Love and Kauffman (1969) and Love (1969) assigned the Morgantown section to the upper Cambrian Conococheague Group based on carbonate mapping in the area. Bascom and Stose (1938), however, had considered the quarry to be part of the Cambrian Elbrook Limestone. Trilobite cranidia discovered in the section (Busch and Fedosh, 1977) are upper Middle Cambrian age (Taylor and others, 2012; John Taylor and David Brezinski, personal communication, 2015), confirming the Morgantown rocks as the upper Middle Cambrian Buffalo Springs Formation, as mapped by the Pennsylvania Geological Survey (Miles and Whitfield, 2001), correlating with the Elbrook Formation as being the uppermost unit within the Sauk II supersequence (a stratigraphic succession spanning 3 to 50 m.y.) (see Fritz and others, 2012, for a detailed discussion).

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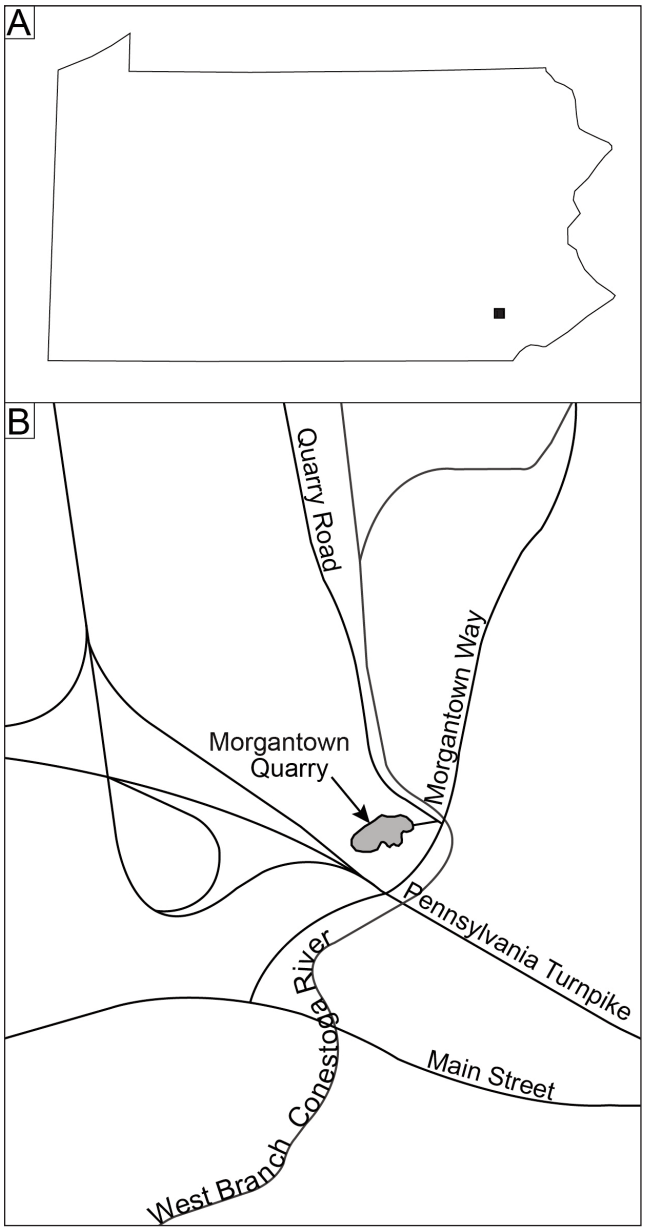

Figure 1. Location map of Pennsylvania and the former Morgantown lime quarry. The quarry is located near exit 298 of the Pennsylvania Turnpike (Interstate Route 76).

Present Study—Fieldwork

Lithologies and sedimentary structures were measured and described in detail for two complete and two partial shallowing-upward cycles (Figure 2). Three lithofacies are present within each cycle. The cycles range in thickness from 6.7 m to 10.9 m. Love (1969) measured 89 m of section; however, the quarry floor was later partially covered by gravel and vegetation. The quarry rocks strike east and dip 85°–90° to the north. Stratigraphic up direction is to the north.

In addition to fieldwork, 75 thin sections were studied petrographically, and geochemical analyses were conducted (see a description of our methods in the Appendix, p. 11).

Depositional and Diagenetic Features and Lithofacies Interpretation

MUDCRACKED DOLOMITE (LITHOFACIES I). This lithology is a well-bedded, yellow-weathering dolomite having abundant mudcracks (Figure 3A) and ripple marks (see cover photograph). Petrographically, the dolomite is very fine grained, sucrosic, fabric-obscuring, nonferroan dolomite (type 1; see "Processes of Dolomite, Evaporite, and Calcite Cement Formation" on p. 8) with relatively high Mg^{2+} values (Table 1; Appendix, Table 2). (Table 1 contains a summary of lithofacies characteristics and Table 2 in the Appendix contains geochemical results.) Patches of relict calcitic micrite and silt- to sand-sized detrital quartz grains occur. Gypsum and/or anhydrite nodules (sulfate minerals, some partially replaced with calcite) are in one horizon within this lithofacies (at the top of cycle 4) (Figures 2 and 3B). Bed thicknesses range from 2.0 to 3.5 m. This lithofacies is interpreted as having been deposited in a supratidal setting. Mudcracks indicate subaerial exposure. Ripple laminations indicate episodic seawater inundation or freshwater storm events. Seawater flooding and subsequent evaporation may generate primary or very early replacement dolomite (Ruppel and Cander, 1988), such as the Buffalo Springs dolomite. This facies has fewer diagenetic phases than the intertidal and subtidal facies because early dolomitization eliminated most of the primary porosity and permeability.

