Mill Springs Limestone Submember (New) of the Point Peak Member, Wilberns Formation, Moore Hollow Group, Texas

By Brian B. Hunt, André W. Droxler, Daniel J. Lehrmann, and Pankaj Khanna

Chapter C of

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Contents

Figures

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as $°F = (1.8 \times °C) + 32$.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as $°C = (°F - 32) / 1.8$.

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Abbreviations

USGS U.S. Geological Survey

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Chapter C

Mill Springs Limestone Submember (New) of the Point Peak Member, Wilberns Formation, Moore Hollow Group, Texas

By Brian B. Hunt,[1] André W. Droxler,[2] Daniel J. Lehrmann,[3] and Pankaj Khanna[4]

Abstract

This study proposes a new mappable unit, the Mill Springs Limestone Submember, within the Upper Cambrian Point Peak Member of the Wilberns Formation of the Moore Hollow Group in the Llano Uplift, central Texas. The submember is characterized by thick microbial boundstones that distinguish it from the thinly bedded heterolithic mixed clastic and carbonate strata of the Point Peak Member. The submember contains discontinuous individual bioherms up to 4.5 meters (m) thick, and cluster up to 15 m thick. The Mill Springs Limestone generally occurs in the upper and middle portions of the Point Peak, from west to east in the study area, and when present is mappable at the quadrangle (1:24,000) scale. In the western part of the study area the Peak Member contains facies that reflect a shift from tidal-flat deposition in the lower part of the Point Peak, to more open, outer-shelf conditions in the upper part of the Point Peak and development of thick bioherms characteristic of the Mill Springs Limestone Submember. The new designation aids geologic mapping and future paleoenvironmental studies.

Introduction

We propose a new mappable unit, the Mill Springs Limestone Submember, within the Upper Cambrian Point Peak Member of the Wilberns Formation of the Moore Hollow Group in the Llano Uplift, central Texas. The Point Peak Member is a heterolithic mixed siliciclastic-carbonate unit about 45 meters (m) thick on average. The new submember is comprised of discontinuous individual and clustered microbial boundstones (bioherms) that generally occur in the upper and middle to lower portions of the Point Peak, from west to east in the study area, respectively (refer to fig. 1 of Khanna and others [2019]). Thin stratiform boundstones (biostromes) are found discontinuously in the lower portion of the Point Peak Member but are not considered part of the submember. These bioherms in the Point Peak and associated rocks, recognized informally since Comstock (1889), have been the focus of numerous stratigraphic studies (Deen, 1923; Ahr, 1967, 1971; Barnes and Bell, 1977; Hopson, 2018; Khanna, 2017; Khanna and others, 2019, 2020; Lehrmann and others, 2020; Lee and Riding, 2022) and appear in a number of fieldtrip guide books (for example, Ruppel and Kerans, 1987; Droxler, 2021).

It is important to designate the Mill Springs Limestone as a submember because of distinctive, readily recognizable attributes mappable at a regional scale that collectively comprise a unique lower Paleozoic stratigraphic interval of abiding interest. Formal recognition of such a submember would aid current and future geologic mapping (STATEMAP program) of the Point Peak Member (for example, Hunt and others, 2022a, b; Hunt, 2023a, b), and with mapped aerial extents, it can allow for regional paleoenvironmental studies.

Setting

The Point Peak Member of the Wilberns Formation crops out within the Llano Uplift in central Texas. The Llano Uplift is an erosionally breached structural dome that forms a topographic depression because of the low weathering of relatively less resistant Mesoproterozoic (circa [ca.] 1.3 to 1.0 Ga) igneous and metamorphic basement rock exposed in its core (Mosher, 1998). The basement rocks are in turn overlain by the relatively more resistant Paleozoic and Mesozoic sedimentary strata (fig. 1; Barnes, 1981).

In the Llano Uplift area, Upper Cambrian to Lower Ordovician sedimentary rocks are divided, respectively, into the Moore Hollow and Ellenberger Groups (Cloud and Barnes, 1948; Barnes and Bell, 1977). The Cambrian–Ordovician boundary is in the uppermost part of the Moore Hollow Group (Barnes and Bell, 1977; Miller and others, 2012). The Upper Cambrian Moore Hollow Group is generally divided into the predominantly siliciclastic Riley Formation (about 260 m thick) and the overlying predominantly carbonate Wilberns Formation. The Wilberns Formation, approximately 190 m thick, is further subdivided into the Welge Sandstone, Morgan Creek Limestone, Point Peak (subject of this paper), and San Saba Members. The Point Peak Member is approximately 45 m thick on average and locally up to 65 m thick (Barnes and Bell, 1977).

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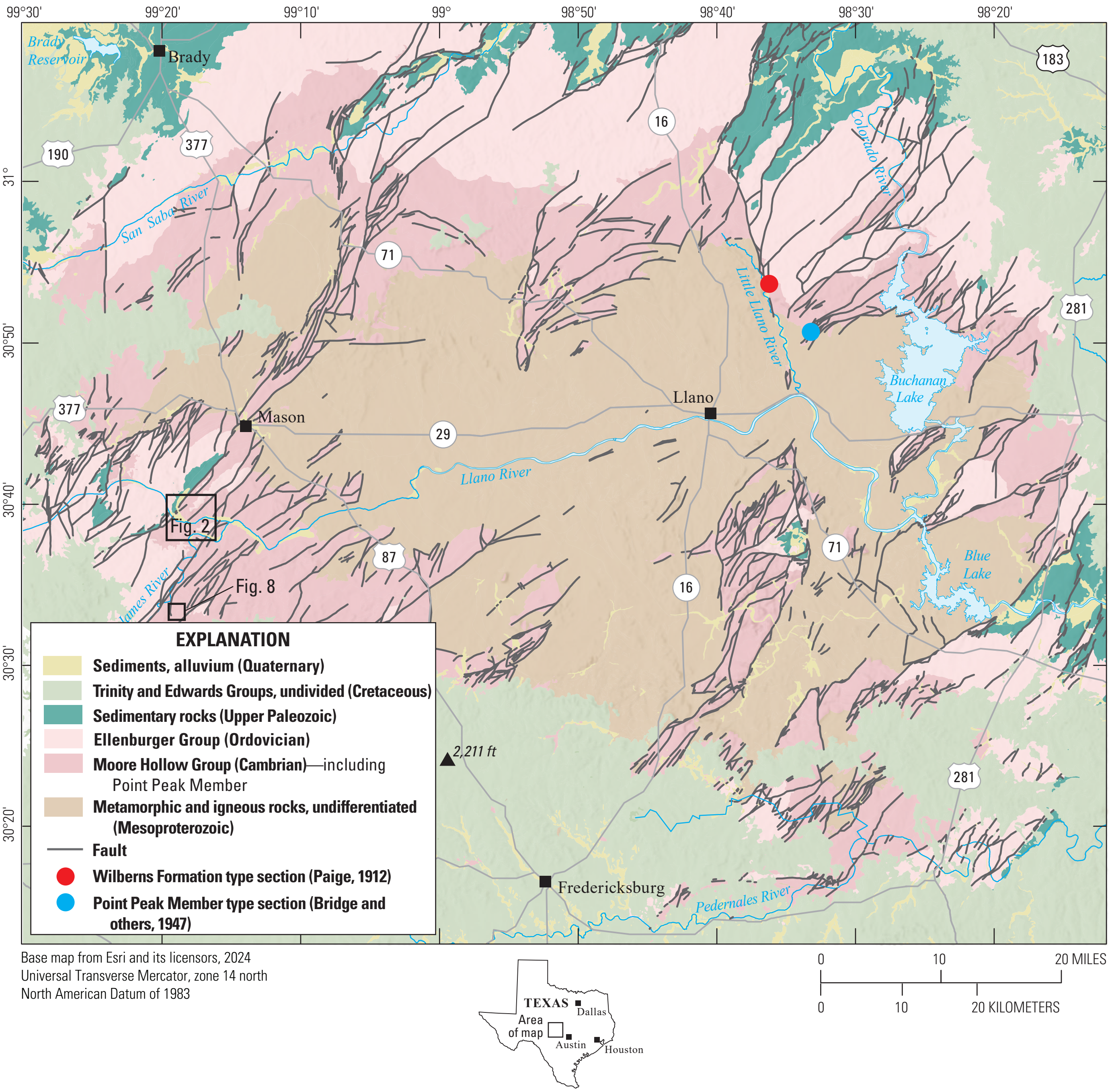

