Geology in Michigan – Waterfalls of the Marquette, Michigan Area

By David Adler, CPG-11377

Introduction

Falling water seems to have a special allure that stirs something inside us. Waterfalls induce relaxation and a special sense of peace and tranquility. It's hard to describe, but is nonetheless especially appealing in an almost universal way. Waterfalls also happen to be great places to experience geology firsthand.

Michigan has approximately 300 waterfalls, almost all of which are located in the Upper Peninsula. The Marquette area alone has upwards of 70 or more waterfalls, many of which are within or in close proximity to the city limits. Some of the Marquette area's waterfalls are quite spectacular, others not so much. Almost without exception, each waterfall offers an opportunity to observe and examine the local bedrock geology.

This field trip guide focuses on 17 waterfalls located in and around the city of Marquette; all but two are located within or just outside the city limits (see Figure 1). Nine of the 17 waterfalls covered in this guide are located in the Dead River Gorge. Four more (Reany Falls #1 through #4) are located just a very short walk from the Dead River Gorge parking area. Pinnacle Falls and Yellow Dog Falls are both located on the Yellow Dog River approximately 30-35 miles driving distance northwest of Marquette (see Figure 2). One of the waterfalls located within the city limits is an unnamed waterfall where some of the most interesting bedrock outcrops in the Marquette area can be observed.

FIGURE 2 | AREA MAP 2

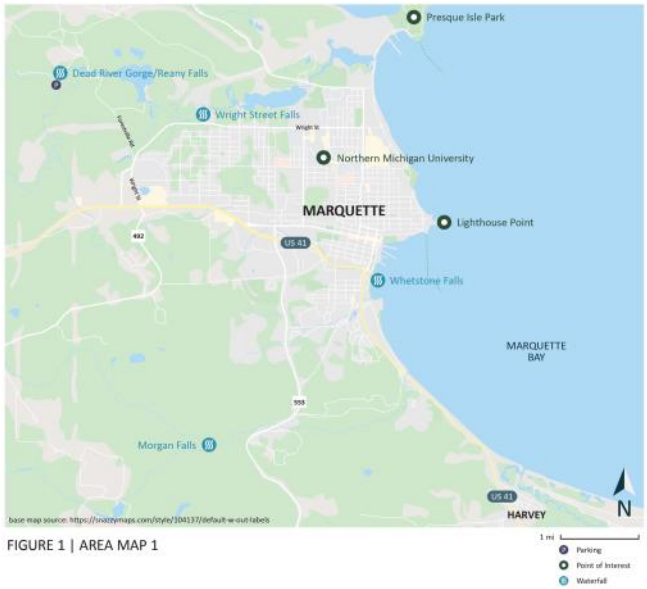

FIGURE 1 | AREA MAP 1

Each of the 17 waterfalls included in this field trip guide was visited by the author during the summer and early autumn of 2021. The waterfall names, locations, location coordinates, and directions are for the most part based on those used by Stagg (2017). Other waterfall names, directions, and even location coordinates may be used for these same waterfalls in the various guidebooks and available sources of information.

Geologic Setting

The geology of the Marquette area and surrounding region is complex to say the least. Bedrock formations in and around Marquette range in age from Archean/Lower Precambrian rocks on the order of 2-3 billion years old (e.g., the Mona Schist and Compeau Creek Gneiss) to the Jacobsville Sandstone whose age is described in the published literature as Cambrian by Door and Eschmann (1970), Middle Proterozoic by Sims (1991), questionable

Late-Proterozoic to Lower and Middle Cambrian by Regis and Anderton (1999), Early and Middle Cambrian by Hamblin (1958), Middle Proterozoic by Cannon and Nicholson (1996 and 2001), and as Upper Precambrian/ Upper Keweenawan by Bornhorst, Rose, and Paces (1983). The geologic and tectonic history, stratigraphy, bedrock structures, age relationships, and stratigraphic nomenclature of the region remain subjects of ongoing research and debate.

The Marquette area is located in the southern portion of the Superior Province of the Canadian Shield. To demonstrate the complexity of the regional geology, the Lake Superior segment of the Canadian Shield has been described by Sims (1996a) as: "…a collage consisting mainly of Archean cratonic elements (3.6-2.5 Ga), assigned to the Superior province, a flanking Early Proterozoic (~2.1-1.84 Ga) orogenic belt (Penokean orogen), and a Middle Proterozoic (~1.1 Ga) intracratonic rift assemblage (Midcontinent rift system) that transects older Archean and Proterozoic rocks. In addition, intracratonic igneous and sedimentary rocks in the approximate age range 1.82-1.63 Ga overlap older rocks on the south, and anorogenic intrusions (~1.47 Ga) intrude older rocks in central Wisconsin. The rocks represent several major crust forming events, reactivation of Archean basement rocks locally within the Penokean orogen, the erosion and deposition of epicratonic successions, and the local intrusion of anorogenic magmas." It doesn't get much less complex as one works through the public domain literature.