The discovery of gypsum/anhydrite relicts and pseudomorphs within the Buffalo Springs dolomite contributes to the refining of our interpretation of the Middle Cambrian depositional environment, because evaporite minerals indicate a semiarid to arid climate (Demicco and Hardie, 1994).

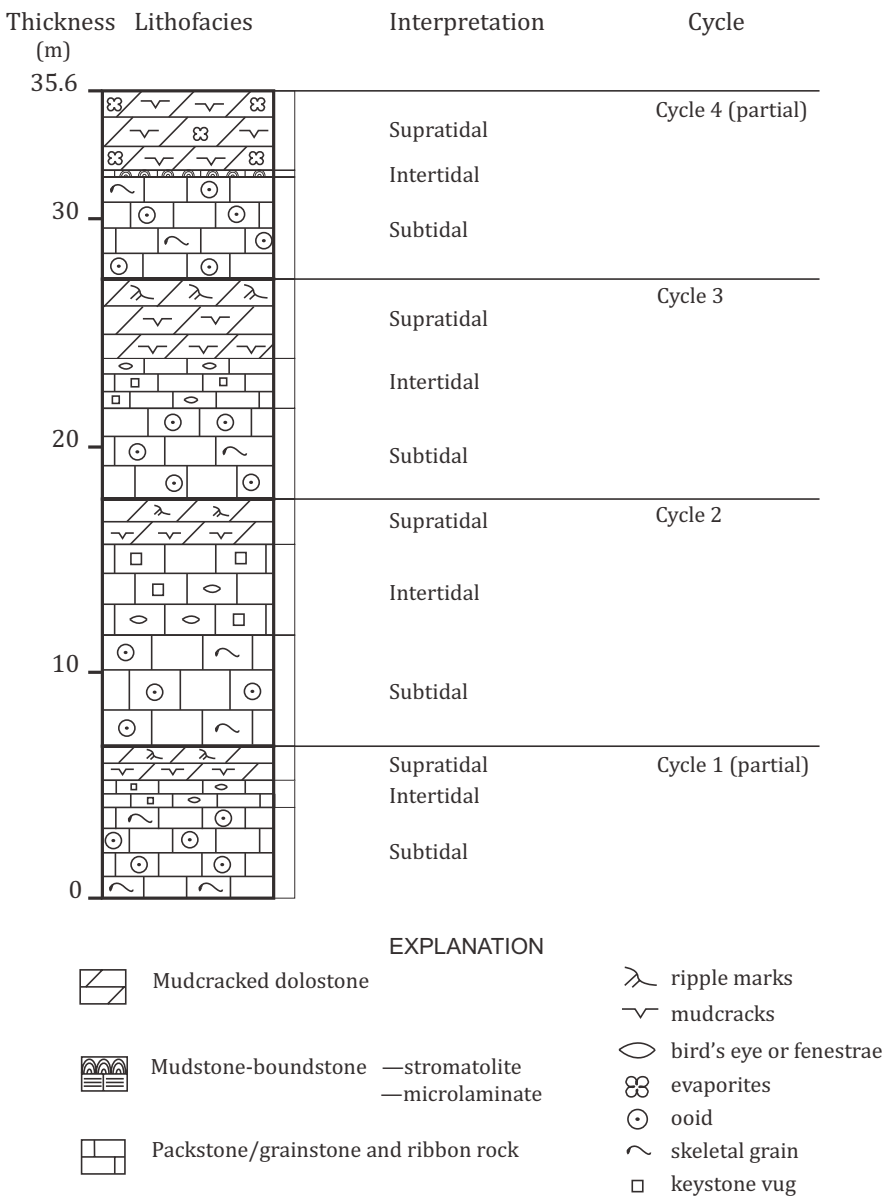

Figure 2. Representative stratigraphy exposed in the former quarry illustrating two well-preserved full cycles and two partial cycles (the base of cycle 1 is covered by vegetation and the top of cycle 4 is truncated by modern erosion).

MUDSTONE/BOUNDSTONE (LITHOFACIES II). This lithology is a laminated mudstone to microbial boundstone (grains bound together during deposition), having beds ranging from 0.3 to 4.0 m thick. A horizon of domal stromatolites is present in cycle 4 (Figure 4A). Recent erosion has apparently removed other stromatolite and thrombolite beds relative to the description by Love (1969), as he reported numerous stromatolites and thrombolites. Crinkly black laminations associated with former voids (fenestrae, bird's-eye structures, and keystone vugs), now filled with calcite cement, are common.

