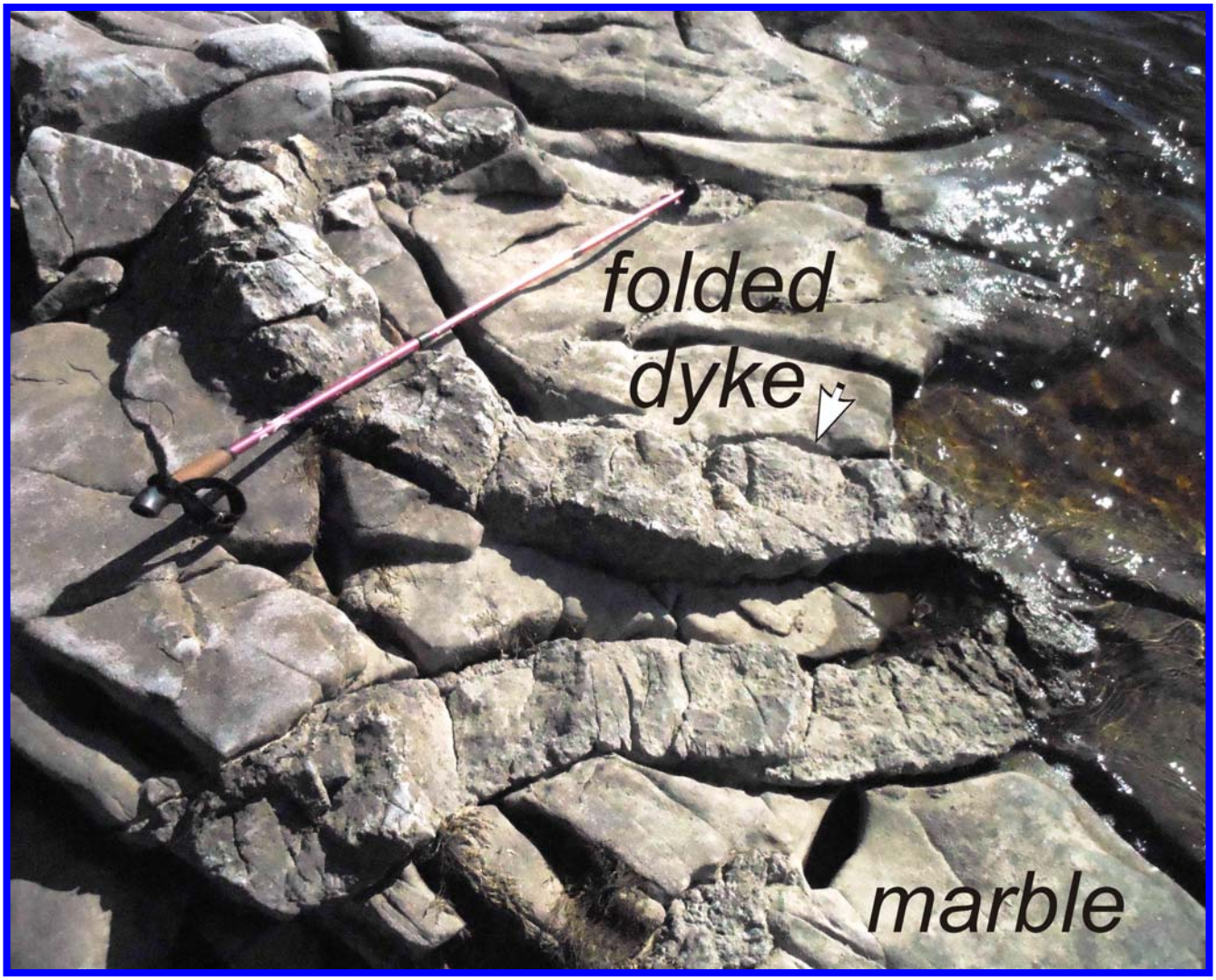
# *A geology primer for the Morris Island Conservation Area*




The Precambrian to Paleozoic exposures preserved within the Morris Island Conservation Area form a geological benchmark for the Nopiming Game Sanctuary to the west and the Fitzroy Provincial Park to the east.
We hope these observations will aid understanding the geological history of both.

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# *A geology primer for the Morris Island Conservation Area*

## *Introduction*

The Morris Island Conservation Area (MICA) covers a small section of the marble-rich Sharbot Lake Terrane, one of several geological segments or "terranes" making up the Central Metasedimentary Belt (Fig.1). A west-to-east model of the Earth's crustal structure (Fig. 2) derived from Geological Survey of Canada (GSC) seismic sections shows the terranes are the exposed edges of crustal slices thrust to the northwest over older parts of the Canadian Shield.

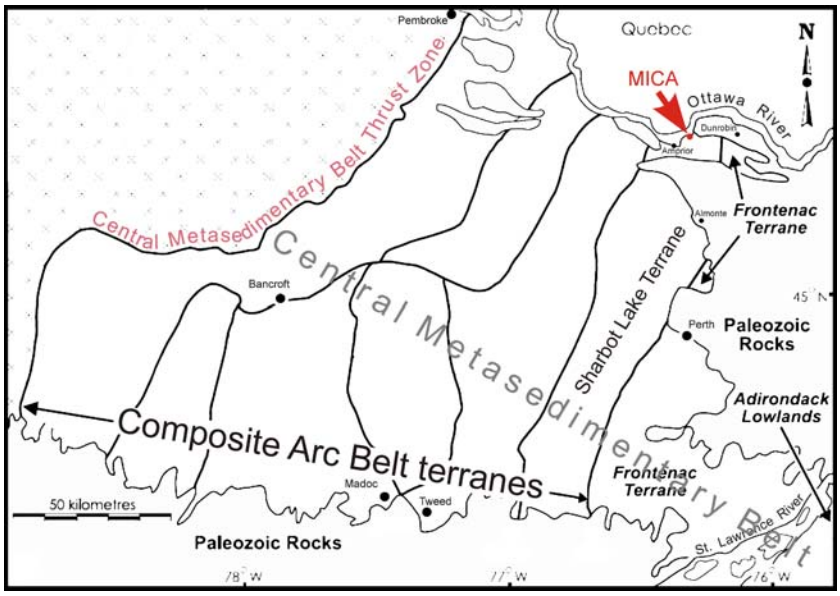


***Figure 1.*** Location of the Morris Island Conservation Area (MICA) within the Sharbot Lake Terrane

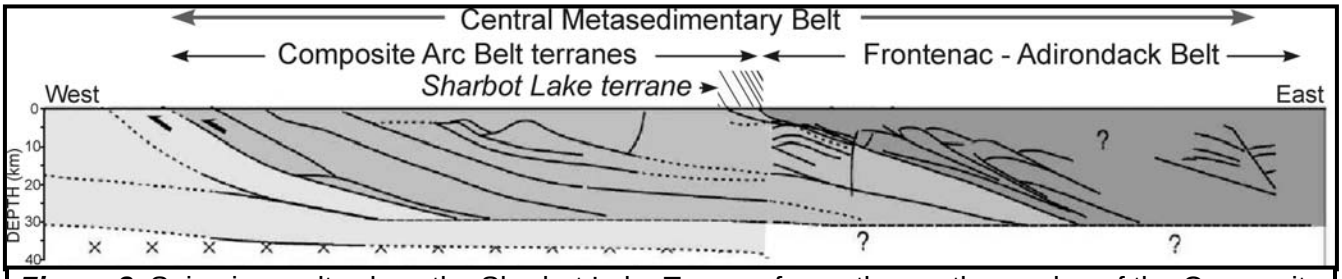


***Figure 2.*** Seismic results show the Sharbot Lake Terrane forms the southern edge of the Composite Arc Belt, a group of crustal slices thrust northwestward over older parts of the Canadian Shield.