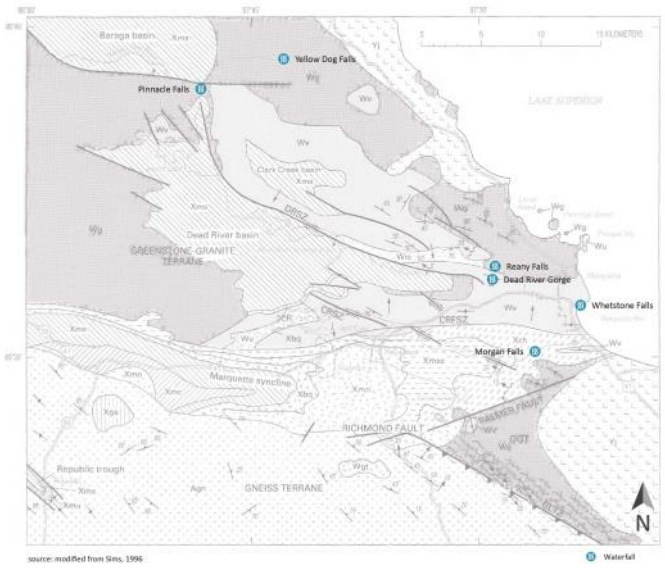

FIGURE 3a | REGIONAL GEOLOGIC / TECTONIC SETTING

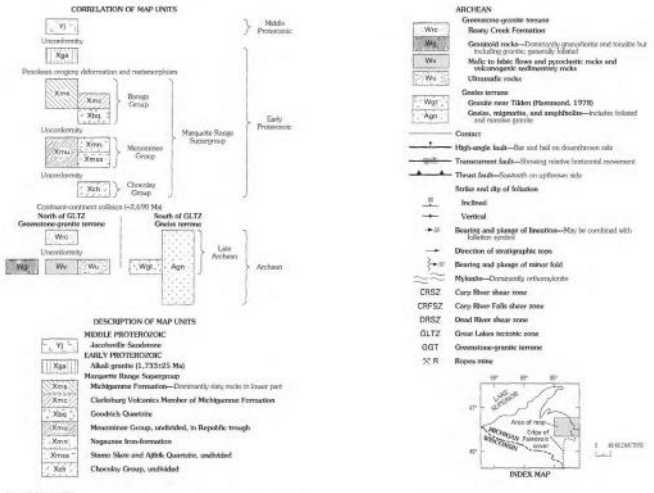

FIGURE 3b | LEGEND FOR FIGURE 3a

Two of the better depictions of the Marquette area's regional geologic setting have been developed by Sims (1996b) and by Puffett (1974). See Figures 3a/3b and Figure 4, respectively. Although not altogether different, these two models of the regional geology demonstrate the ongoing evolution of our understanding of the complex geology in and around Marquette. For simplicity's sake, the description of the regional geology by Puffett, using bedrock formation names that are most familiar, is summarized below. Figure 5 gives the stratigraphic nomenclature and general age relationships.

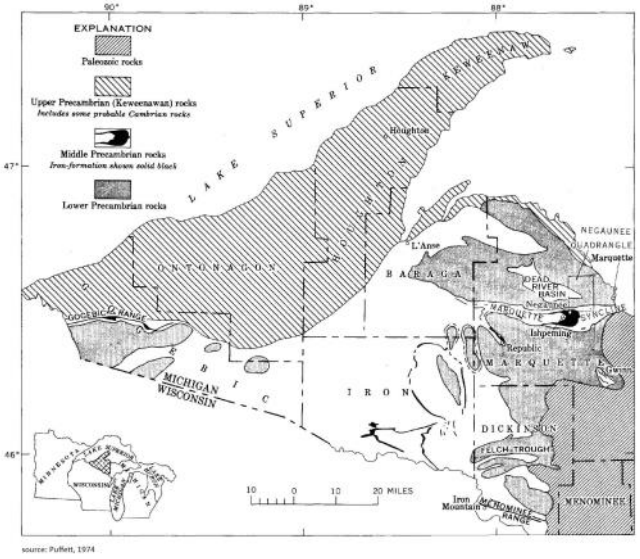

FIGURE 4 | REGIONAL GEOLOGIC SETTING

Marquette is located at the east end of the east-west trending Marquette Syncline, an assemblage of downfolded Middle Precambrian sedimentary and metasedimentary rocks of the Marquette Range Supergroup. The Marquette Syncline is bordered on the north and south by older uplifted Lower Precambrian (Archean) mafic to intermediate metavolcanic rocks (Kitchi Schist and Mona Schist) and younger Archean granitic rocks (Compeau Creek Gneiss and Dead River Pluton).

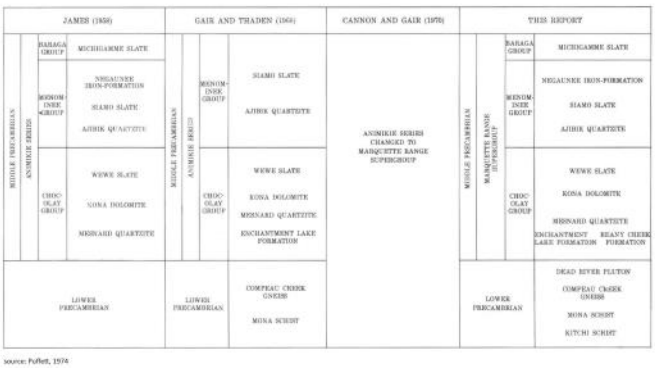

FIGURE 5 | STRATIGRAPHIC NOMENCLATURE

The Kitchi Schist is a foliated greenstone containing pebbles and boulders of pyroclastic rock. It is described by Puffett (1974) as mainly pyroclastic rock ranging from coarse agglomerate with accessory lapilli tuff to relatively fine-grained crystal tuff and crystal-lithic tuff. In some outcrops, the Kitchi Schist resembles a conglomerate, in others a breccia. It can also have a porphyritic appearance.