Figure 1. Regional geologic map of the Llano Uplift, central Texas. The core of the uplift is composed of Mesoproterozoic metamorphic and igneous rocks that are rimmed by Paleozoic rocks within a window through the Cretaceous cover. Geology is from Stoeser and others (2005).

Historical Background

The Wilberns Formation was named by Paige (1912) for exposures in Wilberns Glen, on Little Llano River, in Llano County (fig. 1). In the upper part of the unit, Paige (1912) describes tidal-flat facies containing “sun-cracked surfaces” and “peculiar boulder-like forms of lime muds”—likely unrecognized microbial bioherms or stromatolites. Barnes and Bell (1977) formally defined the Moore Hollow Group, containing the Riley and the overlying Wilberns Formations, each with several members. The Point Peak Member of the Wilberns Formation was originally named by Bridge and others

(1947) for a location at a hill about 6.5 kilometers (km; 4 miles [mi]) northeast of Lone Grove, Llano County, Texas. The hill is in the U.S. Geological Survey (USGS) Lone Grove 7.5-minute quadrangle (lat 30.850273° N., long 98.552746° W.). The type section, about 80 m thick, is on the south slope of the hill. Bridge and others (1947) describe a bioherm zone within the Point Peak Member:

> "The Point Peak shale member consists of well-bedded, soft, greenish, calcareous shales with subordinate amounts of fine-grained, compact dolomite; medium- to fine-grained glauconitic limestone; intraformational conglomerates; and, near the top, occasional beds of oolitic limestone and commonly extensive to scattered stromatolitic bioherms that locally coalesce to form biostromes."

Numerous mapping-focused master's theses in the western Llano Uplift area describe and map an informal bioherm subunit within the Point Peak, including Alexander (1952); Polk (1952); Duvall (1953); Fritz (1954); Grote (1954); Sliger (1957); Miller (1957); Dannemiller (1957); Fuller (1957); Bryant (1959); Harwood (1959); Pool (1960); and Becker (1985). Spincer (1997) also describes the bioherm units in detail in his doctoral dissertation.

It is worth noting that a variety of terms and descriptions have been applied to this type of unit, including stromatolites, stromatolitic bioherms, buildups, mounds, and algal reefs to name a few (Bridge and others, 1947; Ahr, 1971; Barnes and Bell, 1977; Ruppel and Kerans, 1987). Modern stratigraphic studies describe the primary lithology as microbialite boundstones (Lehrmann and others, 2020). Boundstone is an autochthonous, carbonate-dominated rock in which there is evidence that the original components were organically bound at the time of deposition and showed some relief (Dunham, 1962; Lokier and Al Junaibi, 2016). Microbialites are in-place lithified organo-sedimentary deposits that form as a result of benthic microbes trapping and binding sediment, which forms a locus for mineral precipitation (Riding, 2011). Microbialites may form structures with well-laminated lithified sedimentary growth features called stromatolites, or more massive, nonlayered, and clotted accretionary features called thrombolites. These rocks can have a variety of structures and geometries that include domal, columnar, stratiform, and so on (Riding, 2011; Lee and Riding, 2022). Fossil remains of such microbialites preserve a continuum of morphologies, from clusters described as bioherms to more stratiform deposits called biostromes (Laborel, 2011).

Derivation of Name

The name of the Mill Springs Limestone Submember is derived from a spring proximal to the proposed type section. Mill Springs is within the Geographic Names Information System (GNIS; feature ID 1998452, https://www.usgs.gov/tools/geographic-names-information-system-gnis) and is located within the Llano River channel (lat 30.6585148° N., long 99.325334° W.). Both the springs and the type section occur within the USGS Turtle Creek 7.5-minute quadrangle of Mason County, Texas.

Designation of Mill Springs Submember Type Section

The type section for the proposed Mill Springs Limestone Submember is a cliff along the south side of the Llano River, about 0.8 km (0.5 mi) downstream from the bridge of Farm to Market Road 1871 and Mill Springs. The cliff location is bordered on the east by the mouth of Mill Creek and occurs directly across from the mouth of Honey Creek, both of which are tributaries of the Llano River (fig. 2). The cliff base is located at lat 30.648387° N., long 99.312440° W. (using North American Datum of 1983), within the USGS Turtle Creek 7.5-minute quadrangle, Mason County, central Texas.

The cliff is referred to as "Shepard cliff" in a recent publication (Khanna and others, 2019; fig. 2) after its location within the Shepard ranch. At this location, clusters of bioherms up to approximately 15 m thick are well-exposed and publicly accessible along the Llano River, with large (25 m in diameter) boulders of bioherm rock fall in the river (Droxler, 2021). Additional exposures we refer to as reference sections occur in the immediate area and include: a composite measured section from exposures along Mill Creek, along the Llano River at Zesch cliff , and exposures along the James River (figs. 2, 3). In addition, a series of isolated bioherms is accessible along Mill Creek, (that is, the DroxRock and Fallen Blocks outcrops of Khanna and others [2019, 2020]). Note that these additional reference section locations are on private property and permission from owners must be obtained as a condition of access.