Petrographically, nonferroan calcite spar or fine-grained dolomite fill bedding-parallel, oval to spherical fenestrae and vugs (Figure 4B). Silt- to sand-sized detrital quartz grains are concentrated along dark laminations. Equant, subhedral dolomite crystals (type 2) form laminations that are either interlayered with calcitic laminations or form a mosaic texture of calcite and type 2 dolomite. The latter

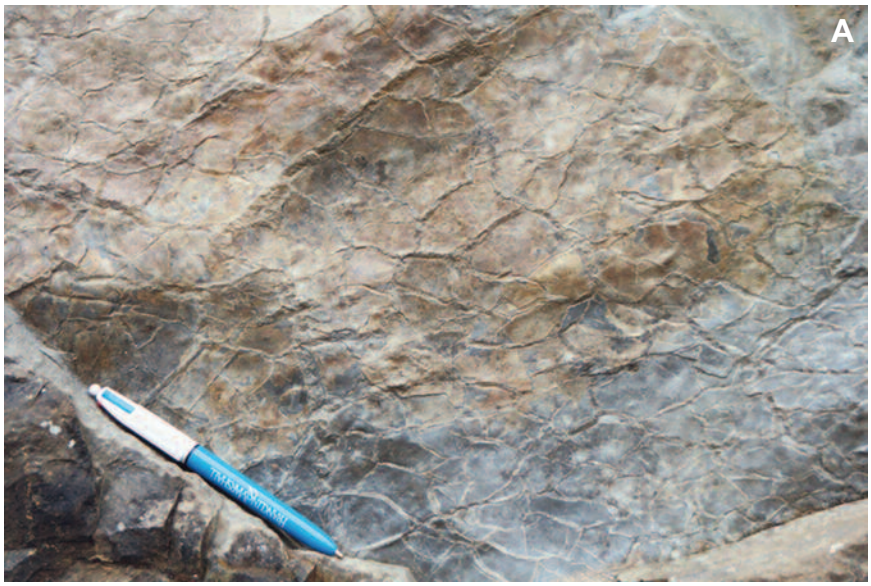

Figure 3A. Field photograph of yellow-weathering, mudcracked supratidal dolomite from cycle 3. The pen is 14.5 cm long.

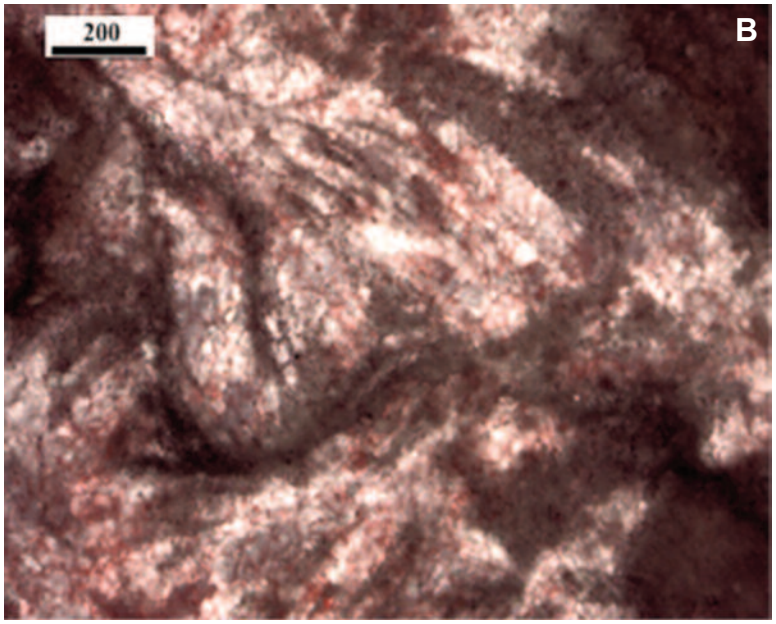

Figure 3B. Photomicrograph of partially calcitized gypsum/anhydrite nodule (note relict fibrous texture in central feature and unstained [white] sulfate crystal relicts within it) in the supratidal dolomite facies of cycle 4. Nonferroan (iron-poor) calcite is stained pink. Scale bar in microns.

texture is produced by partial replacement of original lime mud by dolomite (Figure 4B). Sparse baroque dolomite (type 3), characterized by large rhombs with curved crystal faces and sweeping extinction under crossed nicols, fills vugs and replaces matrix. This lithofacies, which yields Mg^{2+} concentrations that fall between the supratidal and subtidal samples (Appendix, Table 2), directly overlies grainstone/packstone and ribbon rock lithologies and is always overlain by supratidal dolomite.

The mudstone/boundstone lithofacies is interpreted as having been deposited in an intertidal to shallow subtidal setting. Black crinkly laminations are interpreted as microbial laminites, either flat-lying or domal stromatolites (Hardie and Ginsburg, 1977). Sand-sized grains and linear concentrations along the margins of the microbial laminations are likely terrigenous sediments deposited by storm events and/or eolian processes (Demicco and Hardie, 1994). The fenestrae and bird's-eye structures are interpreted as former gas-bubble voids, and keystone vugs as dissolution pores or amalgamated

Table 1. Characteristics of the Cyclic Deposits

(Supratidal, intertidal, and subtidal depositional and diagenetic features and their interpretation in the rock's diagenetic history.)

