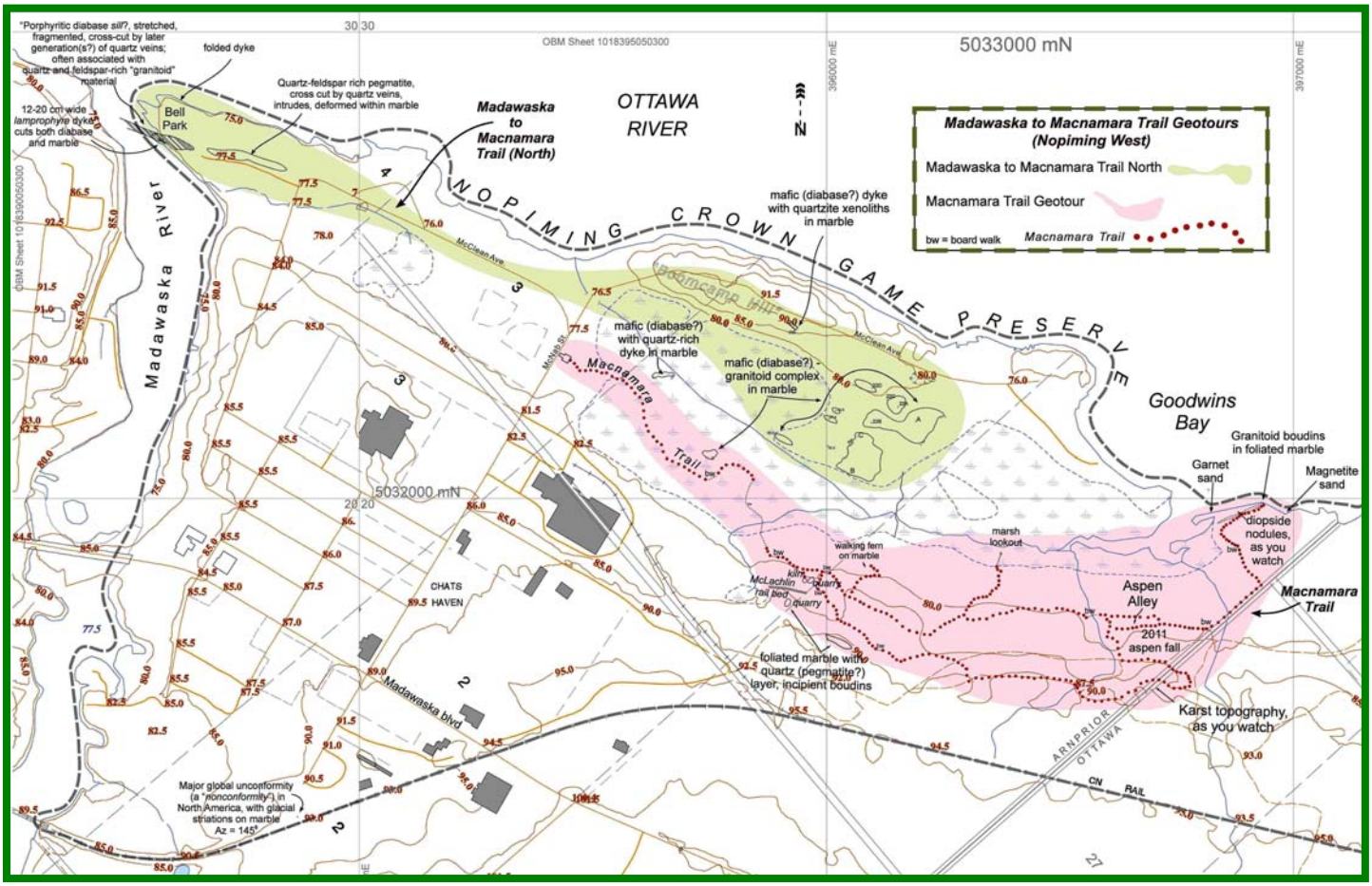
Madawaska to Macnamara Trail and Macnamara Trail Geotours