The Mona Schist consists primarily of greenstone and mafic and felsic schist, with the mafic schist being of basaltic to andesitic origin. The Mona Schist has been subdivided into several members by various researchers. Puffett's 1974 subdivision of the Mona Schist includes the Lower Member, the Nealy Creek Member, the Sheared Rhyolite Tuff Member, and the Lighthouse Point Member. The Lighthouse Point Member includes a felsic augen zone and undifferentiated greenstone.

Outcrops of the Mona Schist located within the Marquette city limits at Lighthouse Point and near the mouth of Whetstone Brook consist of foliated amphibolite schist (metabasalt) and chlorite-sericite schist of the Lighthouse Point Member. The layering observed in the schist at Lighthouse Point strikes generally E-W and dips approximately 70 degrees to the north and is interpreted to be metamorphosed highly flattened basalt pillows (Johnson and Bornhorst, 1999). The pillow structures are vividly evident in the outcrops near Whetstone Falls, as discussed below.

The Dead River Pluton has been described by Puffett (1974) as a non-foliated, generally porphyritic composite body of syenite, diorite, and granodiorite of uncertain age. The Dead River Pluton consists primarily of granodiorite porphyry with lesser amounts of hornblende diorite and coarsely porphyritic syenite. The Compeau Creek Gneiss was named by Gair and Thaden (1968) and includes primarily light colored foliated tonalitic and granodioritic rock with lesser amounts of chloritic, biotoitic, monzonitic/quartz monzonitic, and hornblendic varieties (Puffett, 1974). The Compeau Creek Gneiss is exposed at the Reany Creek waterfalls described herein (Reany Falls #1 - #4) and at Pinnacle Falls and Yellow Dog Falls on the Yellow Dog River.

The Middle Precambrian Marquette Range Supergroup includes, in ascending order:

- The Chocolay Group consisting of the Enchantment Lake and Reany Creek Formations, the Mesnard Quartzite, the Kona Dolomite, and the Wewe Slate that is exposed at Morgan Falls near the Marquette Mountain ski area.
- The Menominee Group consisting of the Ajibik Quartzite, the Siamo Slate, and the Negaunee Iron Formation.
- The Baraga Group consisting of the Michigamme Formation (primarily black slate and greywacke), the Goodrich Quartzite, the Greenwood Iron Formation, the Clarksburg Volcanics, and the Bijiki Iron Formation (Bornhorst, 1999).

The Kona Dolomite includes crystalline dolomite, some of which is cherty; argillite and argillaceous dolomite; quartzite interbedded with ferruginous, sericitic slate; and chert breccia. Stromatolitic algal layers are common in some exposures. The Kona Dolomite is used locally as aggregate, road and stream bank stabilization material, as riprap, and for landscaping. The pink and salmon-colored varieties of the Kona Dolomite, including the curvilinear-banded stromatolitic layers, are also used as lapidary material for cutting, slabbing, polishing, jewelry making, as bookends, and for other lapidary-related applications.

The Negaunee Iron Formation occurs to the west and southwest of Marquette and is the principal host rock for the significant iron ore deposits that have been historically mined in the Marquette Iron Range of Michigan. Iron mining is still active at the Tilden open pit mine located in Tilden Township approximately 20 miles southwest of Marquette. According to Bornhorst (1999, after Gair, 1975), the Negaunee Iron Formation consists of carbonate iron formation (iron carbonate and chert with minor magnetite), oxide iron formation (hematite or magnetite and chert), magnetite-banded iron formation (laminated magnetite and chert), hematite banded iron formation (laminated hematite and chert), silicate iron formation (iron silicate minerals and chert), and combinations of these types. The origin of the iron minerals in the Negaunee Iron Formation is a complex process of primary sedimentary depositional, diagenetic, and metamorphic processes (Bornhorst, 1999).

Reany Creek Waterfalls

There are four waterfalls on Reany Creek just upstream from its confluence with the Dead River. Stagg (2017) calls these Reany Falls #1 - #4. The GPS location coordinates are as follows:

Reany Falls #1 – N46 34.418 W87 28.600

Reany Falls #2 – N46 34.412 W87 28.615

Reany Falls #3 – N46 34.414 W87 28.645

Reany Falls #4 – N46 34.422 W87 28.660

Figure 6: Parking Area for Dead River Gorge Waterfalls and Reany Creek Waterfalls. Note Power Plant Building and Dirt Road Leading to Dead River Gorge in Background. Photo by Dave Adler.

Directions: From downtown Marquette, take Washington Street west to U.S. 41/M28 west. Turn right (west) onto U.S.41/M-28. Turn right (north) onto Wright Street/County Road 492. In a little over ½ mile, turn left (northwest) onto

Figure 7: Compeau Creek Gneiss Bedrock Exposed at Reany Falls #1. View West. Photo by Dave Adler.

Forestville Road. Follow Forestville Road around until it ends at a fairly large circular parking area just below the McClure Hydroelectric Project powerhouse. See Figures 1 and 6. This is also the parking area for the Dead River Gorge waterfalls. Walk about 450 feet back up Forestville Road and you'll come to a bridge just above the confluence of Reany Creek and the Dead River. On your left will be a wooden sign that says Reany Falls. Take the trail on the south side of Reany Creek to see Reany Falls #2, #3, and #4. It's a short, easy hike of only about ¼ mile or so from the road to Reany Falls #4. Reany Falls #1 can be seen by climbing down the bank on the downstream side of the bridge.

Figure 8: Compeau Creek Gneiss Bedrock Exposed at Reany Falls #2. View West. Photo by Dave Adler.