Geology maps (Fig.3) of the MICA have been published since 1919. Works include GSC maps 1739 and 1363A printed in 1919 and 1974, and Ontario Geological Survey (OGS) Map 2462, part of OGS Report 212 published in 1982. Map 1363A appears to be based on work done from the 1940s to the mid-60s. Map 1739 accompanied GSC Memoir 136 and indicates only marble bedrock. Note the MICA shoreline on the 1919 map that

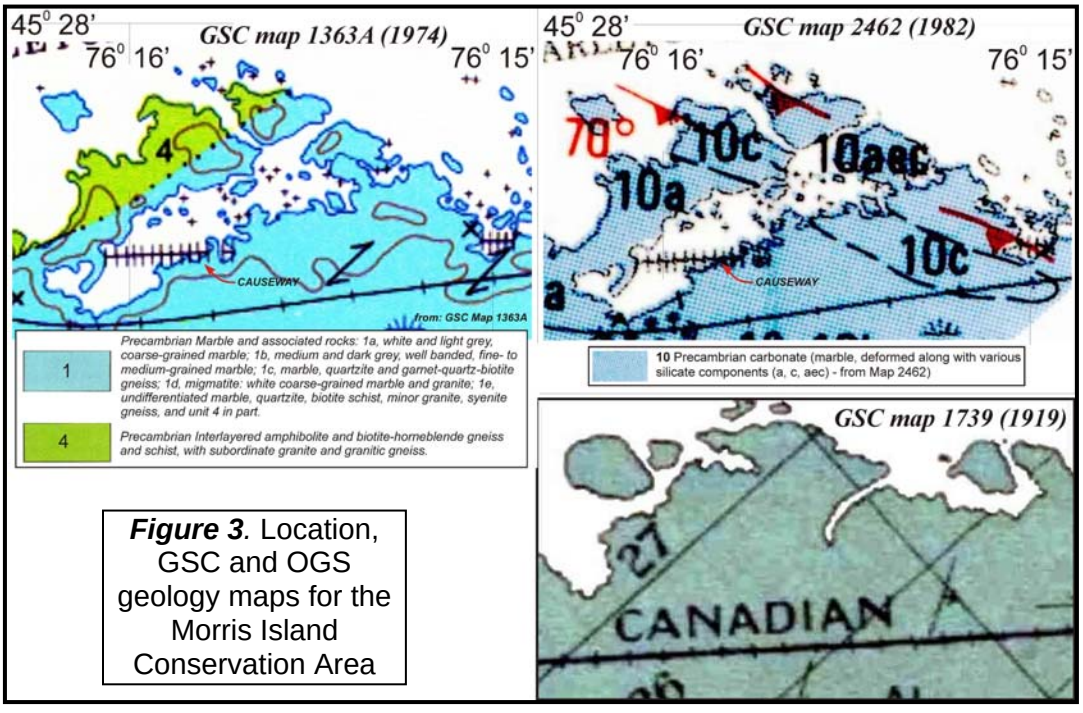


***Figure 3***. Location, GSC and OGS geology maps for the Morris Island Conservation Area

preceded flooding by the Chats Falls dam. Dam construction started in October 1921 and units were in service in 1931 and 1932.

Although the deformed marble and incorporated granitic (quartz + feldspar + accessory diopside, tremolite, garnet and other minor minerals) material is recognized on both the 1974 and 1982 maps, there are distinct differences in the mapped distribution and classification of the marble and non-marble, quartz-rich or "silicate" rock types. The differences indicate much remains to be resolved.

This report does not try to reconcile the published maps but simply points out geological features, many apparently undocumented, that may be readily observed along the MICA trails.

***Geological features along the MICA trails***

The map in Figure 4 was compiled from Ontario Base Map sheets 1018400050350 and 1018400050300 together with trail maps provided by Mississippi Valley Conservation Authority.