Dedicated to the hope that the pages of Nopiming's geological history will be a little less blank

Suggested citation:
Forsyth, D.A. and Forsyth, M.E. 2013. Madawaska to Macnamara Trail and Macnamara Trail Geotours. Macnamara Field Naturalists Club: www.mfnc.ca

You are free to Share — to copy, distribute and transmit the work. You may not use this work for commercial purposes. You must attribute the work in the manner specified by the authors (but not in any way that suggests that they endorse you or your use of the work). You may not alter, transform, or build upon this work**.**

Madawaska to Macnamara Trail and Macnamara Trail Geotours

Introduction

These tours examine 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

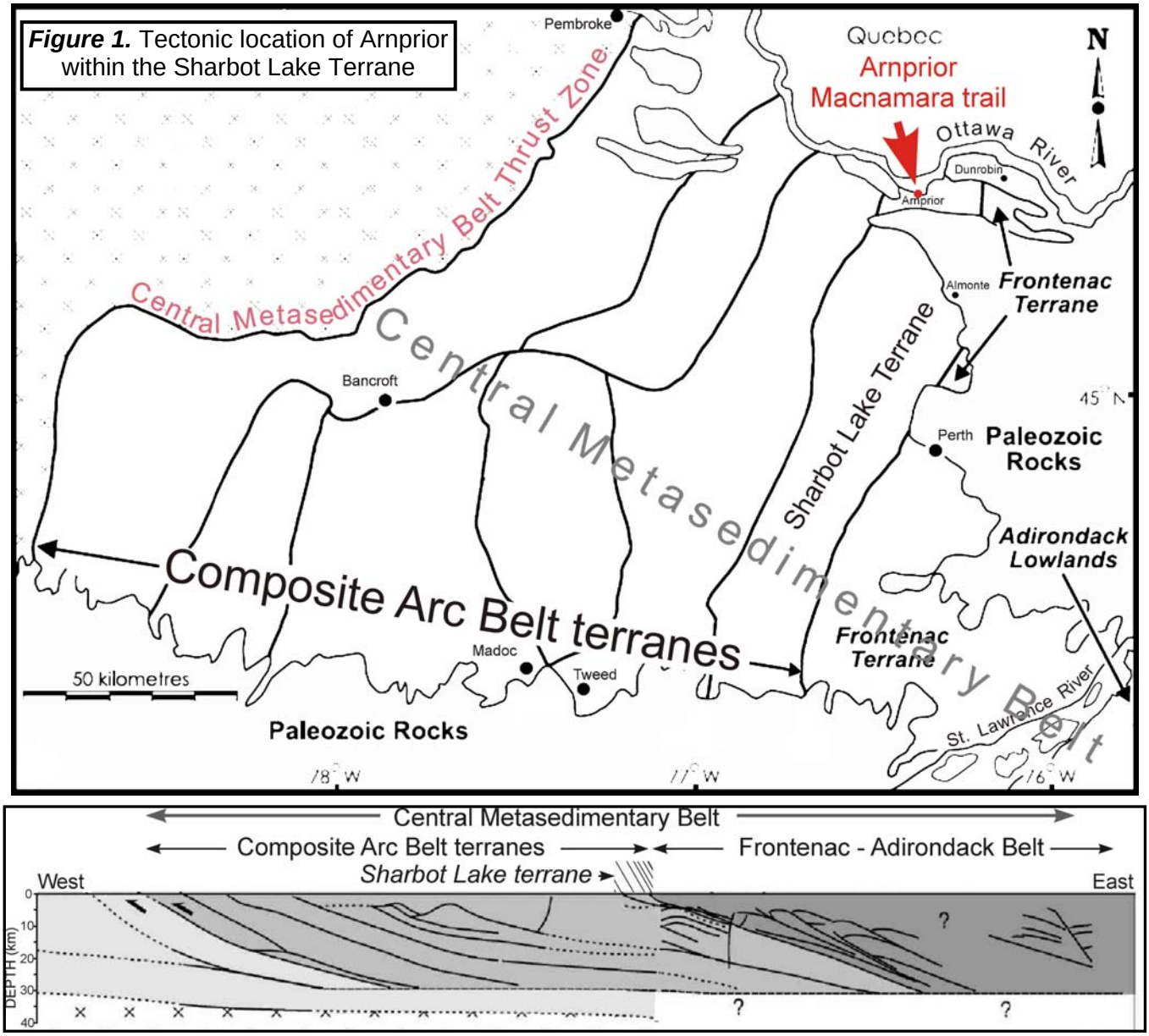


Figure 1. Tectonic location of Arnprior within the Sharbot Lake Terrane

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

Earth's crustal structure (Fig. 2) derived from seismic sections shows the terranes are the exposed edges of crustal slices thrust to the northwest over older parts of the Canadian Shield.

Those exploring the colourful world of marble mineralogy will welcome Arnprior's metamorphic geology. The rounded form of the softer host carbonates (calcitic and dolomitic marble), is readily distinguished from the harder, sharply angular outcrops of the secondary granitic and mafic silicates.

On the Madawaska to Macnamara Trail tours (Fig.3), superb examples of folded dykes with chilled margins, dykes pulled apart within the deformed marble, granite-cored boudin structures, sparkling crystals in nodules emerging from the dissolving marble and karst forming as you watch, are evident. The tours provide a glimpse into the contrast between mafic and granitoid material within the prevailing marble, their dramatic ductile difference and the effect of rock type in producing the present land forms.