Geology: Reany Creek flows down from the west through a steep, narrow rocky gorge just above its confluence with the Dead River. The bedrock in this area is the Compeau Creek Gneiss, described by Gair and Thaden (1968) as: foliated light colored tonalite and granodiorite, and small amounts of monzonite, quartz monzonite, and granite. Mainly pink or salmon. Faint streaky layering in many places. Widespread but small amounts of amphibolite and well-layered amphibolite gneiss.

The Reany Creek waterfalls are located near the southern margin of a large area of Compeau Creek Gneiss bedrock that extends northward and northwestward for several miles. The Compeau Creek Gneiss is exposed at each of the four Reany Creek waterfalls. See Figures 7 and 8. The bedrock exposed at Reany Creek is generally massive, light pink to salmon and gray colored granitic rock that doesn't show obvious foliation or gneissic texture, as is fairly typical of the Compeau Creek Gneiss exposures in the Marquette area. A good example of the weak foliation in the Compeau Creek Gneiss can be seen in the hand specimen in Figure 9. This specimen was collected at one of the Wright Steet waterfalls on the Dead River in Marquette located approximately two miles southeast of the Reany Creek waterfalls. The weakly developed gneissic texture is expressed by the linear assemblages of quartz grains trending from left to right in the specimen shown in Figure 9.

Figure 9: Compeau Creek Gneiss Showing Faint Foliation. Photo by Dave Adler.

Dead River Gorge Waterfalls

The Dead River Gorge is a popular spot among Marquette locals, Northern Michigan University students, and tourists, especially during the warm weather months (generally May through October). There are 10 waterfalls (as named by Stagg, {2017}) in the gorge, nine of which are accessible along an approximately one-mile long stretch of the trail along the northwest side of the Dead River. No special climbing skills or climbing gear are needed, although there are a couple of short stretches along the trail where a bit of scrambling comes in handy.

The hike through the gorge to see the waterfalls is relatively easy and is suitable for those of us who qualify as senior citizens at places like Bob Evans and Cracker Barrell. Each of the waterfalls is aesthetically pleasing. Some are quite spectacular. Bedrock is exposed along the river throughout the gorge. The gorge and surrounding forest are unencumbered by anthropogenic development.

The names and GPS coordinates of the Dead River Gorge waterfalls, as provided by Stagg (2017) are as follows:

Dead River Cascades – N46 34.193 W87 28.707

Dead Island Falls (Lower) – N46 34.171 W87 28.743

Dead Island Falls – N46 34.158 W87 28.730

Dead Pool Falls – N46 34.112 W87 28.708

Dead Pool Falls (Upper) – N46 34.100 W87 28.716

Dead Hook Falls – N46 34.039 W87 28.719

Dead Plunge Falls – N46 33.996 W87 28.819

Stony Mills Falls (Lower) – N46 33.887 W87 28.963

Stony Mills Falls – N46 33.839 W87 28.914

Stony Mills Falls (Upper) – N46 33.808 W87 28.899

Stony Mills Falls (Upper) is located just a short distance upstream from Stony Mills Falls, but is not easily accessible from the trail that takes you to the other nine waterfalls.

Figure 10: Dead River Cascades - View Upstream. Photo by Dave Adler.

Directions: The Dead River Gorge waterfalls are best accessed from the Reany Falls parking area described above. From the parking area, walk up the dirt road on the right side of the powerhouse (see Figure 6). The dirt road curves and then turns to the right at the top of the hill. Continue walking on the dirt road for a very short distance. You'll see signs for Dead River Falls on your left. Then you'll see a wooden sign on the ground with an arrow pointing to the left leading down a wooden stairway. Take the stairway into the gorge and onto the bluff overlooking the river. The first waterfall will be the Dead River Cascades just below the bluff (see Figure 10). Continue hiking upstream along the trail that parallels the Dead River to the other eight waterfalls that are accessible. The entire hike to the last accessible waterfall (Stony Mills Falls) is just under a mile. Stony Mills Falls is shown in Figure 11. To return, follow the trail back to the stairway above Dead River Cascades and proceed back to the parking area by the way you came.

Figure 11: Stony Mills Falls - View Upstream. Photo by Dave Adler.

Geology: Bedrock is exposed at each of the Dead River Gorge waterfalls and at many areas along the river as you hike through the gorge. The bedrock has been mapped by Gair and Thaden (1968) as the Lighthouse Point member of the Lower Precambrian Mona Schist, believed to be the second oldest bedrock formation in the region. The rocks along the gorge are described as interlayered massive metabasalt and amphibolitic schist. The greenish gray to black metabasalt and schist tend to be strongly foliated. Veins of felsic rock intruding the metabasalt and schist are commonly observed. The intruding veins tend to be oriented parallel to the foliation. Younger (Keweenawan Series) dark gray to black diabase dikes also intrude the Mona Schist.

Puffett (1974) gives a total thickness of approximately 24,000 feet for the Mona Schist. Gair and Thaden (1968) give a thickness of 4,500-11,600 feet for the Lighthouse Point Member in the Marquette area. The mineralogy is primarily hornblende and plagioclase with lesser amounts of sericite, epidote, clinozoisite, pyrite and leucoxene.

Figure 12: Foliation in the Mona Schist at Dead Island Falls. Photo by Dave Adler.