Lithologic Description and Distinguishing Features

The Mill Springs Limestone Submember commonly occurs within the upper and middle to lower portions of the Point Peak Member, from west to east in the study area, which is otherwise composed of thin bedded, heterolithic mixed clastic and carbonate strata (fig. 3). A description of the Point Peak Member is provided below, followed by a description of the Mill Springs Limestone Submember. These descriptions emphasize field identification and mapping characteristics. Further detailed descriptions can be found in Khanna and others (2019, 2020), and Lehrmann and others (2020).

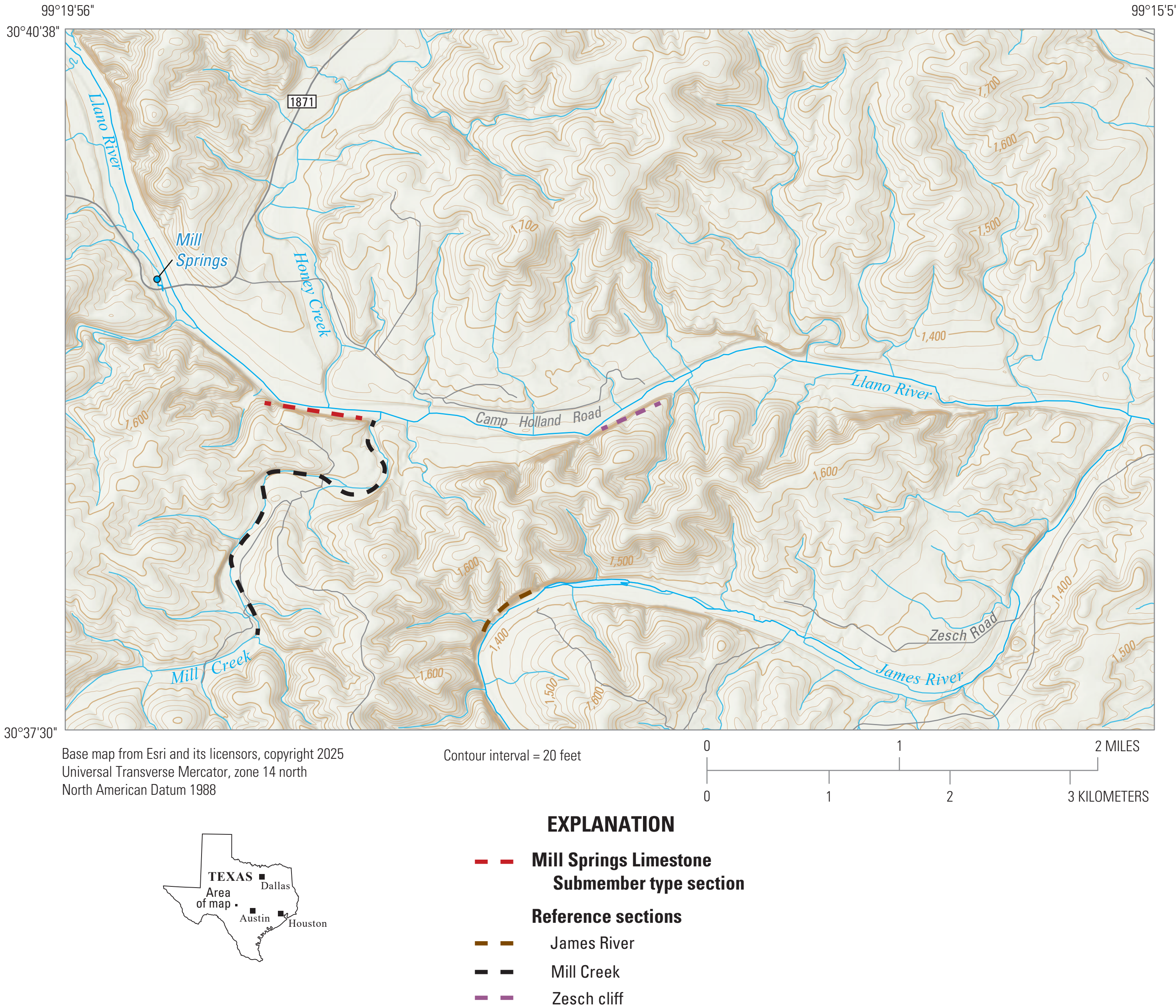

Figure 2. Map showing the topography and the locations of the reference sections and type section of the Mill Springs Limestone Submember, Mason County, Texas. The area of this map is shown in figure 1 and can be placed within the U.S. Geological Survey Turtle Creek 7.5-minute quadrangle Mason County, Texas. Shepard cliff and Zesch cliff can be viewed from the Llano River, a publicly accessible waterway (from the bridge on Farm to Market Road 1871, also known as White's Crossing). However, the Mill Creek and James River reference sections are on private property and permission to access is required.

Point Peak Member

The Point Peak Member is a yellow to green-gray, thinly bedded, and heterolithic mixed clastic and carbonate unit composed of intercalated fine-grained sandstone, siltstone, grainstone, and packstone (fig. 4). Beds of varicolored intraformational conglomerate with tabular, flat clasts of rounded silty limestone are common. Glauconite is abundant throughout the member. The lower portion of the Point Peak generally contains more silt and shale than the upper portion, and easily erodes to underlie flat hilltops or valleys. The silty lower portion commonly weathers into a light-colored soil with flaggy siltstone clasts, locally suitable for agricultural use. Locally, beds contain ripples, cross-beds, burrows, and other trace fossils (for example, *Cruziana*). Discontinuous thin (less than 0.5 m) stratiform stromatolites (biostromes) commonly occur locally within the