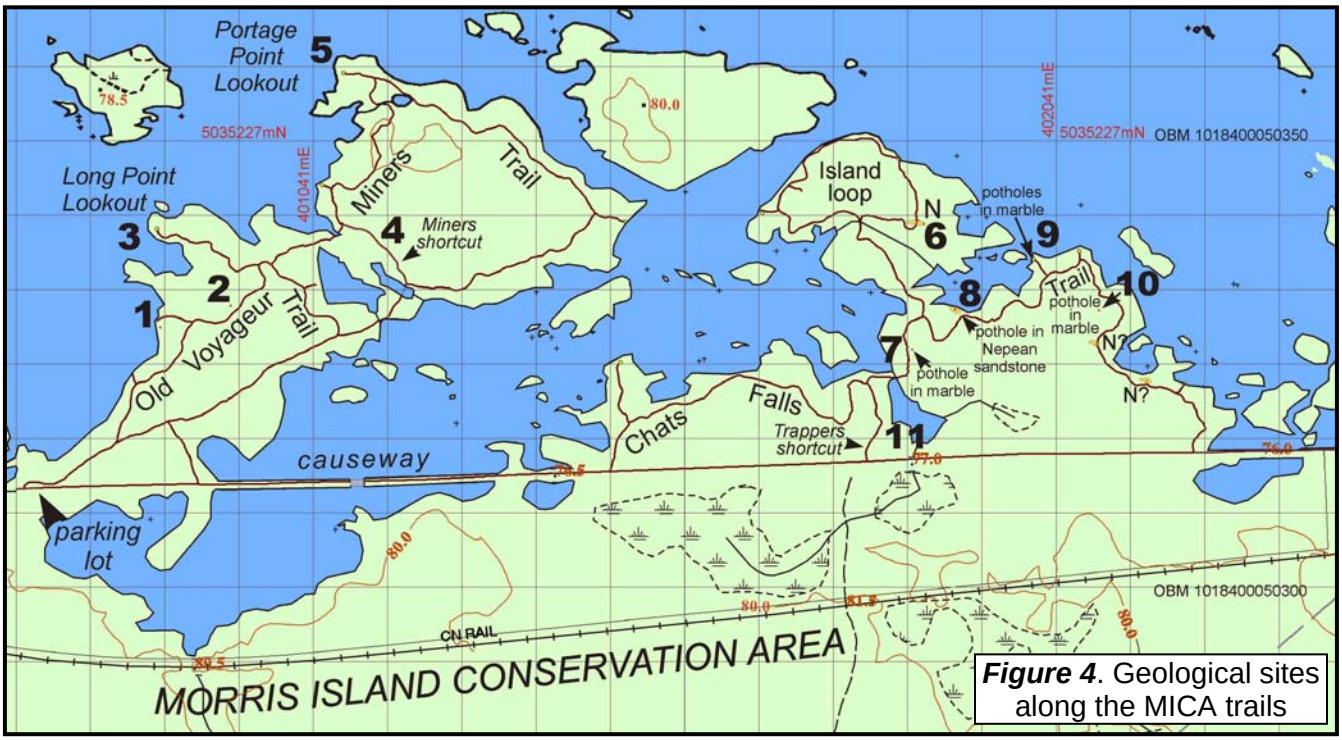


***Figure 4***. Geological sites along the MICA trails

The present MICA shoreline and the present water table are a changing product of the reservoir water level set by the Chats Falls hydro dam. The reservoir depth at the dam is some 20 meters above the river's level before the dam was constructed. The present reservoir water level thus approximates a level closer to an ancestral phase of the Ottawa River following the last glaciation.

The marble rich Sharbot Lake Terrane basement underlying the MICA extends to beyond Arnprior on the west, east to the Carp Ridge and southwest through the Almonte area. Studies there indicate the marble has experienced temperatures of from 400$^0$C to 700$^0$C and has been deformed at depths of 10-20 km within the Earth's crust, probably during several episodes.

The marble may represent the metamorphosed product of beds of limestone and sandy material deposited at some distant location some 1.2 – 1.3 billion years ago. By about 1 billion years ago, the movement of the Earth's continents (plate tectonics) had merged the Sharbot Lake Terrane and the MICA with the rest of the area's geology.

***Old Voyageur Trail***

The internal marble structure or metamorphic "fabric" is particularly evident along the shoreline between Site **1** and site **3** at Long Point Lookout (Fig.5). A ribbed surface is due to differential weathering along bands of harder silicate minerals within the marble (white arrows in Figure 5**a**). The harder mineral grains are released as the softer marble dissolves resulting in a series of troughs (Figure 5**b**). Also evident in Figure 5 are a series of fractures that cross-cut the marble fabric and are occupied variably along the fractures by coarsely crystalline quartz- and feldspar–rich "pegmatite" dykes ranging in width from inches to a few feet. As the dykes weather out, open fractures are left.

***Figure 5***. Site **1**. **a**: The ribbed surface of the marble (white arrows) result from erosion of metamorphic mineral bands shown in **b**. Open cross-cutting fractures (red arrows) represent now eroded fractures, parts of which contain pegmatite dykes.

Figure 6 shows how a wind blown pine tree has picked up several inches of a Y-shaped, weathered pegmatite dyke (red arrows in Figure 6) from the underlying open fracture system. The weathered dyke structure may have hosted germination of the original pine tree. Many mineral occurrences that eventually became operating mines, including the galena (lead sulphide) at the Kingdon Mine site a few km to the southeast, were discovered as shiny metallic materials lodged in uprooted trees.

***Figure 6***. Site **1**. Several inches of relatively fresh pegmatite dyke material from the underlying Y-shaped fracture system (red arrows) has been extracted by the root of a windblown pine tree.

Inland at site **2**, serpentine trending elements of a quartz-rich vein network stand above the softer

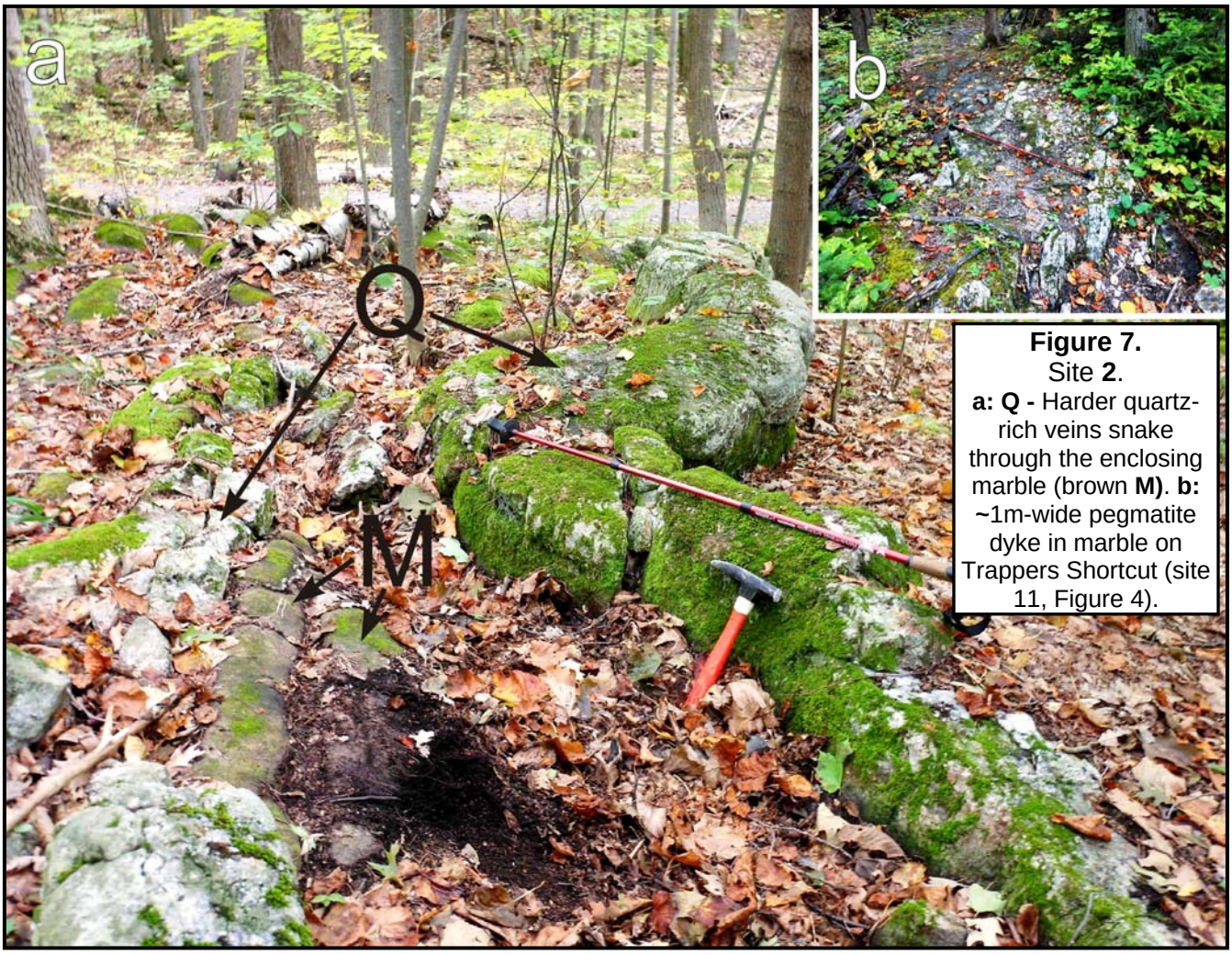


**Figure 7.** Site **2**. **a: Q -** Harder quartz-rich veins snake through the enclosing marble (brown **M)**. **b:** ~1m-wide pegmatite dyke in marble on Trappers Shortcut (site 11, Figure 4).