The well-developed foliation in the Mona Schist is readily apparent at Dead Island Falls (see Figure 12). As shown in Figure 13, the Mona Schist takes on an almost slaty appearance at Dead Island Falls. This may be the

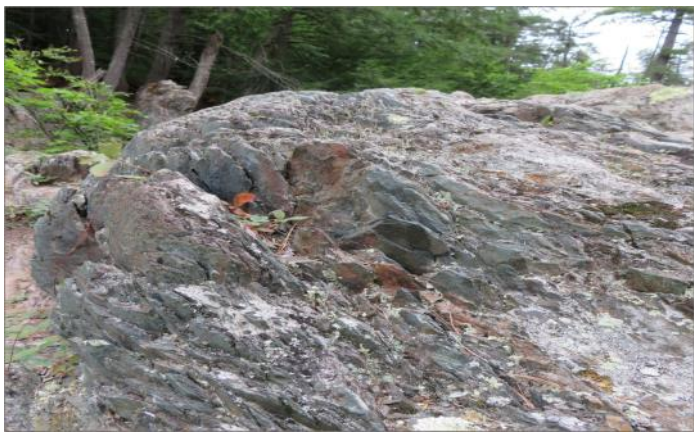

Figure 13: Foliation in the Mona Schist at Dead Island Falls. Photo by Dave Adler.

result of localized shearing of the schist rock mass. Figure 14 shows examples of felsic veins oriented parallel to the foliation, as observed at Dead Island Falls.

Figure 14: Felsic Veins Oriented Parallel to Foliation in the Mona Schist at Dead Island Falls. Photo by Dave Adler.

Figure 15: Scenery and Bedrock at Dead Pool Falls. Photo by Dave Adler.

Some of the best scenery and most interesting features of the Mona Schist in the Dead River Gorge are at Dead Pool Falls and Dead Pool Falls (Upper) located just above Dead Pool Falls. Dead Pool Falls (see Figure 15) is one of those picture postcard kind of waterfalls and is said to be a favorite spot for college students, some of whom enjoy diving off the rocks at the top of the falls into the pool below (not recommended). Just above Dead Pool Falls is Dead Pool Falls (Upper), a four-segment waterfall whose entirety is difficult to photograph. The two middle segments are shown in Figure 16. The large, well-rounded bedrock knob located at the top of Dead Pool Falls (Upper) is an ideal spot to relax, picnic, and observe some of the geologic features of the Mona Schist. As shown in Figures 17 and 18, the well-developed foliation and prominent felsic veining oriented parallel to the foliation occur here and are easily accessible for observation and examination.

Figure 16: Scenery and Bedrock at Dead Pool Falls (Upper). Photo by Dave Adler.

Figure 17: Foliation and Veining in the Mona Schist at Dead Pool Falls (Upper). Photo by Dave Adler.

Figure 18: Foliation and Veining in the Mona Schist at Dead Pool Falls (Upper). Photo by Dave Adler.

Another interesting geologic feature of the Mona Schist observed in the Dead River Gorge is linear assemblages of light-colored minerals (presumably feldspars) oriented sub-parallel to parallel with the foliation. A good example of these linear assemblages, shown in Figure 19, was observed at the water's edge between Stony Mills Falls (Lower) and Dead Plunge Falls. A number of theories regarding the origin of these metamorphic features have been offered, but, like many geologic features in ancient metamorphic terranes, general agreement of their mode of formation seems elusive.

Figure 19: Linear Assemblages of Light-Colored Minerals in Mona Schist. Photo by Dave Adler.

Morgan Falls

Morgan Falls is located at the confluence of Morgan Creek and the Carp River just outside the Marquette City limits. It is a beautiful waterfall that's accessible via an easy and scenic walk along one of Marquette's many bike paths. There are six additional waterfalls located on the Carp River upstream from Morgan Falls that are both attractive and offer exposures of different rock formations of the Marquette Range Supergroup. Unfortunately, the six waterfalls on the Carp River are difficult to access.

Figure 20: Entrance to the Main Bike Trail Leading to Morgan Falls. Photo by Dave Adler.

Directions to Morgan Falls: From downtown Marquette, take Washington Street west towards US 41 and turn left at South 7th Street. Follow South 7th Street (which becomes Grove Street) to County Road (CR) 553, also known as McClellan Ave. and turn left onto CR553. Go south on CR553 for about two miles and park in the Noquemanon Trail Network free parking area located on the east (left) side of CR553 just north of the Marquette Mtn. ski area. Parking in the ski area parking lot is not recommended.

Walk or bicycle south (towards Marquette Mtn.) along the west side of CR553 for about ¼ mile until you come to the entrance for the main bike path. It will look a lot like the scene shown in Figure 20. Proceed along the bike path for approximately 1.4 miles. It's an easy and pleasantly scenic walk through the woods. You'll see a wooden sign for Morgan Falls and a set of wooden stairs leading down to the falls on your left. Take the stairway down and follow the path over a wooden bridge where you can get a great view of Morgan Falls and the confluence of Morgan Creek and the Carp River. There are also some picnic tables here. The GPS location coordinates for Morgan Falls are as follows: N46 30.321 W87 26.272. The view of Morgan Falls from the picnic area is shown in Figure 21.

Figure 20: Wewe Slate at Morgan Falls. Photo by Dave Adler.

Geology: The bedrock exposed at Morgan Falls is the Middle Precambrian (Early Proterozoic) Wewe Slate of the Chocolay Group, which is part of the Marquette Range Supergroup, a broad grouping of the primarily sedimentary and metasedimentary rocks of the Marquette Syncline that were deposited unconformably on older Archean basement rocks. The Wewe Slate formation in the Marquette area consists primarily of light to dark gray, dull green, or salmon colored massive and laminated slate. The formation also includes sericitic quartzite, wacke, and conglomerate (Gair and Thaden, 1968). The dominant minerals in the slate are quartz, chlorite, and sericite. Leucoxene, magnetite, rutile and iron oxides are minor constituents. According to Gair and Thaden (1968), the Wewe Slate conformably overlies the Kona Dolomite and is overlain disconformably or with slight angular unconformity by the Ajibik Quartzite.