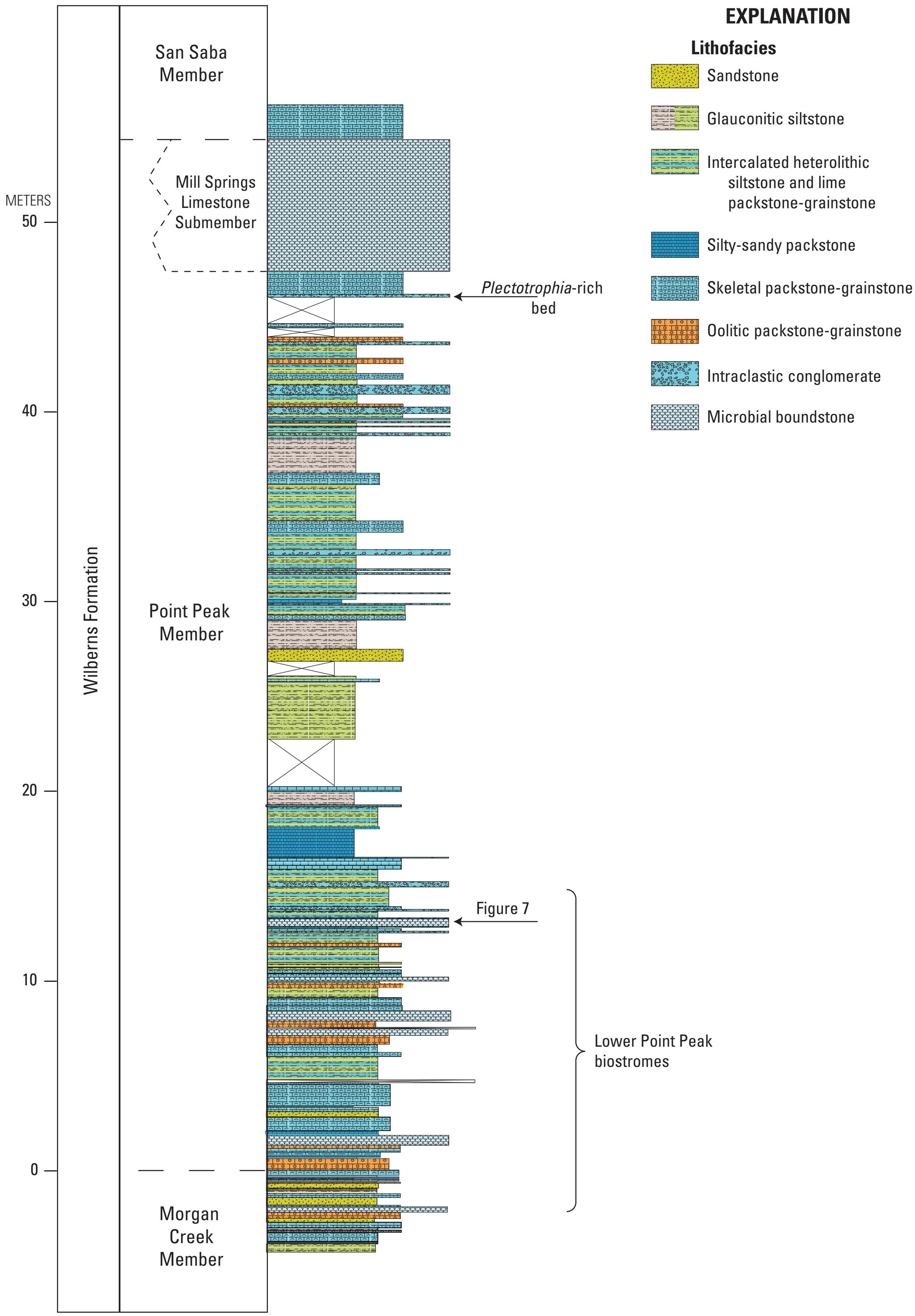

Figure 3. Figure showing composite measured section along Mill Creek, Texas. The large microbial bioherms in the upper part of the section consists of the Mill Springs Limestone Submember. Note that while other thin microbial boundstones (biostromes) are present in the lower portion of the section, they were not considered mappable at the scale of 1:24,000 of Hunt and others (2022b). Refer to figure 2 for location along Mill Creek. Modified from Lehrmann and others (2020).