marble host rock (Fig. 7**a**). On Trappers shortcut, a pegmatite dyke cuts through marble in Figure 7**b**). Nearly all-upland knolls are composed of silicate material or are structurally supported by a network of quartz veins or pegmatite dykes. The intervening lows are underlain by marble.

***Miners Trail***

Figure 8 shows the details of a quartz-feldspar vein with minor black, triangular-shaped crystals of tourmaline along Miners shortcut (site **4** in Figure 4). Miners trail appears to cross more and larger silicate lenses within the marble than Voyageur trail. The stromatolite boulders described later are from the eastern part of Miners Trail.

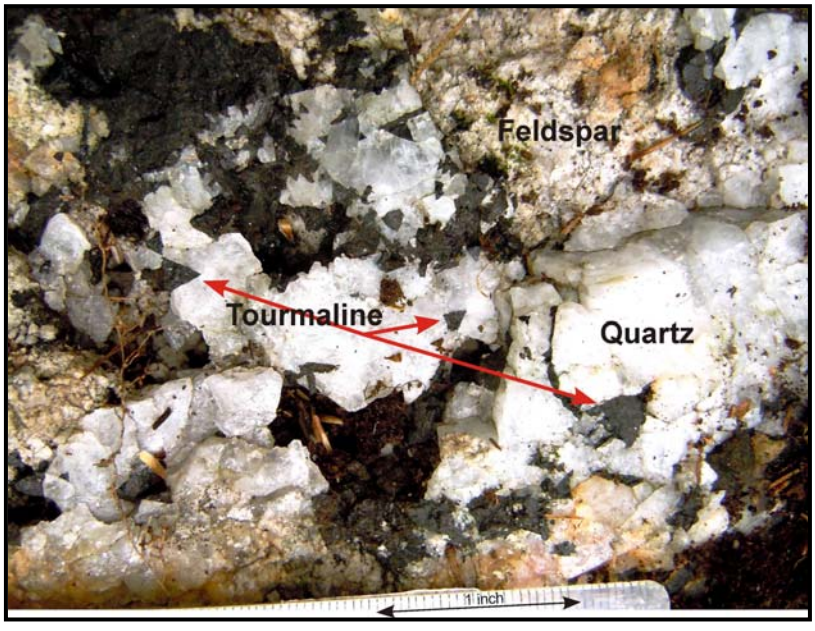


***Figure 8***. Mineral details within a quartz-feldspar vein on Miners Shortcut.

At site **5**, low water near Portage Point lookout reveals the clear S-form of a folded, meter-scale

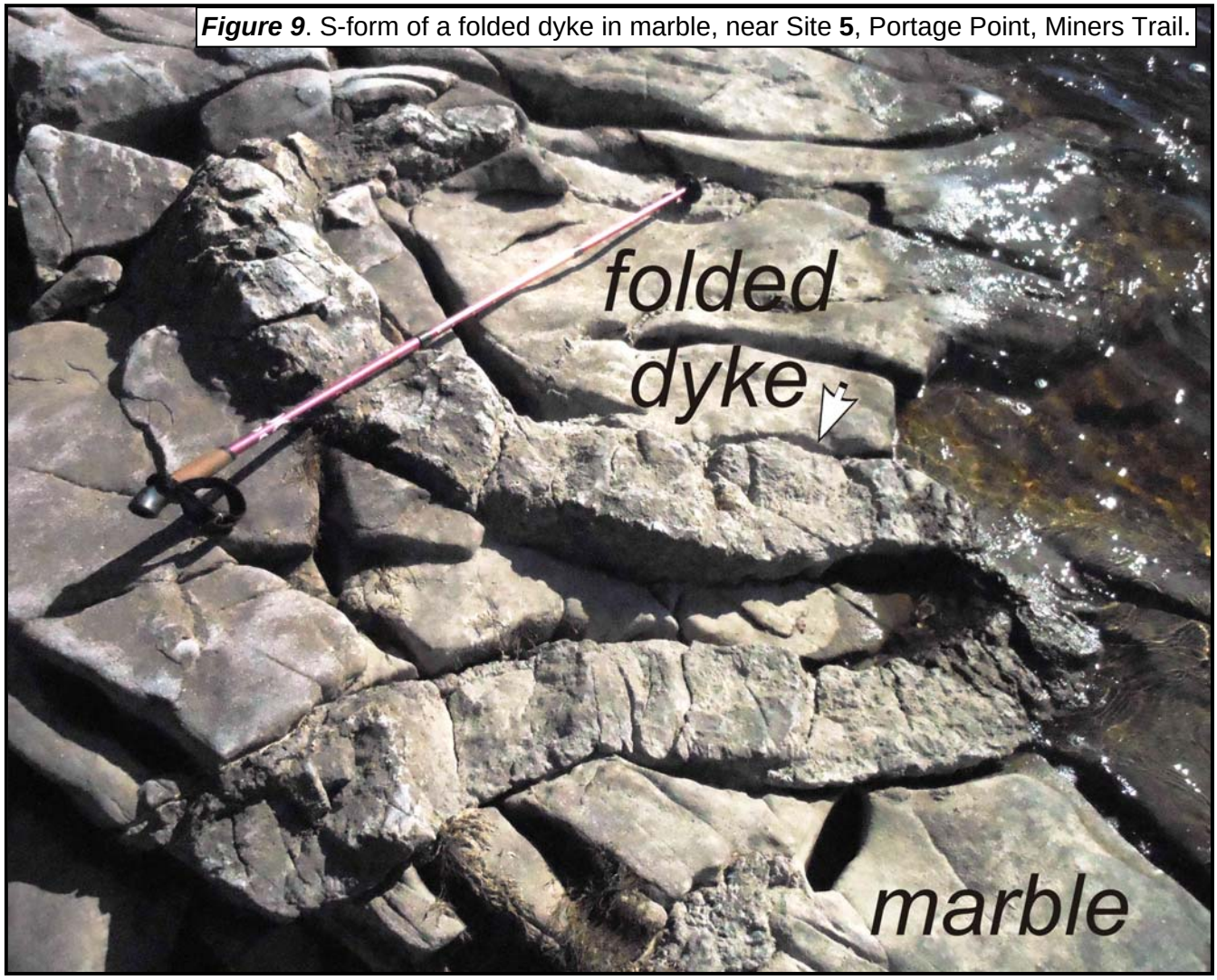


***Figure 9***. S-form of a folded dyke in marble, near Site **5**, Portage Point, Miners Trail.

dyke (Fig. 9). The fold attests to both the deformational history within the marble and the dramatic ductile difference between the softer marble and the harder silicate composition of the dyke under elevated temperature and pressure. The dyke clearly features chilled margins (Fig. 10) reflecting the abrupt cooling as the dyke intruded the marble. Between the margins, larger crystals formed as the core cooled more slowly. As the marble deformed, a nearby dyke has been pulled apart and left as separated "boudin" (sausage-like) segments in the marble (arrows, Figure 11). Similar structures mark the beaches at low water levels around Long Point Lookout (Site **3** in Figure 4).