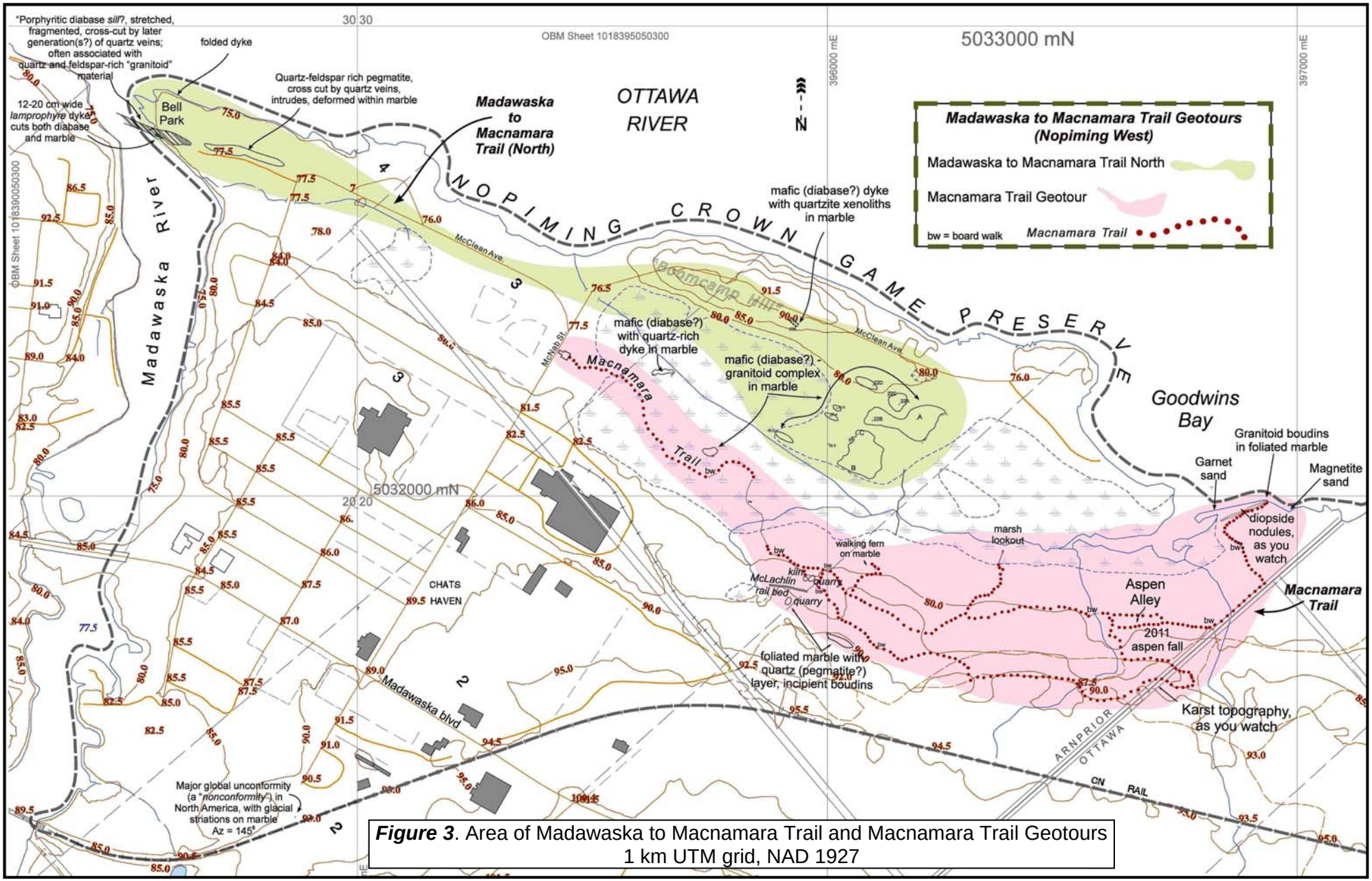


Figure 3. Area of Madawaska to Macnamara Trail and Macnamara Trail Geotours
1 km UTM grid, NAD 1927

Madawaska to Macnamara Trail Geology

Geology maps of Arnprior (Fig.4) include Geological Survey of Canada (GSC) maps 1739 and 1363A - printed in 1919 and 1974 respectively - and map 2462 from Ontario Geological Survey (OGS) Report 212 published in 1982. Recent maps 1363A and 2462 do not differ greatly. Except for the distribution of incorporated "granitoid" silicate material (quartz + feldspar + accessory diopside, tremolite, garnet and other minor minerals), the maps agree in showing Arnprior rests mainly on metamorphosed, deformed marble.

Both the 1919 map and Charles Macnamara agreed in showing the distribution of Ordovician "dolomite" sediments extended to near the Madawaska River north of the CNR (red line is true - an error on map 1363A). The dolomite/marble contact (units 01/A3) was clearly recognized in 1917 by M.E. Wilson on GSC map 1739. Subdivision development south of Madawaska Boulevard has recently removed some of this contact. The intrusive and other quartz-rich "silicate" exposures on map 1739 are also missing on the later maps.

Note that map 1739 made from work in 1917 includes the surficial clay cover and differs from the strictly "bedrock" maps made later.