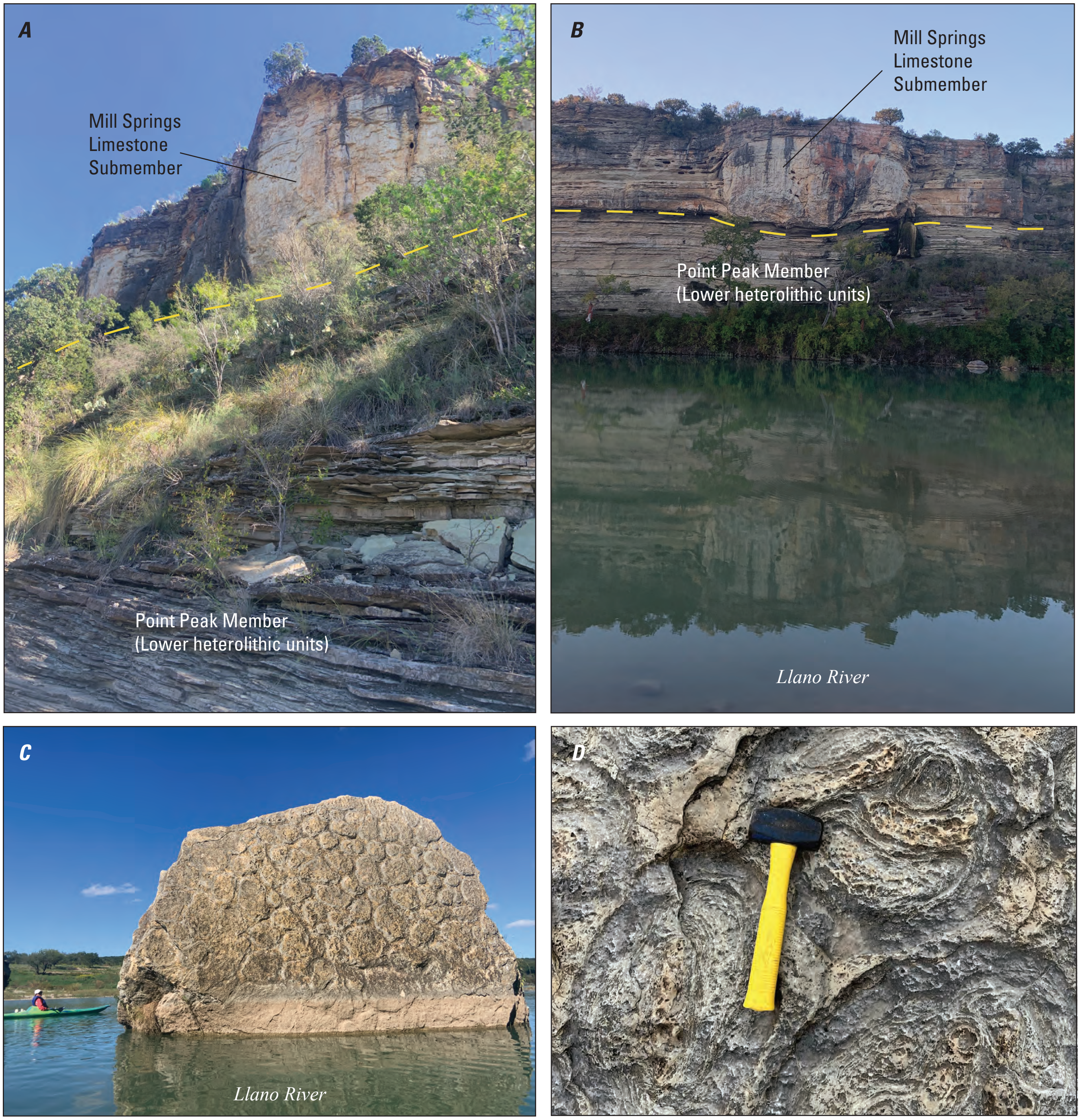

Figure 4. Photographs showing examples of outcrops with the Mill Springs Limestone Submember of the Point Peak Member. All locations shown on figure 2. *A*, Photograph showing the Zesch cliff reference section, as viewed from the Llano River, that exposes much of the Point Peak Member section, including the lower siliciclastic unit overlain by the Mill Springs Limestone Submember. Yellow dashed line approximates the base of the Mill Springs Limestone Submember. *B*, Photograph of the type section of the Mill Springs Limestone Submember at Shepard cliff, looking south as viewed from the Llano River. Yellow dashed line approximates the base of the Mill Springs Limestone Submember. *C*, Large rockfall from a bioherm in the Llano River, from the Mill Springs Limestone Submember just below Shepard cliff. *D*, Plan view of the top of an exposed bioherm along the James River. All photographs by Brian Hunt, The University of Texas at Austin, Bureau of Economic Geology.

lower portion. Distinct index fossils include the *Plectotrophia* Biozone, which corresponds to a brachiopod-rich bed found near the top of the member, just beneath the upper thick bioherm clusters in the western Llano Uplift area, and above the bioherms in the eastern Llano Uplift area (Barnes and Bell, 1977; Khanna and others, 2019; Lehrmann and others, 2020).

The contact with the underlying Morgan Creek Limestone Member is gradational, defined as the top of the uppermost, laterally continuous, glauconitic calcarenite (fig. 3; Becker, 1985). Gann (2000) defined the contact as the base of a siltstone or base of the first intraformational conglomerate, but noted the contact is arbitrary when those units are absent. For mapping purposes, the contact is mapped at a break in slope associated with the transition from the bench-forming character of the resistant Morgan Creek to the erodible lower part of the Point Peak Member.

Mill Springs Limestone Submember (New)

The Mill Springs Limestone Submember forms discontinuous clusters of bioherms with stromatolitic and thrombolitic textures, and intervening grainstones. The largest bioherms occur in the upper and middle to lower portions of the Point Peak Member from west to east in the study area (figs. 4–6; refer to fig. 1 in Khanna and others [2019]) (Barnes and Bell, 1977; Lehrmann and others, 2020; Lee and Riding, 2022). Bioherms are fine-grained, light gray to white to darker gray micritic carbonate clusters. Clusters often contain multiple phases of growth, defined by a white limestone outer structure (a meter-thick “rind”) up to 10 m in diameter (plan view) and an interior of darker gray to orange-gray internal dolomitic mudstone with numerous oval to circular textures up to 0.6 m in diameter (Khanna and others, 2020). In profile, individual bioherms have up to 4.5 m of vertical relief but can locally produce thicknesses up to 30 m when clustered (fig. 4; Barnes and Bell, 1977; Khanna and others, 2019, 2020). Thin-bedded heterolithic units of calcarenites and carbonate siltstones occur between and drape over bioherms, dipping toward or away in multiple directions. The bioherm interval is generally less glauconitic compared to the lower portion of the Point Peak Member.