Pinnacle Falls and Yellow Dog Falls

The Yellow Dog River flows eastward from its origins in the McCormick Wilderness Area through a large watershed of mostly remote and undeveloped country (including the area known as the Yellow Dog Plains) before emptying into Lake Independence near Big Bay (see Figure 2). Along the way, there are several waterfalls, many of which are in remote and secluded wilderness locations. Two of the nicer and more accessible waterfalls on the Yellow Dog River are Pinnacle Falls and Yellow Dog Falls. A number of other waterfalls are located on Big Pup Creek and on Bushy Creek in the general area of Yellow Dog Falls.

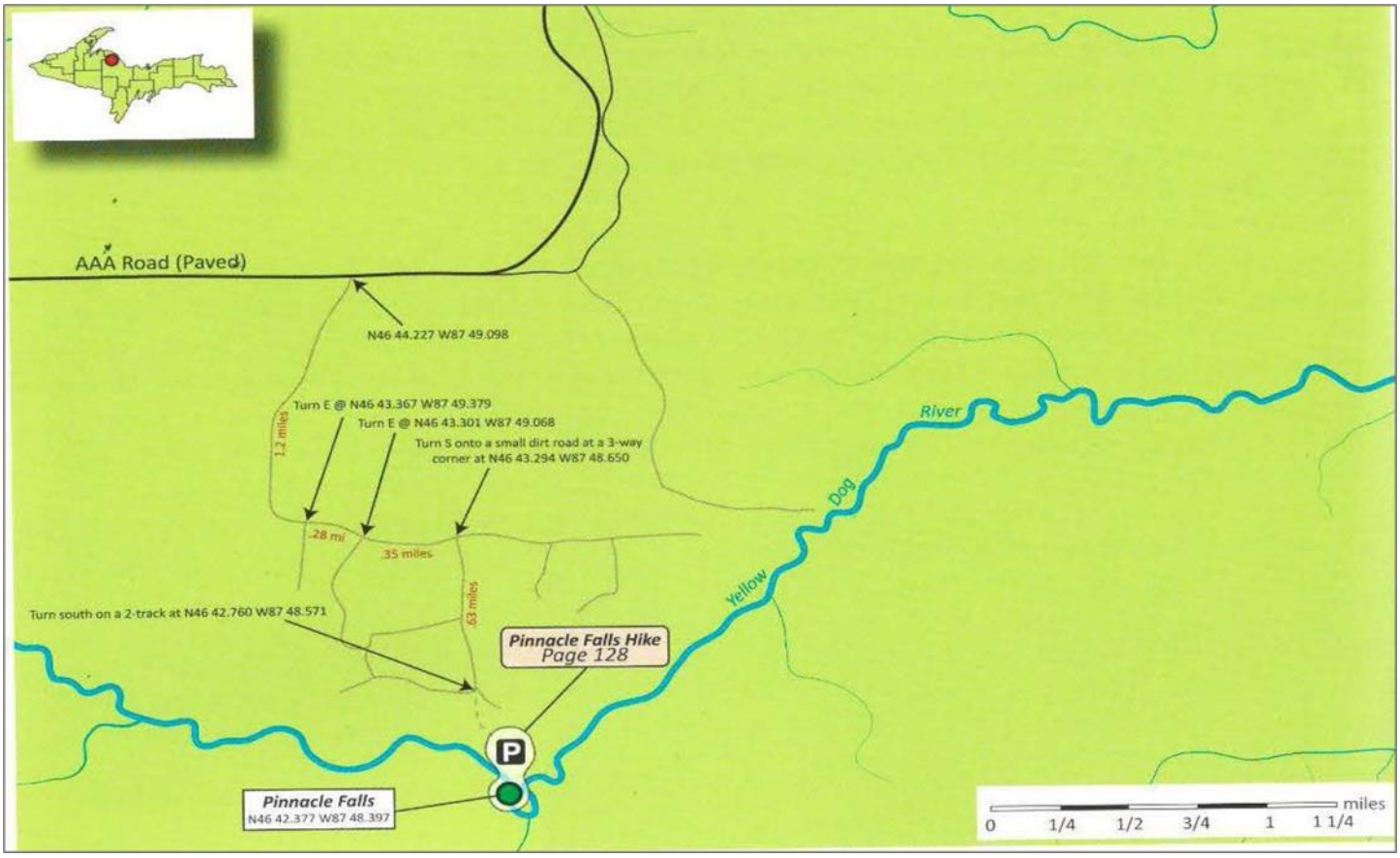

Figure 22: Route to Pinnacle Falls Parking Area Via AAA Road. Source: Stagg, 2017.

Directions to Pinnacle Falls: From downtown Marquette, take Lakeshore Blvd. northward towards Presque Isle Park and turn left (west) onto Hawley Street which becomes Big Bay Road/CR550. Follow CR550 for about 25 miles or so to CR510 and turn left onto CR510 heading south/southwest. After passing the Thomas Rock Overlook scenic area (highly recommended), CR 510 turns sharply to the south at its intersection with AAA Road. Stay straight and proceed southwest on AAA Road (paved) towards the Eagle copper/nickel mine. Shortly after AAA Road turns to the west and straightens out, you'll see a dirt road on your left with a white and black sign that says MJ VanDamme Inc. at GPS coordinates N46 44.227 W87 49.098. Turn left (south) onto this dirt road and proceed south past a gravel pit operation for about 1.3 miles. The road will bend to the left before forking. Bear left at the fork, proceed another 0.3 miles, and turn right. Proceed another 0.6 miles southward to the parking area for Pinnacle Falls. Walk down the trail for about 1/2 mile until you reach Pinnacle Falls at GPS coordinates N46 42.377 W87 48.397.