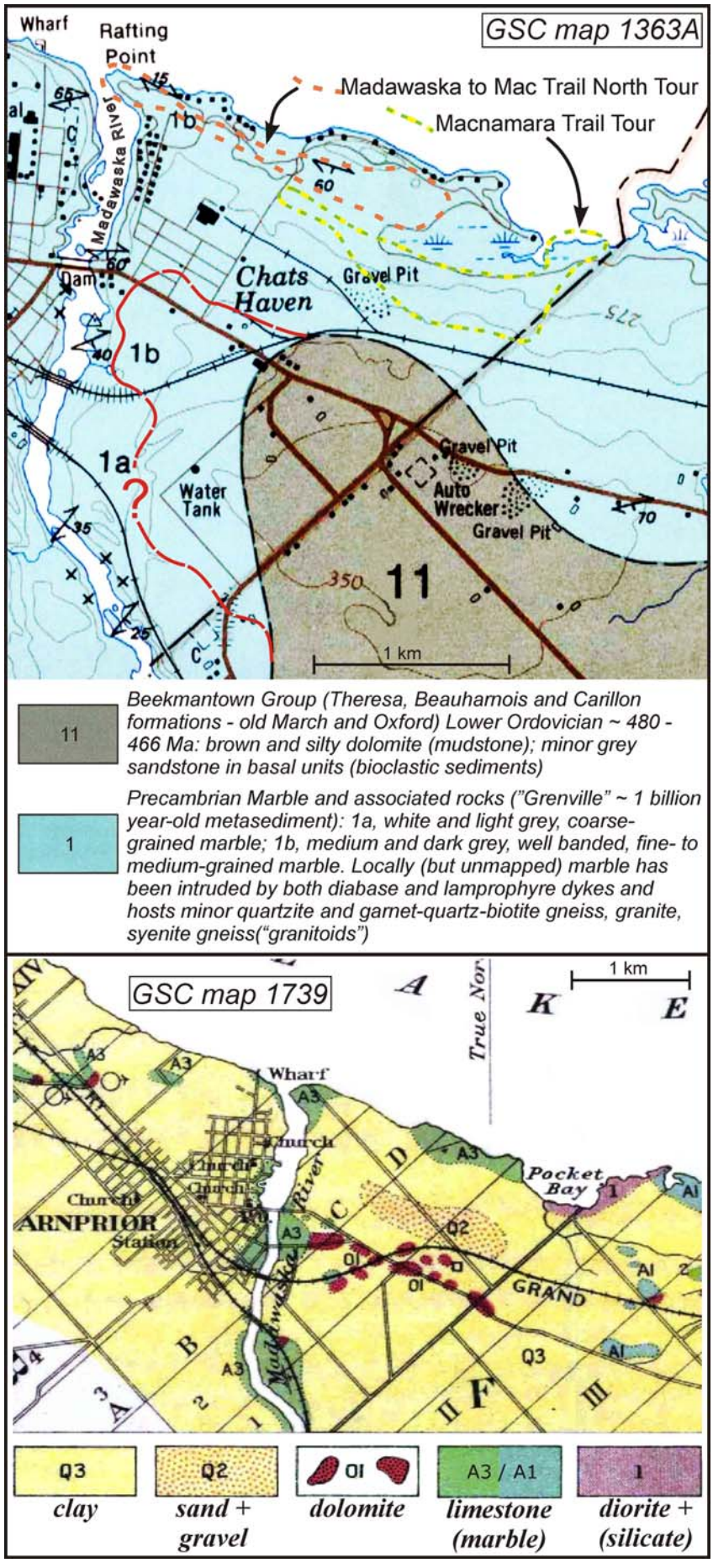


Figure 4. Arnprior geology from GSC maps 1363A (top) and 1739. Note the *Unit* 11 dolostone sediments on 1363A should extend to the red line as indicated by the "dolomite" on map 1739.

Madawaska to Macnamara North

Along the Ottawa River (Fig.5), outcrops in Bell Park illustrate the effects of intrusion and later deformation of the ductile, "plastic" marble and mafic rock complex. Near the intersection of the Madawaska and Ottawa rivers, the marble envelops a large body of rusty black magnesium- and iron-rich (mafic) rock (Fig. 6). White, quartz-rich granitic rock is found in contact with, or forms veins in, the mafic material. The Bell Park