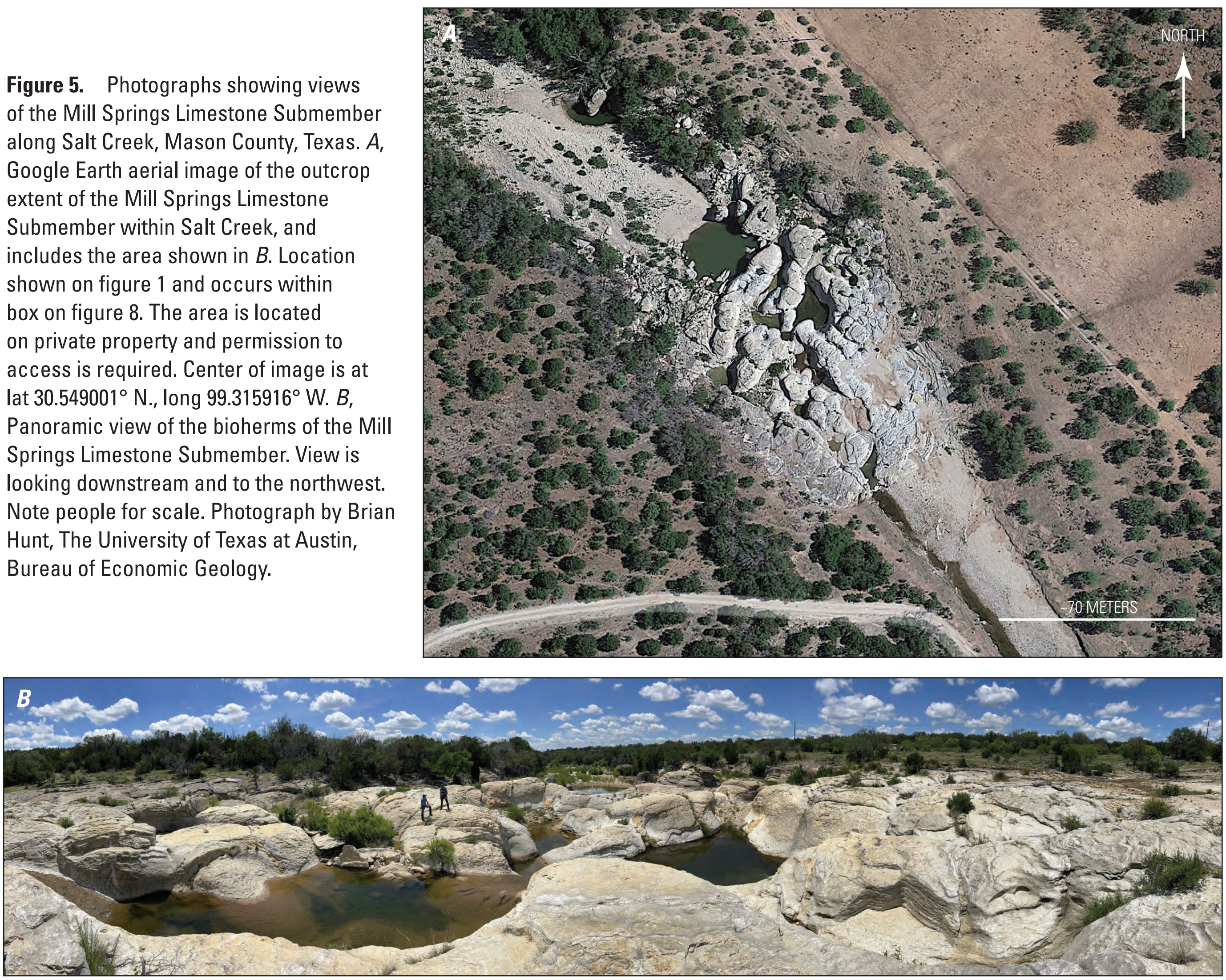

Figure 5. Photographs showing views of the Mill Springs Limestone Submember along Salt Creek, Mason County, Texas. *A*, Google Earth aerial image of the outcrop extent of the Mill Springs Limestone Submember within Salt Creek, and includes the area shown in *B*. Location shown on figure 1 and occurs within box on figure 8. The area is located on private property and permission to access is required. Center of image is at lat 30.549001° N., long 99.315916° W. *B*, Panoramic view of the bioherms of the Mill Springs Limestone Submember. View is looking downstream and to the northwest. Note people for scale. Photograph by Brian Hunt, The University of Texas at Austin, Bureau of Economic Geology.

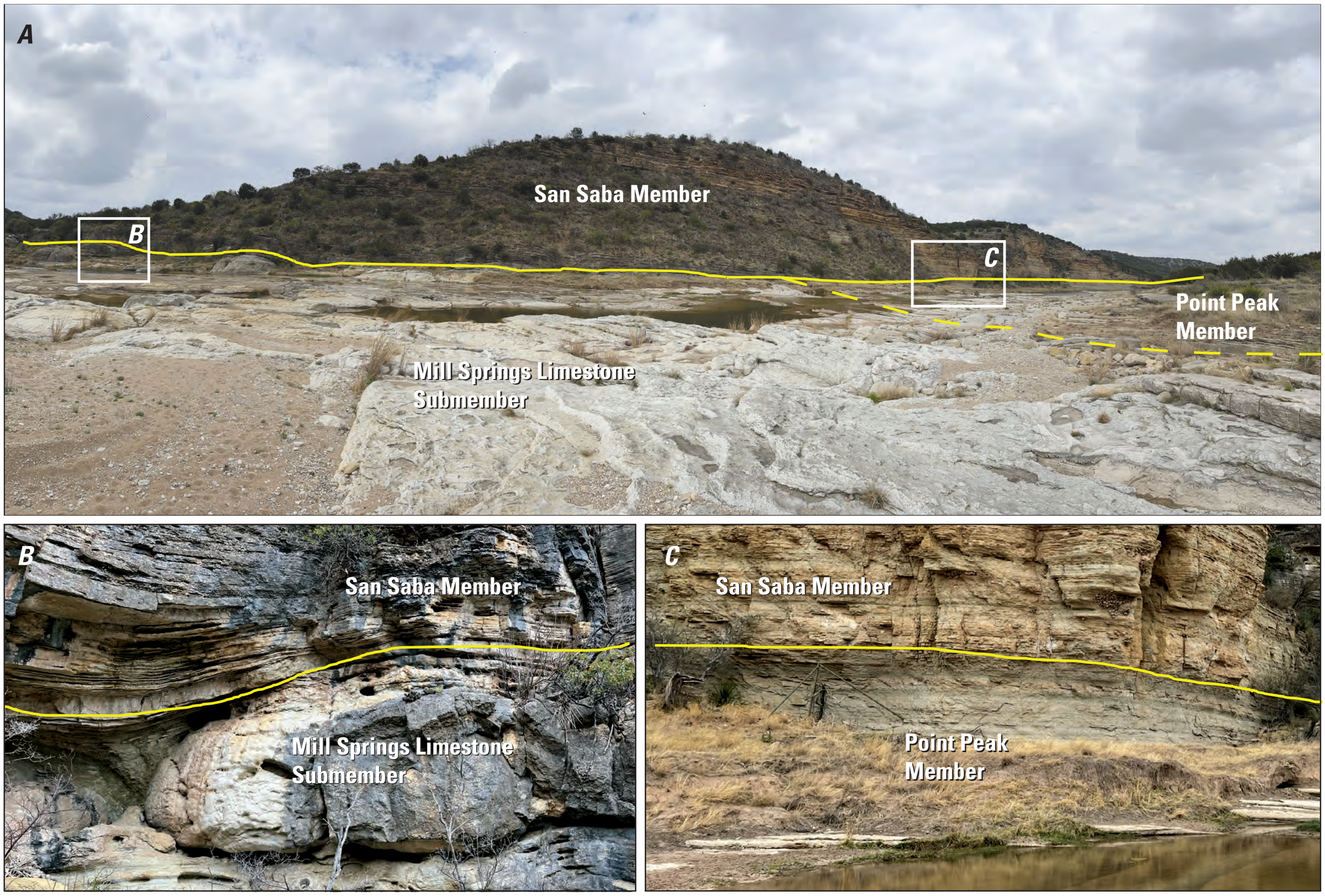

Figure 6. Photographs showing the upper contact of the Point Peak Member with the San Saba Member. *A*, A panoramic view to the northwest, at a location of lat 30.633599° N., long 99.298791° W. Refer to figure 2 for the location of the James River reference section. *B*, The upper contact where the Mill Springs Limestone Submember is present. *C*, The upper contact where the Mill Springs is absent. All photographs by Brian Hunt, The University of Texas at Austin, Bureau of Economic Geology.

Boundaries

Mappable boundaries of the bioherm submember are well-defined and sharp. The bioherm submember, though not continuous, is more resistant than both the underlying part of the Point Peak Member and overlying San Saba Member, commonly producing topographic breaks suitable for geologic mapping (fig. 8).

The top of the Point Peak Member is transitional into the San Saba Member when bioherms are not present, and is mapped at the first thin-bedded, glauconitic, calcarenite beds above the bioherms (fig. 6; Becker, 1985). When bioherms are present, the contact with the overlying San Saba Member is generally considered to be thin-bedded units above the buildups. Bioherms may be ridge-forming and can have a distinctive, irregular pattern or texture on lidar digital terrane models and aerial photographs (fig. 5; Khanna and others, 2019, 2020). The base of the submember is defined by the sharp boundary between thin-bedded, recessive, green-gray, mixed clastic and carbonate beds that contain glauconite of the Point Peak Member and the overlying massive, light-colored, microbialite bioherm nearly devoid of siliciclastics of the Mill Springs Limestone Submember.