Lithofacies	Depositional features	Facies interpretation	Diagenetic features	Paragenetic sequence interpretation
I	Mudcracks	Supratidal zone	Fine-grained, pervasive dolomite—type 1	Early syndepositional dolomitization
	Ripple marks		Pyrite	Burial diagenesis
	Quartz sand and silt grains			
	Microbial laminations			
	Gypsum/anhydrite nodules		Fractures filled with calcite spar	Late-stage regional deformation
II	Intraclasts	Intertidal zone	Nonferroan calcite spar	Meteoric water cementation
	Bird's-eye structures, fenestrae, keystone vugs		Fine-grained patchy dolomite—type 2	Early syndepositional to shallow burial diagenesis
	Domal stromatolites		Pyrite	Burial diagenesis
	Microbial laminations		Authigenic quartz	Burial diagenesis
			Stylolites	Burial diagenesis
	Quartz sand and silt grains		Baroque dolomite—type 3	Late-stage burial diagenesis
			Fractures with spar	Regional deformation
III	Ooids	Subtidal zone	Nonferroan calcite spar	Meteoric water cementation
	Peloids		Fine-grained patchy dolomite—type 2	Early shallow burial diagenesis
	Intraclasts		Stylolites	Burial diagenesis
	Shell fragments		Pyrite	Burial diagenesis
	Bioturbated fabric		Baroque dolomite—type 3	Late-stage burial diagenesis
			Fractures with spar	Regional deformation

gas-bubble voids (Ginsburg, 1975; Demicco and Hardie, 1994). These features indicate an intertidal environment where the substrate was submerged at high tide and subaerially exposed at low tide.

GRAINSTONE/PACKSTONE AND "RIBBON ROCK" (LITHOFACIES III). Three- to six-meter-thick, gray, cross-stratified beds consist of bioturbated grainstones and packstones having ooids, peloids, intraclasts, and relict shell fragments in nonferroan calcite spar and/or micrite (Table 1). The spar and micrite have relatively low Mg^{2+} values (Appendix, Table 2). Ooids are 0.2 to 1 mm in size; most have a radial internal fabric (Figure 5A). Micritic peloids are small and oval shaped. Intraclasts are <1 mm to 3 cm in size and have truncated allochems at their margin. Echinoderm spines are recognizable from single-crystal extinction and syntaxial overgrowth cements (Figure 5B). Euhedral to subhedral dolomite rhombs and baroque crystals replace micrite and/or allochems or occur within fractures and vugs that crosscut all other features (Figure 5A).

Some of the packstone beds consist of alternating millimeter- to centimeter-thick layers of gray limestone and brown-weathering dolomite. This lithology has been termed "ribbon rock" and is well described in the great American carbonate bank literature (Demicco and Hardie, 1994).

Oolitic grainstones/packstones and the ribbon rocks are interpreted as having accumulated under subtidal conditions. Current activity, generating oolitic shoals, was likely moderate to high, whereas packstones formed in intershoal areas and back-shoal lagoons (Scholle and others, 1983).

Figure 4A. Field photograph of centimeter-scale domal stromatolites in the intertidal facies of cycle 4. The pen is 14.5 cm long.

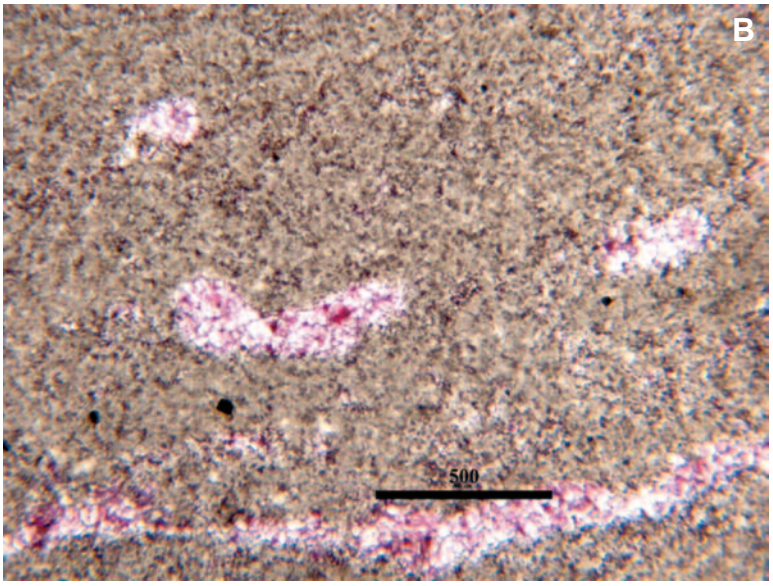

Figure 4B. Photomicrograph of partially dolomitized intertidal micrite. Fenestrae and bird's-eye structures are filled with nonferroan (stained pink) equant calcite sparry cement. Red-stained remnants of the primary micrite are visible within the type 2 replacive dolomite (unstained groundmass). Small black crystals are pyrite. Scale bar in microns.