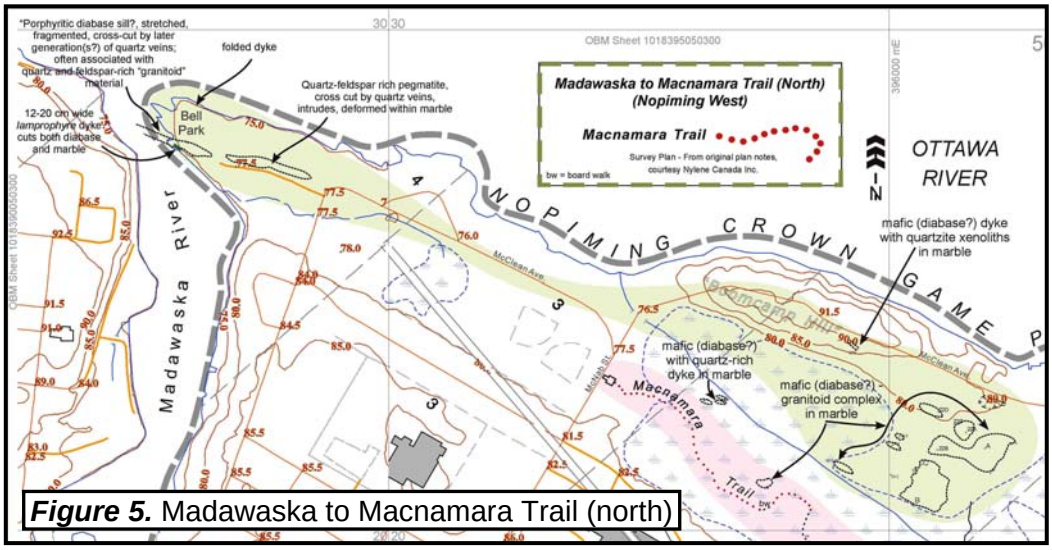


Figure 5. Madawaska to Macnamara Trail (north)

Figure 6. Ductile marble has enveloped the mafic (porphyritic) diabase that forms a hill where the Madawaska joins the Ottawa River. This resistant block helps explain the intersection.

body may have been a diabase sill with appendage dykes that intruded both the granitic rocks and marble. Diabase is a fine grained, intrusive igneous rock rich in magnesium and iron ("mafic") and poor in quartz and feldspar. In addition to deformation along with the marble, the body has been subjected to intrusion and development of quartz veins indicating a complex history. Since the mafic and quartz-rich rocks remain rigid at lower temperatures (600-700^{0}C) and pressures (6-9 kilobars or ~ 87000-130,000 psi) that are sufficient to make marble ductile, the marble has wrapped around and into the blocky surface of the brittle

components (Fig. 6, inset).

As the marble stretched in a direction that parallels the present Ottawa River shoreline, brittle, rectangular pieces drawn from the parent body were left as chains of isolated, often apparently folded blocks in the more "plastic" marble (Fig.7). Details in the marble show that deformation was "left lateral" or "sinistral" to produce the observed off-set and rotated diabase blocks. Some 50 meters north of the diabase hill, the Ottawa shoreline displays a folded dyke with apparent chilled

Figure 7.
Top: West end of diabase body. Brittle mafic blocks have been drawn from the larger body to form chains of rectangular inclusions with positive relief in the ductile marble.

Bottom: Many examples of local sinistral displacement (arrows) have combined with the more westerly compression to produce the observed component geometry.

margins in deformed marble (Fig. 8). The dyke closely resembles a dyke within the marble of the Morris Island Conservation Area to the east. Similar Precambrian (Neoproterozoic) forces probably shaped

Figure 8. Comparison of intricately folded silicate bands in marble near Marshalls Bay with simpler flexures near the Ottawa-Madawaska intersection and at Morris Island. The Marshalls Bay image of 'Silicified limestone" was taken by Charles Macnamara in 1930 and may be under the Chats Falls reservoir. CM = Chilled Margin

the marble terrane between the Madawaska at Arnprior and the Morris Island Conservation Area. Compare the chilled margins on the diabase from Arnprior and Morris Island (Fig. 8) compared with the margins of

the mafic body and appendages in Figures 6 and 7.