Pinnacle Falls isn't as tricky to find as it may sound. See the map on Figure 22. There are several wooden signs, most with orange lettering, guiding you to the parking area after you turn off AAA Road. The trail to the falls does get fairly steep in one stretch, but nothing more than a little stamina is required as you return to the parking area after visiting the falls.

Directions to Yellow Dog Falls: Yellow Dog Falls is easier to find than Pinnacle Falls. From downtown Marquette, take CR550 towards Big Bay to CR510 as described above for Pinnacle Falls. When you get to the juncture of CR510 and AAA Road, stay left on CR510 and proceed southward until you reach the bridge over the Yellow Dog River. The total driving distance on CR510 from CR550 to the bridge is about 6.5 miles. Park in the parking area on the far (south) side of the bridge. There is a well-marked trailhead with signs. The ½ mile hike through the woods to Yellow Dog Falls is easy. The trail is well maintained. The GPS coordinates for Yellow Dog Falls are N46 43.720 W87 42.403.

Geology: Both Pinnacle Falls (Figure 23) and Yellow Dog Falls (Figure 24) are located within the large area of Archean granitoid rock (granodiorite, tonalite, and granite) that extends from Marquette to the north-northwest and is commonly referred to as the Compeau Creek Gneiss. As

Figure 23: Pinnacle Falls on the Yellow Dog River. Photo by Dave Adler.

Figure 24: Yellow Dog Falls on the Yellow Dog River. Photo by Dave Adler.

shown on Figure 3a, Pinnacle Falls is located near a regionally prominent east-west trending high angle fault that separates the Compeau Creek Gneiss from the younger (Early Proterozoic) Michigamme Formation of the Baraga Basin to the northwest. Yellow Dog Falls lies within a large body of Compeau Creek Gneiss bordered by the Baraga Basin on the west and younger Jacobsville Sandstone on the east along the Lake Superior shoreline.

Figure 25: Pegmatite Vein Crosscutting Compeau Creek Gneiss at Yellow Dog Falls. Photo by Dave Adler.

Figure 26: Compeau Creek Gneiss at Yellow Dog Falls. Photo by Dave Adler.

The bedrock at Pinnacle falls is not all that well exposed. The bedrock exposures at Yellow Dog Falls are better and more accessible. The rock exposed at Yellow Dog Falls includes felsic intrusive rocks, some of which exhibit gneissic foliation; remnants of the Archean country rock (Mona Schist or Kitchi Schist) that was intruded by the Compeau Creek Gneiss; and numerous crosscutting granitic and pegmatitic vein and dike-like features. Examples of these geologic features are shown on shown on Figures 25 and 26.

Whetstone Falls

The unnamed waterfall near the mouth of Whetstone Brook in Marquette seems to have gone unnoticed by most, if not all of the Michigan waterfall guidebooks. Although it is located less than ½ mile from the heart of downtown Marquette, this waterfall doesn't attract crowds. Whetstone Falls isn't all that large in terms of vertical drop, nor perhaps as spectacular as some of the other waterfalls in the area, but it is aesthetically pleasing, close to a nice stretch of sandy Lake Superior beach, and is easy to get to. There are also some very interesting geologic features to be seen near Whetstone Falls.

Directions to Whetstone Falls: From the intersection of Washington Street and S. Lakeshore Blvd. in downtown Marquette, go south on S. Lakeshore Blvd. for approximately 0.4 miles until you come to the bridge where S. Lakeshore Blvd. crosses over Whetstone Brook. You can park in the free parking areas along S. Lakeshore Blvd. in this area. If the lots are full, try parking in the larger parking lot at the nearby Fairfield Inn & Suites hotel (808 S. Lakeshore Blvd).

The popular Marquette bike path runs parallel to S. Lakeshore Blvd. just a stone's throw to the east (towards Lake Superior). Whetstone Falls is located about 75 feet downstream of the bridge where the bike path passes over Whetstone Brook. There's an easy trail that you can access from the south end of the bike path bridge. The path begins at a light post and a steel post marker with the inscription IOHT 38. It's easy to find and access. The GPS coordinates for Whetstone Falls are N46 32.204 W87 23.643. The view upstream of the falls will look something like that shown in Figure 27.

Figure 27: Whetstone Falls on Whetstone Brook in Marquette. Photo by Dave Adler.

Geology: The bedrock at Whetstone Falls and the surrounding vicinity is the Lower Member of the Archean Mona Schist, described by Gair and Thaden (1968) as mainly schistose and massive metabasalt, actinolitic and chloritic schist, and ellipsoidal greenstone. These are among the oldest rocks that can be observed in Michigan. If you continue approximately 200 feet further down the trail, you'll come to the mouth of Whetstone Brook. Look up the Lake Superior coastline to your left (northwards) and you'll see the old, inactive iron ore dock in downtown Marquette. The still active ore dock is located 3 miles to the north near Presque Isle Park. If you look downcoast to the right, you'll see a quiet and very nice sandy Lake Superior beach that's frequented mostly by locals and is usually uncrowded.