Geochemistry

Geochemical data (Appendix, Table 2) show Fe^{2+} and Mn^{2+} values greater than reported values for Fe^{2+} and Mn^{2+} in modern marine calcites and dolomites; measured values for Sr^{2+} and Mg^{2+} are roughly the same or lower than standard values in marine carbonates (Veizer, 1983). Sr^{2+}, Mg^{2+}, and Fe^{2+} concentrations in the Buffalo Springs samples are enriched relative to concentrations in modern meteoric water, and Mn^{2+} values are close to the range of modern freshwater concentrations (Veizer, 1983). Our samples containing high Mn^{2+} values commonly show an enrichment in Fe^{2+} concentrations as well. Mg^{2+} values fall into three clusters that roughly correlate with the supratidal, intertidal, and subtidal lithofacies as follows: (1) supratidal—relatively high values from 21,227 to 87,651 ppm; (2) intertidal—intermediate values from 11,051 to 19,952 ppm; and (3) subtidal—relatively low values from 534 to 10,718 ppm.

Processes of Dolomite, Evaporite, and Calcite Cement Formation

We recognize three types of dolomite: type 1, which is fine-grained, sucrosic, fabric-obscuring dolomite, exclusive to the supratidal lithofacies; type 2, which is equant, brownish dolomite, replacing depositional fabrics and calcite spar in the intertidal and subtidal lithofacies; and type 3, which is baroque dolomite, in intertidal and most abundantly in subtidal lithologies.

EARLY DOLOMITE FORMATION. Mudcracked dolomite at the tops of cycles is common in great American carbonate bank deposits and may be interpreted as syndepositional in origin (Bova and Read, 1987). Seawater flooding on modern sabkha surfaces serves as an Mg^{2+} source, and intense evaporation

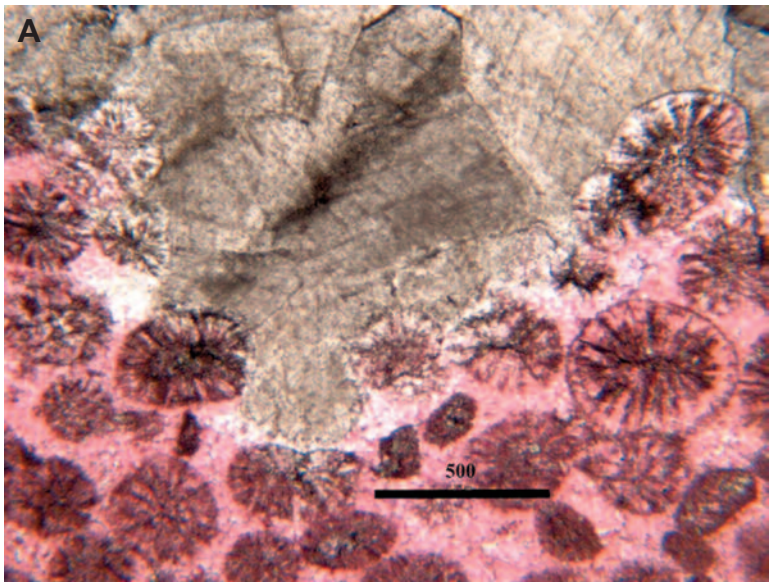

Figure 5A. Photomicrograph of subtidal facies nonferroan calcite radial ooids in sparry calcite cement (all stained pink), partially replaced by large baroque (saddle) dolomite crystals (type 3 dolomite, unstained). Scale bar in microns.

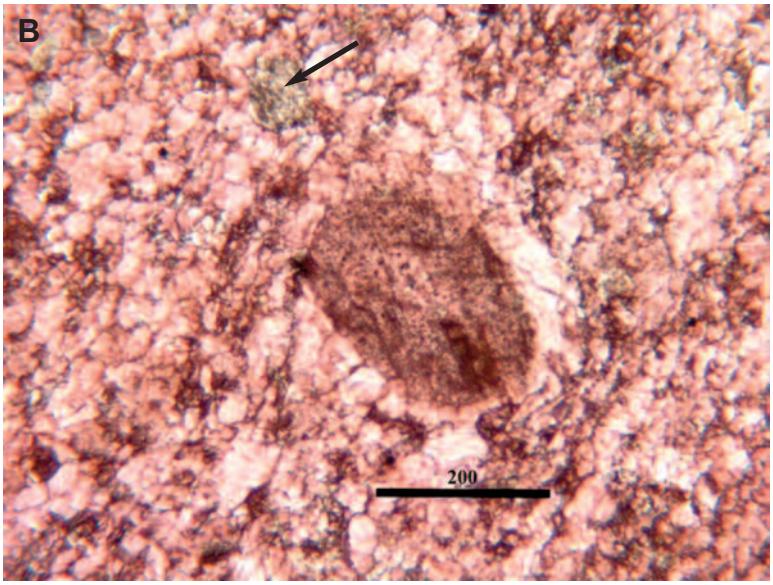

Figure 5B. Photomicrograph of subtidal facies echinoderm fragment with nonferroan calcite syntaxial overgrowth cement (all stained pink). Gray crystals in the oval cluster (arrow) consist of type 2 dolomite that partially replaces the original fabric. Scale bar in microns.

drives syndepositional dolomite precipitation (de Groot, 1973). The formation of gypsum (calcium sulfate) removes Ca^{2+} from pore fluids, increasing the Mg/Ca ratio to favor dolomite precipitation (Tucker, 2001). Our study shows that Buffalo Springs dolomites have high Mg^{2+} values (Appendix, Table 2) and relict gypsum nodules, indicating a sabkha-like depositional environment where seawater and high aridity contributed to syndepositional dolomitization.