While the diabase originated as a dyke or perhaps a sill intruded into marble, both the diabase and marble are intruded by a thin Lamprophyre dyke rich in biotite, a mineral that erodes readily. The lamprophyre dyke (Fig. 9) therefore weathers recessively relative to the host diabase, another of the many interesting features within the diabase hill.

Figure 9. Recessive lamprophyre dyke intruding porphyritic diabase, Bell Park.

Lamprophyres are only one type of hypabyssal intrusive rock, rocks that have been generated from very deep in the Earth's crust or upper mantle. They may originate as very fluid intrusions that are emplaced at temperatures of about 1000^0C. Like at Bell Park, most occur as small, biotite-rich dykes and are minor elements of a given map-area. A similar suite of micaceous rocks known as kimberlites (pipes) are the principal host for diamonds on the planet. Lamprophyres have been found that contain micro diamonds of sub-millimetre scale.

Before development, the route of McLean Avenue from Bell Park to Boomcamp Hill was wetland left by subsiding Madawaska and Ottawa Rivers. East along McLean Avenue, the eastern crest of Boomcamp Hill features a ~1 meter wide mafic dyke within the foliated marble (Fig. 10.). The dyke strikes N 47 W and contains angular pink quartz xenoliths (upper left)

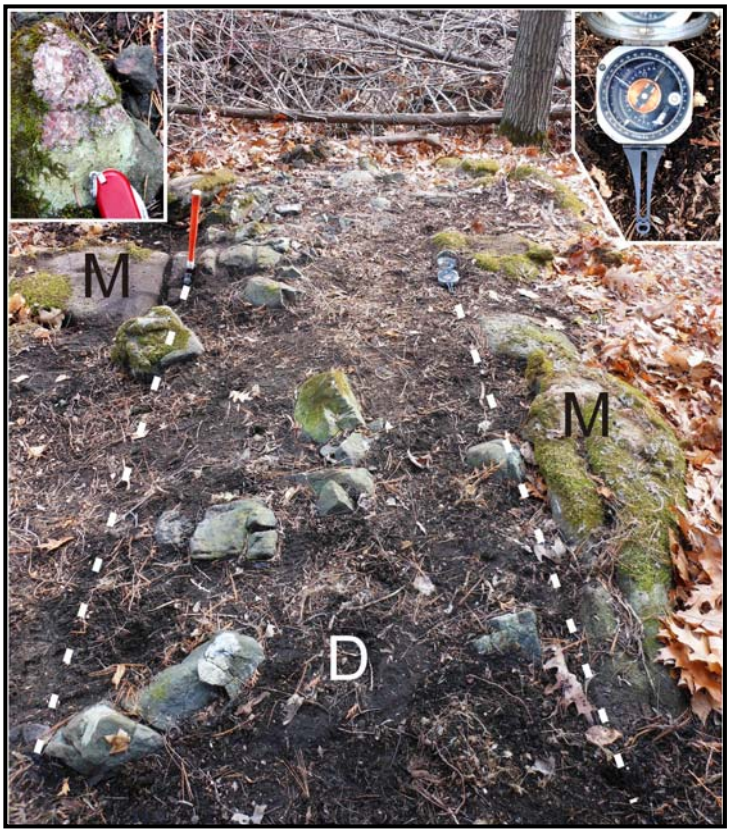


Figure 10. Angular blocks reveal a ~1 metre wide mafic dyke (D) within the rounded weathering marble (M). The dyke contains angular pink quartz xenoliths collected by the dyke during ascent (top left).

collected along the dyke's ascent through the Earth's crust.

The hills east of Boomcamp Hill, although as high as Boomcamp Hill, have curiously escaped the current 1:10,000 scale OBM topographic map but are clearly indicated on 1:2,000 out of print maps (Fig. 11). The hills are actually resistive knobs of mafic and granitic rock (Figures 11 and 12).