Geographic Extent and Thickness

The Mill Springs Limestone Submember has its surficial geographic extent within the Llano Uplift and is generally coextensive with the Upper Cambrian Point Peak Member (fig. 1). The distinctive bioherms are discontinuous, commonly occur as clusters, and are mappable. The subsurface extent and thickness of the Mill Springs Limestone Submember is unknown. Barnes and Bell (1977) mapped the subsurface extent of the Point Peak Member and is shown to have a generally circular extent of about 160 km (approximately 100 mi) diameter centered on the Llano

Figure 7. Photographs showing mixed clastic and carbonate rocks of the lower Point Peak Member along Mill Creek, Mason County, Texas. *A*, Thinly bedded siliciclastic and carbonate sediments that make up the lower portion of the Point Peak Member (location indicated on Figure 3). *B*, The bed highlighted here is a microbialite boundstone (biostrome) of the lower portion of the Point Peak Member. This occurrence is not mappable at the quadrangle (1:24,000) scale but could be mapped or referenced in measured sections (for example, fig. 3) at larger scales. All photographs by Brian Hunt, The University of Texas at Austin, Bureau of Economic Geology.

Uplift. The Point Peak Member attains a thickness up to 65 m of outcrop within the Llano Uplift, and averages 45 m overall (Khanna and others, 2019, 2020; Lehrmann and others, 2020).

When present, the proposed submember contains microbialite boundstones in a variety of forms and thicknesses (Khanna and others, 2019, 2020; Lehrmann and others, 2020; Lee and Riding, 2022). Throughout the Llano Uplift, previous works note stromatolites or bioherms are present within the Point Peak Member (refer to “Historical Background” section). Clusters of thicker microbialites (bioherms) are up to approximately 15 m thick in the western Llano Uplift area but are reported up to 30 m thick in the eastern Llano Uplift (Riley Mountains; Barnes and Bell, 1977), and traceable for several kilometers (Khanna and others, 2019, 2020; Lehrmann and others, 2020). Generally thin (up to approximately 0.5 m) microbialites (biostromes) occur in the lower portion of the Point Peak (fig. 7) and may be traceable for many kilometers. However, these biostromes are not mappable and not considered part of the submember.

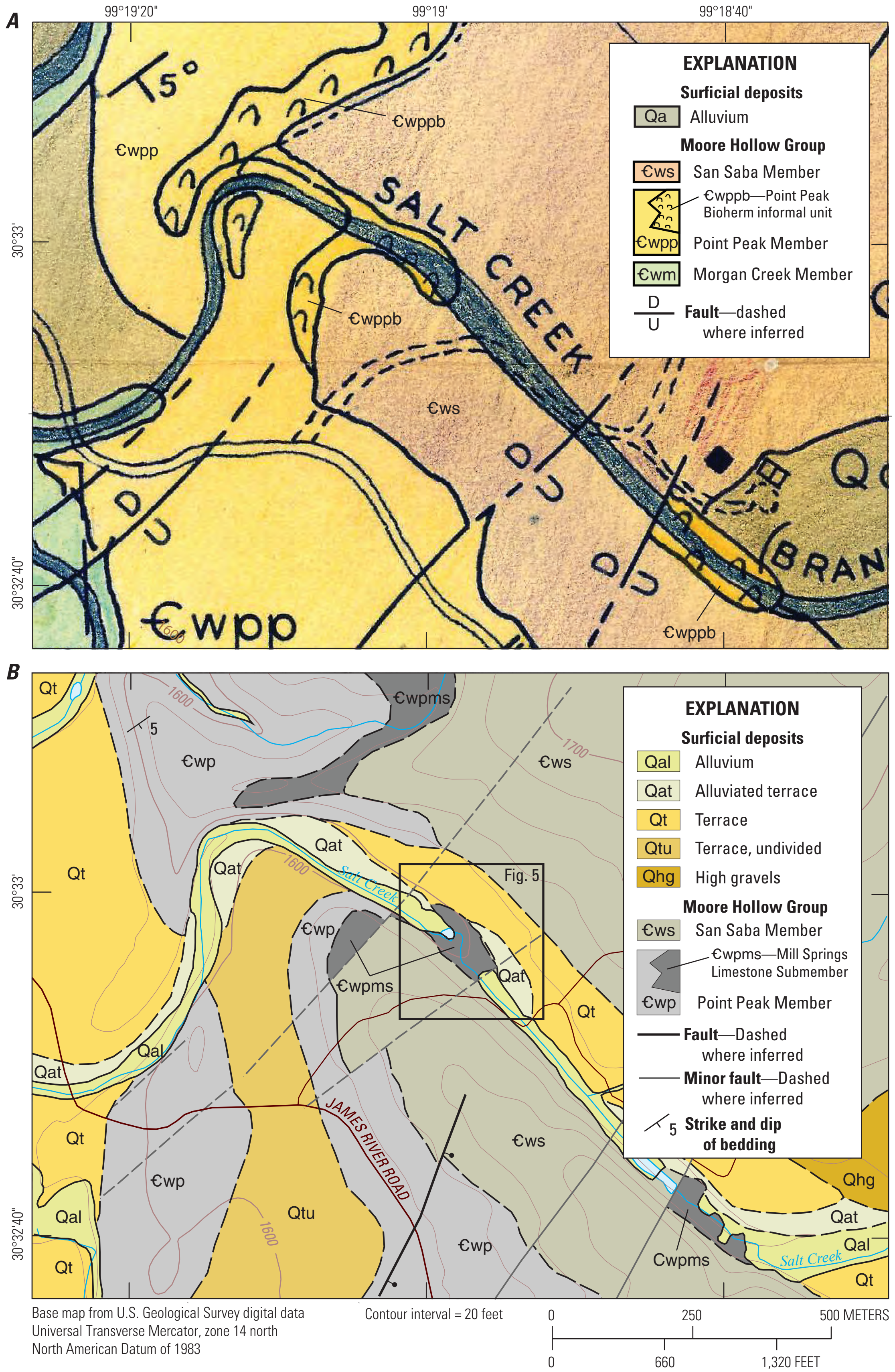

Figure 8. Maps showing a comparison of equivalent parts of the historic (Harwood, 1959) and current (modified from Hunt, 2023b) geologic maps. Location shown on figure 1. *A*, Planimetric geologic map showing the informal biostrome of the Point Peak Member (unit €wppb) of Harwood (1959). *B*, Modified geologic quadrangle map from Hunt (2023b) with same scale as the top map (1:10,000). Note that the Mill Springs Limestone Submember (new unit €wpms) is the equivalent to the informal mapped bioherm of the Point Peak Member (unit €wppb) of Harwood (1959).