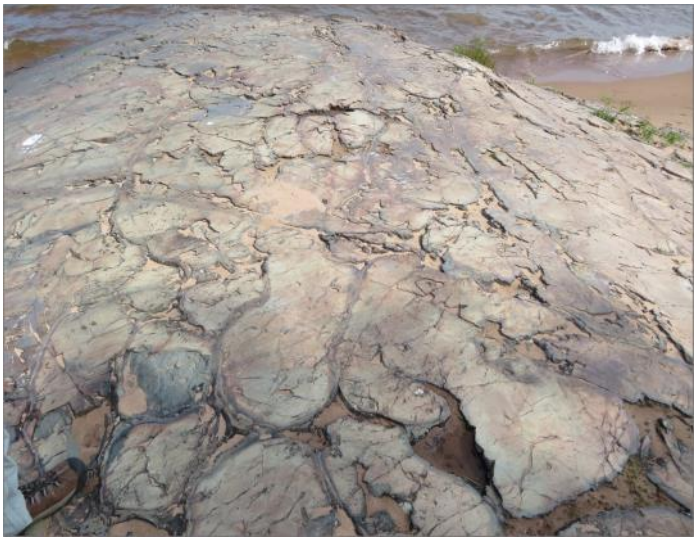

Figure 28: Ellipsoidal Pillow Basalt Structures in the Lower Member of the Mona Schist at Whetstone Brook. Photo by Dave Adler.

There's an outcrop of low-lying rounded gray and tan/brown metabasalt at the mouth of Whetstone Brook that has some of the best examples of remnant pillow basalt structures preserved in the Archean Lower Member of the Mona Schist. The ellipsoidal tops of the basalt pillows or pillow lavas are extremely well defined here. Some good examples can be seen in Figures 28 and 29. These remnant pillow structures are indicative of ancient subaqueous extrusions of basaltic lava that have retained some of their original extrusive igneous structure for eons.

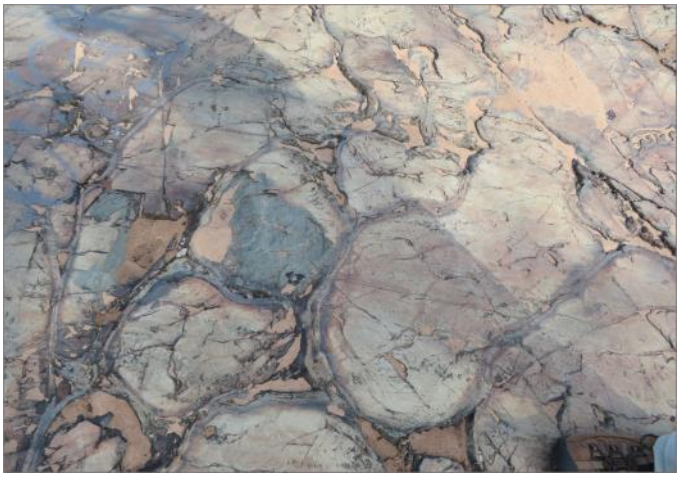

Figure 29: Pillow Lava Structures in the Mona Schist Metabasalt near Whetstone Falls. Photo by Dave Adler.

Figure 30: Well-Developed Foliation in the Mona Schist Metabasalt near Whetstone Falls. Photo by Dave Adler.

Now return up the trail along Whetstone Brook past the waterfall and back onto the bike path. Just south of the bridge where Whetstone Brook crosses under the bike path and just east of the bike path (towards the beach) are several interesting outcrops that can be accessed by a network of primitive trails. At one of these outcrops, shown in Figure 30, the very well-developed foliation in the Mona Schist can be observed. Contrast this foliation with the pillow lavas preserved in the same rock at essentially the same location as seen in Figures 28 and 29. Even more striking is the outcrop shown in Figure 31 where some spectacular pillow structures can be observed in profile view. The excellent outcrop shown in Figure 31 is located just to the south and east of the bike path bridge over Whetstone Brook. Anyone wishing to lead a geology field trip or teach field geology couldn't pick a better spot to conduct a lesson on Archean igneous and metaigneous rocks.

Figure 31: Remnant Pillow Lava Structures in the Mona Schist Metabasalt near Whetstone Falls. Photo by Dave Adler.

Closing

The 17 waterfalls covered in this field trip guide are relatively easy to find and access. There are 50 or more other waterfalls in and around Marquette that you can visit and explore. Some are easy to find and easy to access. Some are more of an adventure, which can add to the fun and enhance the experience. As always, proceed safely, keep an eye out for the safety of those around you, and respect private property.

The complex geology and tectonic history of Marquette and the surrounding region have only been touched on in a general and cursory manner in this field trip guide. Those wishing to know more are encouraged to consult the references below, as well as numerous other sources of information available in the public domain.

And lastly: Have fun, enjoy, and be safe.

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Mark Petrie is a Certified Professional Geologist (CPG) who served with the Michigan Department of Environment, Great Lakes, and Energy Remediation and Redevelopment Division in Marquette for 34 years before retiring as District Geologist in 2019. Mark provided valuable input for this article by way of advice, companionship, navigation skills, and sharing his extensive experience and knowledge of the Marquette area's waterfalls and geology, especially the excellent pillow basalts exposed near Whetstone Falls.

Phil Stagg's detailed and comprehensive Waterfalls of Michigan guidebook series has been a great resource for finding and exploring Michigan's many waterfalls, especially Book 2 • Central that covers Marquette, Menominee, and Dickinson Counties. Phil was kind enough to grant permission to use an excerpt from Book 2 for Figure 22 of this field trip guide. Additional information regarding the four volume Waterfalls of Michigan series is available at www.mifalls.com.

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