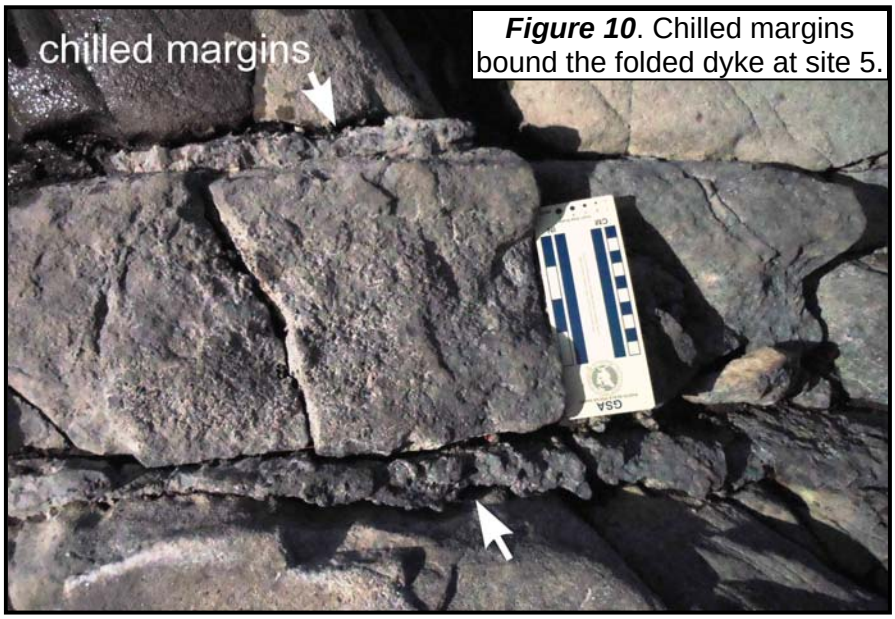


***Figure 10***. Chilled margins bound the folded dyke at site 5.

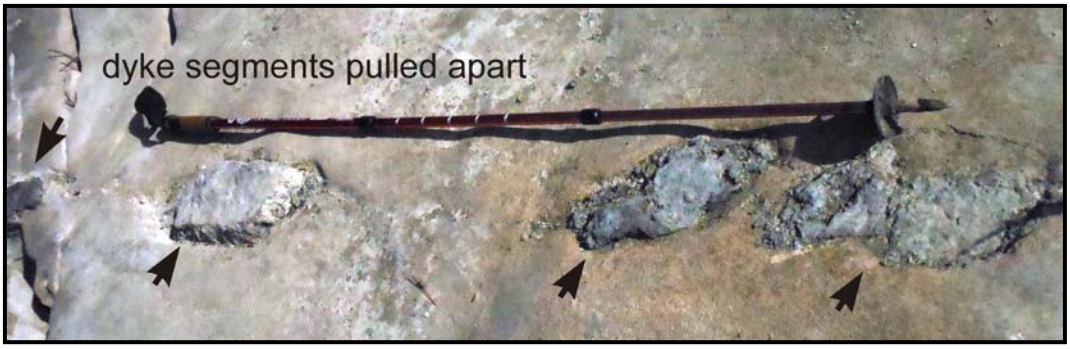


***Figure 11***. A dyke similar to that in Figure 9 has been pulled apart as the marble stretched and folded.

***Chats Falls and Island Loop trails***

Sites along the Chats Falls and Island Loop trails also document particular geological events. At sites **6** and **8** (Fig. 4) isolated, unmapped, remnant outcrops of very pure quartz arenite (sandstone) of the Nepean formation rest on the marble basement (Fig. 12). The sandstone represents well sorted sand