This early dolomite (type 1) reduced porosity and permeability, and the supratidal lithofacies became an aquitard to subsequent fluids, as evidenced by the paucity of calcite spar and type 2 and 3 dolomites in these strata. Pore fluids were instead directed into the more porous and permeable subtidal and intertidal lithofacies, producing different diagenetic features in those lithofacies.

CALCITE AND DOLOMITE IN THE INTERTIDAL AND SUBTIDAL FACIES. Cement in fenestrae and keystone vugs must have precipitated very early during diagenesis to prevent collapse of open pores when the next cycle of sediment was deposited over them. Each sea-level fall lowers base level, leading to subaerial exposure of marine sediment and the potential for freshwater infiltration as the land-based water table moves seaward. Freshwater infiltrated the intertidal and subtidal Buffalo Springs deposits four or more times, as indicated by the number of supratidal cycle caps present in the quarry (Figure 2).

The role of meteoric water in diagenesis is confirmed by our geochemical results. Mg and Sr are more abundant in seawater; Mn and Fe are more abundant in meteoric water (Dickson 1985). During

diagenesis, high-Mg calcite and aragonite convert to calcite in the process of mineralogical stabilization, and trace-element partitioning predicts that Mg^{2+} and Sr^{2+} will be preferentially excluded from precipitating calcite (Veizer 1983). In contrast, diagenetic calcite precipitating under reducing conditions from meteoric water will be enriched in Fe^{2+} and Mn^{2+} if they are present in the pore fluid (Veizer 1983). Our geochemical results show an overall loss of Sr^{2+} relative to marine calcite (and dolomite) values and an enrichment in both Fe^{2+} and Mn^{2+}. The measured values for Fe and Mn fall within, or are enriched relative to, freshwater values, indicating that the Buffalo Springs limestones and dolomites experienced high-Mg (and/or aragonite) stabilization and cementation in reducing meteoric pore fluids.

Equant (type 2) dolomite occurs as patches in intertidal strata and in discrete layers in the subtidal ribbon carbonates. Dolomite having similar characteristics precipitates from groundwater in a shallow burial setting (Demicco and Hardie 1994). During burial, seawater trapped in pore spaces provides Mg^{2+} ions for dolomite formation, supplemented by additional Mg^{2+} as it exsolves from high-Mg calcite allochems during diagenesis (Tucker, Wright, and Dickson, 1990). Ribbon carbonates may form when porous grainstone layers are cemented with calcite during early diagenesis; mudstone layers remain uncemented until after compaction associated with shallow burial (Demicco and Hardie 1994). Under elevated burial fluid pressures, dolomitizing groundwater slowly progresses through the uncemented mudstone layers, producing ribbon dolomite patterns. Isopachous calcite and syntaxial rim spars (calcite that precipitates in optical continuity with echinoderm fossil calcite), enriched Mn^{2+} and Fe^{2+} values, type 2 dolomite, and dolomitized layers in ribbon rocks indicate that freshwater entered Buffalo Springs strata, probably multiple times associated with sea-level falls, during early and shallow burial diagenesis. This produced the calcite cement and type 2 dolomite patterns observed in the intertidal and subtidal lithofacies.

LATE DOLOMITE. Baroque dolomite (type 3) is indicative of precipitation from burial fluids that have elevated temperatures (60°C–150°C) (Radke and Mathis 1980; de Wet and others, 2004). The absence of baroque dolomite in supratidal samples suggests that the dolomite caps served as barriers to fluid migration. Its presence in the intertidal and subtidal strata suggests that depositional lithologies influenced even late-stage diagenesis. Burial fluids reached a minimum of 60°C, in accordance with regional tectonic evidence for significant burial and deformation associated with the Taconian, Acadian, and Alleghanian orogenies in the field area (Brezinski and others, 2012). Baroque dolomite within Buffalo Springs intertidal and subtidal facies is a product of warm pore-fluid migration during deep burial.

EVAPORITES AND PALEOCLIMATE. Arid to semiarid climate conditions produce distinctive suites of sedimentary features (Tucker, Wilson, and others, 1990). In dry climates, supratidal flats are characterized by mudcracks, limited fauna, syngenetic dolomite formation, and evaporite mineralization (Tucker, 2001). The Buffalo Springs Formation supratidal lithofacies is characterized by mudcracks, syngenetic dolomite, and evaporites, indicating that during the late Middle Cambrian, the eastern Laurentian margin experienced considerable aridity. Read (1989) argued that Laurentian margin carbonates represent times of long-term climate aridity, when sea levels were generally low and short-term 10-m oscillations generated the peritidal cycles seen in great American carbonate bank Cambrian strata. During wetter periods, groundwater recharge may have penetrated strata along the Laurentian paleoshoreline, moving slowly through peritidal sediments, leading to meteoric-derived cementation within each shallowing upward carbonate cycle.