Age and Correlation (Upper Cambrian)

Within central Texas, the Cambrian-Ordovician boundary (485.4 million years ago [Ma]) is located within the San Saba Member, stratigraphically above the Point Peak Member (Barnes and Bell, 1977). Ewing (2016) showed the Point Peak Member is of Jiangsanian age (middle Furongian, about 494–491 Ma), regionally correlative to the Fort Sill Limestone of the Arbuckle Group in Oklahoma.

Miller and others (2012) indicate the lower portion of the Point Peak Member ranges from the upper part of the *Idahoia* to the *Ellipsocephaloides* Biozones (trilobite), within the Ptychaspid biomere (North American Laurentia Provincial Sunwaptan Stage of the Millardan Series, [Upper Cambrian]; Geyer, 2019). Lee and Riding (2022) indicate the lower biostromes of the Point Peak Member exposed in Honey Creek (stratigraphically immediately below the Shepard cliff type section) are Late Cambrian (Jiangsanian), about 493 to 490 Ma (fig. 9).

Inferred Geologic History

The Wilberns Formation carbonates, which include the Point Peak Member, were deposited near the margin of the great American carbonate bank (Ewing, 2016), an epicontinental sea formed on a shallow and extensive shelf. That sea was created by the flooding of the continent during the Cambrian through the Ordovician, part of the Sauk transgression or Sauk megasequence (Sloss, 1963; Morgan, 2012; Ewing, 2016). The heterolithic mixed clastic and carbonate strata of the lower Point Peak Member was deposited on the low-gradient shelf within a tidal-flat system. Deposition in the upper portion of the Point Peak Member records more open-marine, outer-shelf conditions where large microbial mounds developed (Khanna and others, 2019, 2020; Lehrmann and others, 2020). Tidal flats produced the biostrome microbialites, while the upper larger bioherms reflect a deeper waters offshore environment (Khanna and others, 2019, 2020; Lehrmann and others, 2020). Thus, the upper and lower portions of the Point Peak Member record two different sea-level cycles, both proximal and distal depositional systems (Lehrmann and others, 2020).

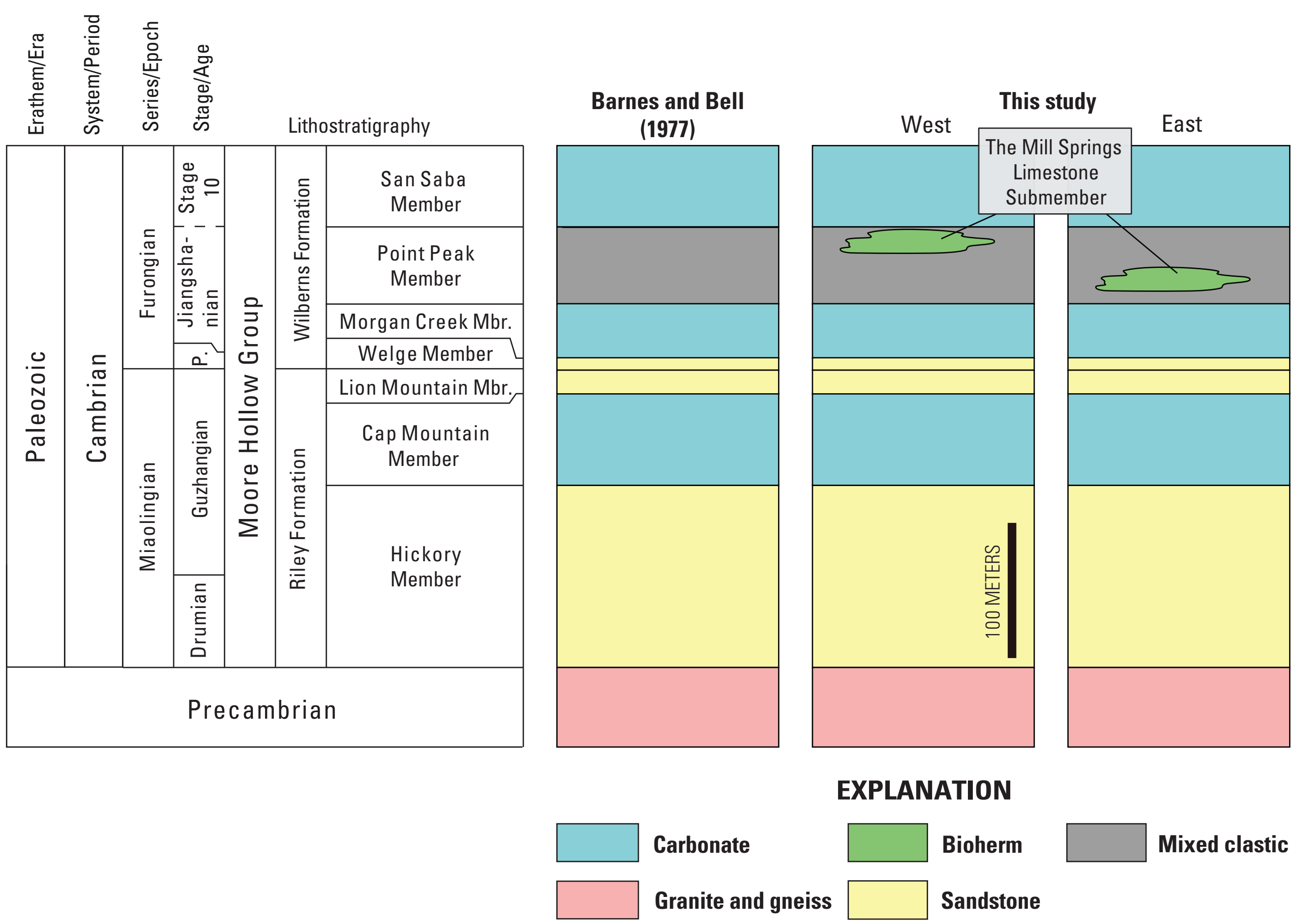

Figure 9. Figure showing chronostratigraphic correlation chart comparing the organization of Barnes and Bell (1977) to the stratigraphy as updated by the work from this study. Note that the Mill Springs Limestone Submember occurs in the upper part of the Point Peak Member on the western side of the study area, whereas it generally occurs in the middle to lower part of the Point Peak in the eastern side of the study (fig. 1 in Khanna and others [2019]). Modified from Lee and Riding (2022). P, Paibian Age; Mbr, member.

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