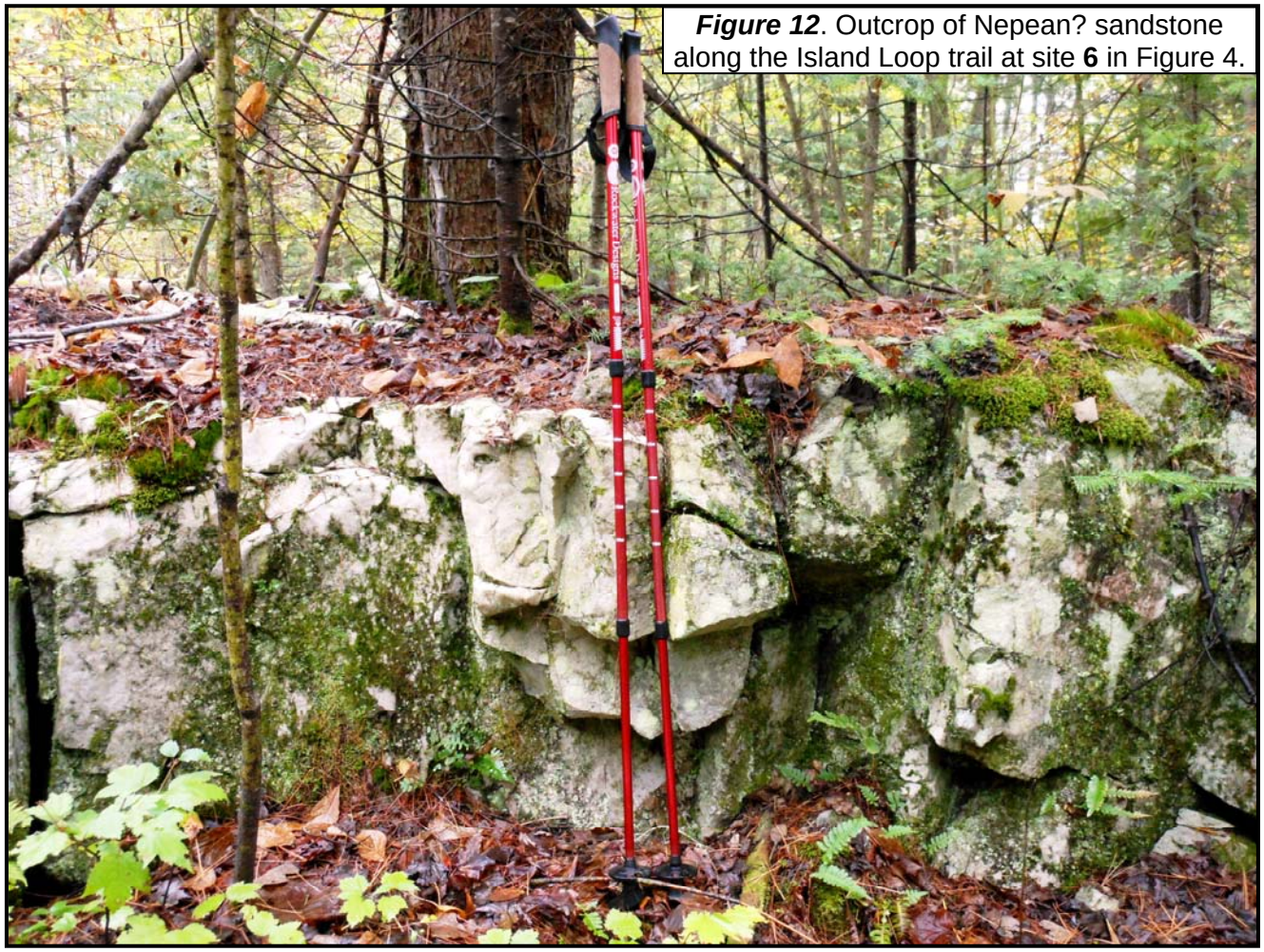

***Figure 12***. Outcrop of Nepean? sandstone along the Island Loop trail at site **6** in Figure 4.

deposited, perhaps partly by wind, along an equatorial marine shoreline some 500 million years after the marble basement had been folded, uplifted and deeply eroded. Although angular blocks up to about 1m across are found along and adjacent to the Chats Falls trail at the sites marked “N?” in Figure 4, clearly in situ sandstone outcrops may be questioned. The Island Loop trail sandstone covers perhaps a few hundred square meters and is not indicated on published maps. Since the nearest outcrops of Nepean lie to the east on the north side of the Carp Ridge, these limited outcrops indicate the limit of

Early Paleozoic sand deposition lies farther west than previously appreciated. At site **8** (Fig. 13**a**), a

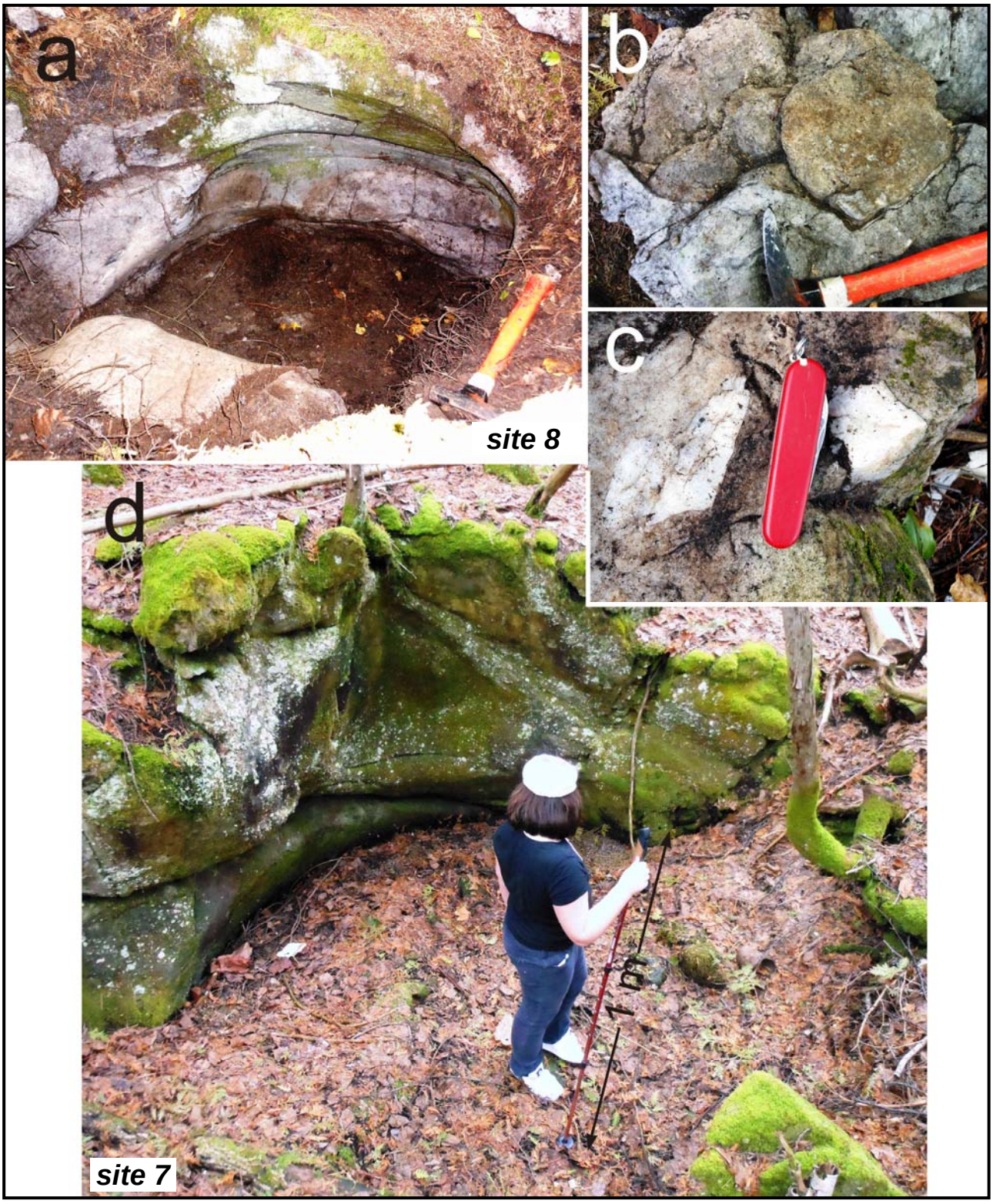


***Figure 13***. **a** and **d**: The smoothly sculpted forms of circulating water are characteristic of potholes at sites **7**, **8**, **9** and **10** in Figure 4. Potholes at sites **7, 9** and **10** are in marble.
13**b** and 13**c**: Site **8** features blocks of sandstone with marble (brown, above hammer in **b**) and sandstone containing sharply angular white quartzite clasts (13**c**).

smoothly sculpted, elliptical pothole about 1 meter across has been formed by circulating subglacial or post glacial waters carrying abrasive sediment. The pothole starts in sandstone but may extend into the underlying marble. Composite blocks of sandstone and marble as well as sandstone blocks with clasts

of sharply angular, white quartzite were found within (Fig. 13**b**) and adjacent to the pothole (Fig. 13**c**). Figure 13**d** shows one wall of a partly collapsed pothole several meters in diameter nearby at site **7** in Figure 4.