Conclusions

The late Middle Cambrian Buffalo Springs Formation formed in equatorial shallows along the eastern Laurentian margin (Morgan, 2012). Cyclic carbonates were deposited in shallowing-upward

subtidal, intertidal, and supratidal environments. Supratidal dolomitized lime mudstones contain previously unreported gypsum/anhydrite nodules, indicating depositional aridity. Petrographic and geochemical evidence shows that early diagenesis was associated with marine pore fluids (supratidal dolomitization), whereas meteoric pore water, associated with sea-level falls, influenced calcite and dolomite precipitation in intertidal and subtidal facies. Warm burial pore fluids were responsible for baroque (or saddle) dolomitization. Thus, moderately deformed sedimentary rocks, such as these uplifted and tilted strata, may still preserve sedimentary features and geochemistry important to the regional history of deposition and diagenesis.

Acknowledgments

We thank Roger Thomas for showing us the Busch and Fedosh trilobite paper, and John Taylor and Dave Brezinski for help with regional stratigraphic questions. Thank you to Steve Sylvester for help with inductively coupled plasma geochemistry, and Diane Kadyk for help with tables. Thanks to Anne Lutz for her excellent editorial assistance.

Appendix—Petrographic and Geochemical Methods and Data

Hand samples and 80 thin sections were examined. Thin sections were stained according to Dickson (1966). Representative samples were microsampled (0.05 g of carbonate [micrite +/− sparry calcite and/or dolomite]) using a Dremel microdrill, dissolved in 10 percent nitric acid, and analyzed at Franklin and Marshall College on a SPECTROBLUE inductively coupled plasma optical emission spectrometer (ICP–OES) with 750 mm focal length, a Paschen-Runge optical system, and 15 linear charged-coupled device (CCD) array detectors. Calibrations were made to seven standards (appropriate to both calcite and dolomite) and diluted to appropriate concentrations from Specpure commercial stock solutions. Results are reported as parts per million (ppm) (Table 2). Each sample was associated with thin-section analysis for petrographic reference.

Note: The quarry is privately owned, and permission to enter must be obtained from Stolzfus Manufacturing, located across the street.

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Table 2. Geochemistry of Buffalo Springs Carbonates and Published Standard Values

(Geochemical results from inductively-coupled argon plasma spectrometry. Published data are from Veizer [1983].)
(All values in ppm)

Sample name	Sr^{2+}	Mg^{2+}	Fe^{2+}	Mn^{2+}
Published calcite—marine	1,000	16,300–75,400	2–39	1
Published dolomite—marine	470–550	130,400	3–50	1
Published calcite—groundwater	.1–5	5–40	.5–100	.01–100
RR–DOL supratidal	144.0	72,816.0	7,822.0	106.0
DV–DOL supratidal	214.0	87,651.0	4,170.0	198.0
EP–SI–DOL supratidal	370.3	28,617.0	6,257.0	79.3
FA–DOL supratidal	604.7	21,227.0	2,095.0	65.0
CH–DOL supratidal	252.9	62,138.0	5,312.0	98.5
TS supratidal	520.9	64,371.0	5,443.0	123.7
DV intertidal	398.0	15,396.0	990.0	50.0
RR–1 intertidal	507.0	16,183.0	1,695.0	66.0
RS intertidal	537.8	15,388.0	789.6	50.3
XD intertidal	432.4	19,011.0	1,508.0	62.5
KD intertidal	41.4	12,210.0	400.7	14.6
DH intertidal	503.7	15,251.0	1,531.0	66.7
MZ intertidal	541.5	11,051.0	1,077.0	52.0
TO intertidal	414.5	19,290.0	1,604.0	64.9
DG intertidal	323.1	15,907.0	899.6	48.8
EL intertidal	395.5	14,149.0	564.3	44.9
SA intertidal	272.3	19,952.0	1,370.0	67.9
CG–oolite subtidal	333.0	5,583.0	445.0	74.0
BB–oolite subtidal	329.0	5,562.0	445.0	80.0
CG–oolite subtidal	330.0	5,571.0	441.0	81.0
EP–S2 subtidal	885.1	6,721.0	723.4	53.2
MP subtidal	629.5	10,437.0	1,241.0	63.9
AD subtidal	833.0	7,395.0	799.2	50.4
HR subtidal	555.0	534.0	898.0	58.0
CT subtidal	589.8	7,557.0	909.1	53.8
JL subtidal	346.2	10,718.0	938.4	54.0
CX subtidal	429.6	8,528.0	1,265.0	55.2
SG subtidal	418.9	3,966.0	864.0	44.4
JD subtidal	233.0	1,840.0	324.0	45.1
SA–1 subtidal	263.3	3,053.0	195.0	44.2
CM subtidal	62.8	4,494.0	2,115.0	105.5
CM–1 subtidal	1,001.0	4,585.0	634.1	66.8

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THE 2016 FIELD CONFERENCE OF PENNSYLVANIA GEOLOGISTS

Energy and Environments—Geology in the "Nether World" of Indiana County, Pennsylvania

The 81st Field Conference of Pennsylvania Geologists was held in October 2016, and was headquartered in Indiana, Pa., in an area that had not been visited recently. The meeting focused on energy production and associated environmental problems and on the ancient sedimentary paleoenvironments in which coal formed. The co-leaders for the trip were Joan Hawk from CME Management in Greensburg, Pa., and Bill Bragonier, a retired coal geologist. Overall, 168 geologists, some from as far away as Florida and Quebec, attended, including 15 college students from New Jersey, Pennsylvania, and West Virginia.