At lower head pond water levels, the increased shoreline exposure reveals a group of potholes above and below water level at site **9** (Fig. 14). The potholes feature smoothly polished, fluted, circular

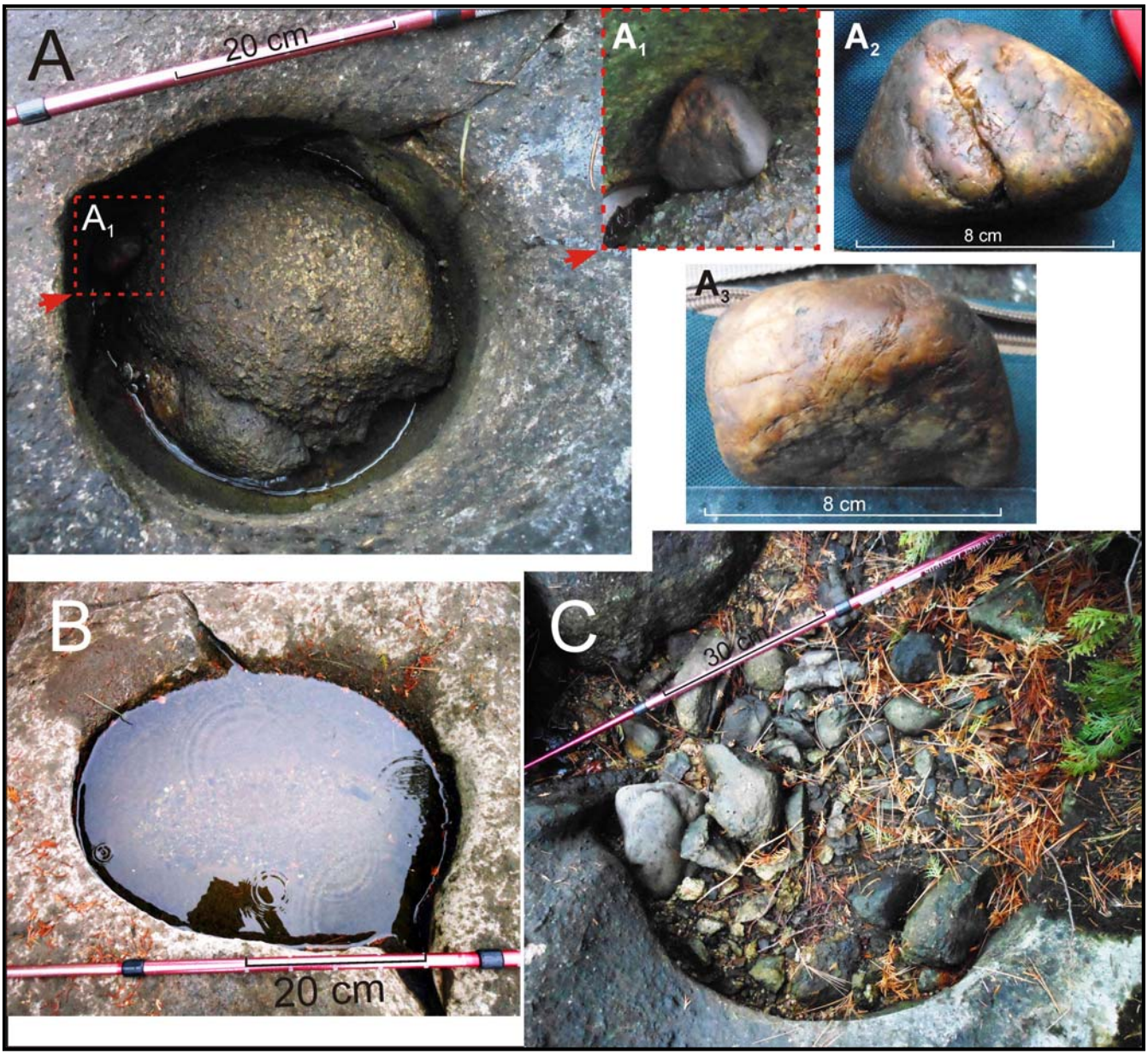


***Figure 14***. Group of potholes at site **9** near the lookout. **A**, **B**, and **C** – potholes from about 30 to 50 cm in diameter. **B** and **C** may have started along fractures. The pothole in **A** contains a polished cobble in situ (red dashed rectangle and $\mathbf{A_1}$ inset) that may be a boring agent (detailed views in $\mathbf{A_2}$, $\mathbf{A_3}$). Larger potholes appear nearby in deeper water offshore.

walls similar to the larger potholes found further inland. The sharper, near perfect circular form, smaller size and lower elevation may indicate later development during an ancestral phase of the Ottawa River.

The pothole at site **10** in Figure 4 is shown in Figure 15. Canoeists report observing similar circular features beneath shallow water near the north shore of the Chat Falls head pond. The circular pits forming much of the topography of large areas of northern Miners, eastern Island Loop and Chats Falls trails together with the adjacent head pond to the north, appear to be produced by pothole structures. Potholes also occur locally along the shoreline bordering Long Point Lookout. The potholes were clearly created by turbulence within the rapids, now calmed by the hydro dam, during an earlier phase of the Ottawa River.