On day 1, the first stop was the Lucerne coal refuse site (Figure 1), where staff from Cambria Reclamation Corp. discussed mining an old boney pile (a mound of coal waste) to power cogeneration plants, the beneficial environmental results, and the regulatory difficulties. At the second stop, outside Blairsville, the group looked at the Upper Pennsylvanian Casselman Formation (Figure 2), which had

Figure 1. View of Homer City power plant from Lucerne coal refuse site. Photograph by Michael E. Moore.

Figure 2. Field Conference participant pointing out mud rip-up clasts above a scour surface in the Casselman Formation. Photograph by Clifford H. Dodge.

been deposited in a braided river environment. At the lunch stop, a Shippensburg University student talked about using core from the Bureau's library to teach students about sedimentology, stratigraphy, and logging.

On the second day, the Field Conference participants headed toward Johnstown. At the first stop, they looked at a brecciated flint clay associated with the Upper Freeport coal, and at the second, they saw the paleosol that had developed on the Mississippian Mauch Chunk Formation at the contact with the overlying Pennsylvanian Pottsville Formation. At the Johnstown National Flood Memorial, the effects of alterations to the dam on its collapse were discussed, and then a lunch stop was held in the town of St. Michael, which, before the flood, was beneath the water of Lake Conemaugh. After lunch, the geologists looked at the delta plain sedimentary sequence of peat swamps, lakes, and crevasse splays of the Pennsylvanian Allegheny Formation (Figure 3). At the last stop, the unresolved origin (marine or aeolian) of the large scale crossbeds of the Loyalhanna Formation was debated (Figure 4).

Seven preconference trips added greatly to the Field Conference experience. Trips included visits to acid mine drainage treatment plants, a miner's museum, the Homer City power plant, an old iron furnace, a cave, a canal and the Conemaugh Dam, a hike near the Conemaugh Gap, and a tour of Johnstown. Many thanks to the preconference trip leaders, to all the stop leaders and speakers, and to the contributors to the guidebook. The guidebook and road log for this year's and all previous conferences may be downloaded at http://fcopg.org. See you next year in State College!

—Stephen G. Shank

Figure 3. Co-leader Bill Bragonier talking about the Allegheny Formation and the Upper Kittanning coal. Photograph by Michael E. Moore.

Figure 4. A Field Conference participant looking at the exceptional large-scale crossbeds in the Loyalhanna Formation. Photograph by Michael E. Moore.

GEOFACT

The Peculiar Habits (and Observations) of Geologists

Stuart O. Reese
Pennsylvania Geological Survey

Geofact 45. Geologists find abandoned prototypes of Flintstone-mobiles from the Late Pleistocene during low water at most major rivers in Pennsylvania. This one was discovered in the Susquehanna River at Conewago Falls, Lancaster County, on September 16, 2016, when the stream gage height at Harrisburg was 3.03 feet.

RECENT PUBLICATIONS

Open-File Miscellaneous Investigation **(September 2016)**

- Water depth of Little Pine Lake—Little Pine State Park, Lycoming County, Pennsylvania

Open-File Miscellaneous Investigation **(November 2016)**

- Water depth of Poe Lake—Poe Valley State Park, Centre County, Pennsylvania

Calling All Authors

Articles pertaining to the geology of Pennsylvania are enthusiastically invited. The following information concerning the content and submission of articles has been abstracted from "Guidelines for Authors," which can been seen in full on our website at www.dcnr.state.pa.us/topogeo/publications/pageolonline/pageoolguide/index.htm.

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Feature Articles: All feature articles should be timely, lively, interesting, and well illustrated. The length of a feature article is ideally 5 to 7 pages, including illustrations. Line drawings should be submitted as CorelDraw (v. 9 or above) or Adobe Illustrator (v. 8 or above) files.

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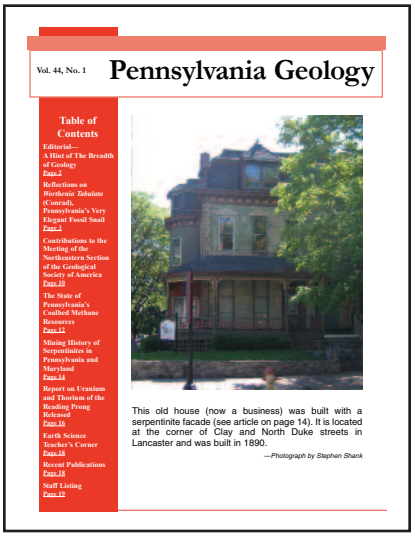
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This old house (now a business) was built with a serpentinite facade (see article on page 14). It is located at the corner of Clay and North Duke streets in Lancaster and was built in 1890.

—Photograph by Stephen Shank

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