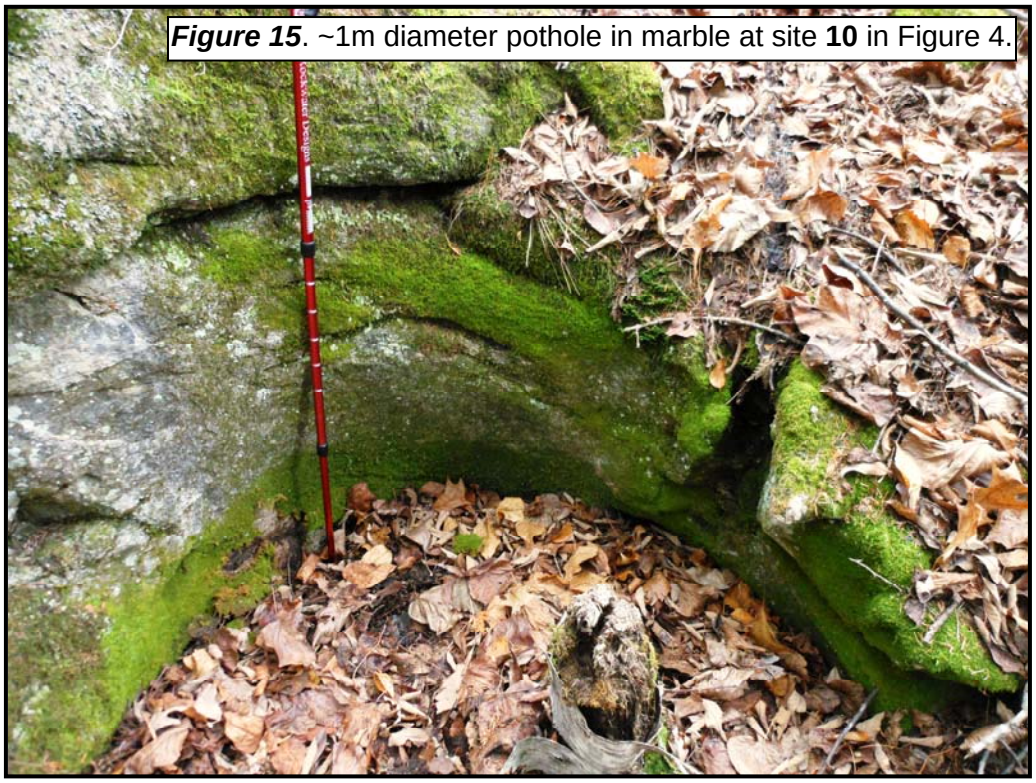

***Figure 15***. ~1m diameter pothole in marble at site **10** in Figure 4.

The head pond water level and the inland potholes indicate that both the water level and the circulating energy of the ancestral Ottawa River were once much higher than the present (see, for example, Cummings et al, 2011).

***Surficial deposits***

On the MICA surface, rounded silicate boulders, mainly one to two feet in diameter, bolster a very thin sandy woodland soil. None of the boulders are derived from the bedrock they cover. The absence

***Figure 16***. Lag deposit. Low water (right) reveals a sorted boulder field left by an earlier phase of the Ottawa River off the eastern Chats Falls Trail. The field provides a model for areas of the MICA before soil was established. Photo courtesy City of Ottawa.

of cobbles and pebbles suggest the boulders represent a “lag” deposit left by a larger and much more active phase of the Ottawa River that removed the smaller grain size sediment. Figure 16 shows boulders (left) from fields (right) off the eastern Chats Falls trail that provide an idea of what the MICA

surface may have looked like before forest soil developed. Similar boulders have been arranged as a border for part of Old Voyageur Trail (Fig. 17**a**).

Larger boulders exceeding 1 meter across (known as erratics) rest along the MICA trails (Fig. 17**b**).

***Figure 17***. Boulders of diabase (**a**) and deformed and intruded granitic gneiss (**b**) are only two of the many rock types that make up the Canadian Shield and have armoured the forest floor to help retain the thin soil of the MICA.




***Figure 18***. **a**: Top view of stromatolite structure in a boulder on Miners trail. **b**: side view of the boulder. Note the layers in b are convex down, suggesting the structure is inverted relative to the original growth orientation.

The composition of the boulders indicates that glacial activity has deposited most of the rock types that form the Canadian Shield from porphyritic black igneous rocks (Figure 17**a**, probably in diabase dykes) to granitic gneiss deformed and intruded by quartz-feldspar (pegmatite) dykes (Figure 17**b**). The extremely thin soil of the MICA contrasts with the much thicker clay and sand soils a few kilometers to the south near Galetta. The boulders are derived from most types of predominantly metamorphic and igneous crystalline rocks of the Canadian Shield. More rarely, a few boulders clearly represent the much softer Ordovician (about 470 million year old) dolomitic mudstones from the Beekmantown sediments that outcrop immediately downstream of the hydro dam in Fitzroy Harbour Provincial Park.

Figure 18**a** shows a horizontal cross section of a stromatolite structure in a trail bed boulder; Figure 18**b**, a vertical section from the side. Since the stromatolite normally forms a convex up structural form, the block is probably overturned relative to its original position while growing.

The domed, laminated, circular-shaped stromatolite structures are formed from successive thin mats of sediment-trapping cyanobacteria (Figs.18**a, b**). Stromatolites presently grow in abundance within the tidal zones of continental margins.

The Ordovician mudstone is younger than the Cambrian Nepean sandstones (about 500 million years) that elsewhere underlie the mudstone. However, at the east side of the Madawaska street bridge in Arnprior about 15 km to the west, the sandstone is absent and mudstone lies directly on the basement marble. Thus, resolving sedimentary and structural evidence within and adjacent to the MICA may add important constraints to the local geological history.

***Summary***

Although geological mapping began earlier, several detailed geology maps have been published for the MICA since at least 1919.

The ~ billion year old folded Grenville marble laced with harder, quartz- and feldspar-rich “silicate” minerals form the bedrock of the MICA. Deformation and ductile contrast between the two rock types is dramatically indicated by folded and stretched dykes and lenses of silicate material. The marble is overlain by small (Nepean) sandstone outcrop remnants of the sands that were deposited in a nearshore equatorial habitat about 500 million years ago. The sandstone remnants indicate the western limit of Cambrian sand deposition lies farther west than has been appreciated.

From the latest glacial period, we have not yet found clear ice contact features such as glacial striations, chatter marks and crescent gouges within the MICA. In the relatively soft marble, these surface forms may have been erased by the large water flows in the Ottawa River following ice retreat. At the MICA surface, clays of the Champlain Sea found nearby to the south are also absent, probably removed by an earlier, higher energy period of the Ottawa River that left a lag deposit of mainly boulders and erratics. None of the boulders appear derived from the bedrock they rest upon. The deposit helps retain the thin sandy soil that supports the present forest habitat. Coarse marble sand characterizes many MICA beaches.

Circular to elliptical potholes were formed by turbulent currents in an earlier stage of the Ottawa River. Potholes formed both in sandstone and in the softer basement marble at water levels above and below the present hydro head pond surface. The potholes indicate that the water level was, as a minimum, about 5m higher than the present head pond surface (or about 20m above the original rapids at the Chats Falls dam) and the circulating energy of the ancestral Ottawa River across the MICA was much higher. The topography and morphology of areas adjacent to northeastern Chats Falls trail and the adjacent head pond may largely result from pothole formation and subsequent collapse.

The rapids that preceded the Chats Falls dam formed as a result of water passing over a geological structure crossing the Ottawa River near the MICA. We suggest the apparent concentration of potholes within and offshore of the MICA have been produced by turbulent currents as water was forced over and around this structure. Might further study of these structures and material within the potholes place constraints on the post-glacial history and the development of the Ottawa River?

The hiking trails and canoe routes within and adjacent to the MICA provide easy access to see and study all of the features described here.

We suggest further study of:

1. small, unmapped, remnant outcrops of very clean, probably Nepean (Potsdam), sandstone,
2. the age and significance of apparent pothole controlled geomorphology and the potholes formed in both Nepean sandstone and Precambrian marble basement upstream of the Chat Falls dam,

and

3. deformation exhibited in folded and stretched dykes and bodies of silicate material

will provide new constraints on the geological history of the MICA and evolution of the Ottawa River.

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***Further reading:***

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