At the X in Fig. 11, the outcrop in Figure 12 of folded interlayered mafic and marble rocks is similar in form to the 1930 image of "silicified limestone" by Charles Macnamara at Marshalls Bay in Figure 8. Hill tops are also decorated with sub-meter scale blocks of Ordovician dolostone suggesting the present erosional level lies near the Precambrian-Paleozoic nonconformity.

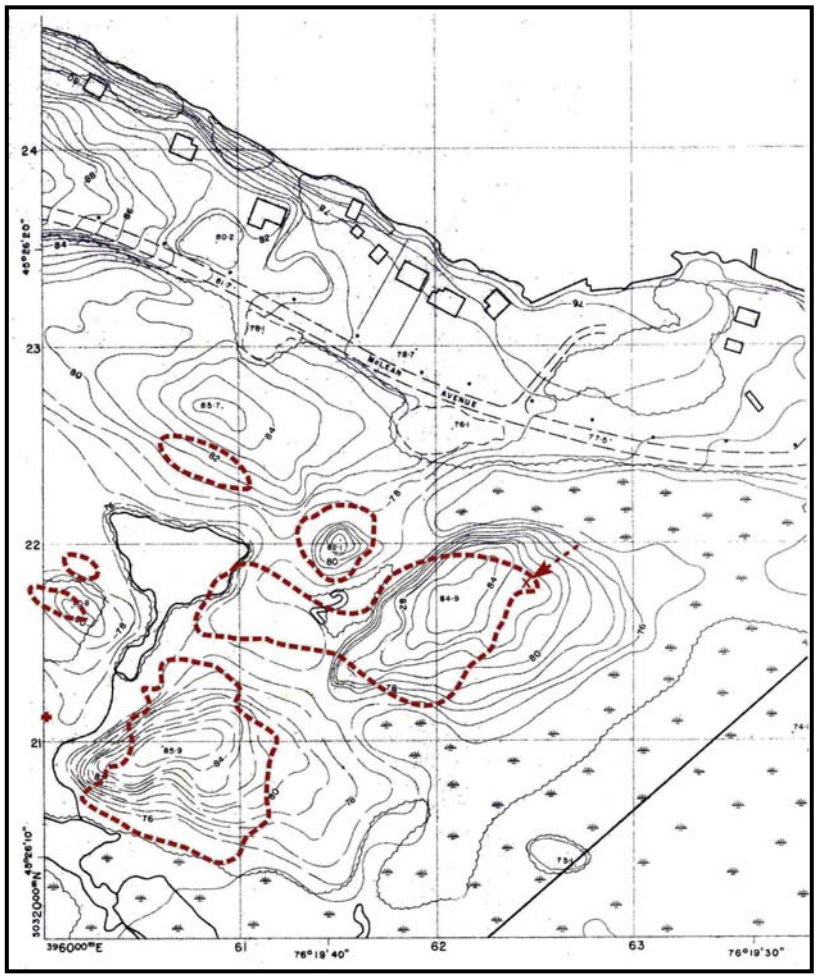


Figure 11. Field mapping and out of print 1:2000 Ontario Base Map sheet 02 18 3960 50320 show the hills south of McLean Avenue are mafic bodies (dashed red). Figure 12 at red X (arrow).

Figure 12. Folds of mafic rocks (diabase?) in marble east of Boomcamp Hill at X in Figure 11.

Macnamara Trail

Forestry, industrial activity beginning in the 1800s and inundation by hydro has produced the present landform, more significantly for the first ~300 meters of the trail (Fig, 13). In a caption for his picture of the nearby area in 1943, Charles Macnamara wrote: *"The wood cut on the Boom-camp Trail, which despite promises has been destructively cut as usual."* By this time the earlier forest had already been lumbered and successor hardwoods were being cut as firewood. That habitat evolves today.

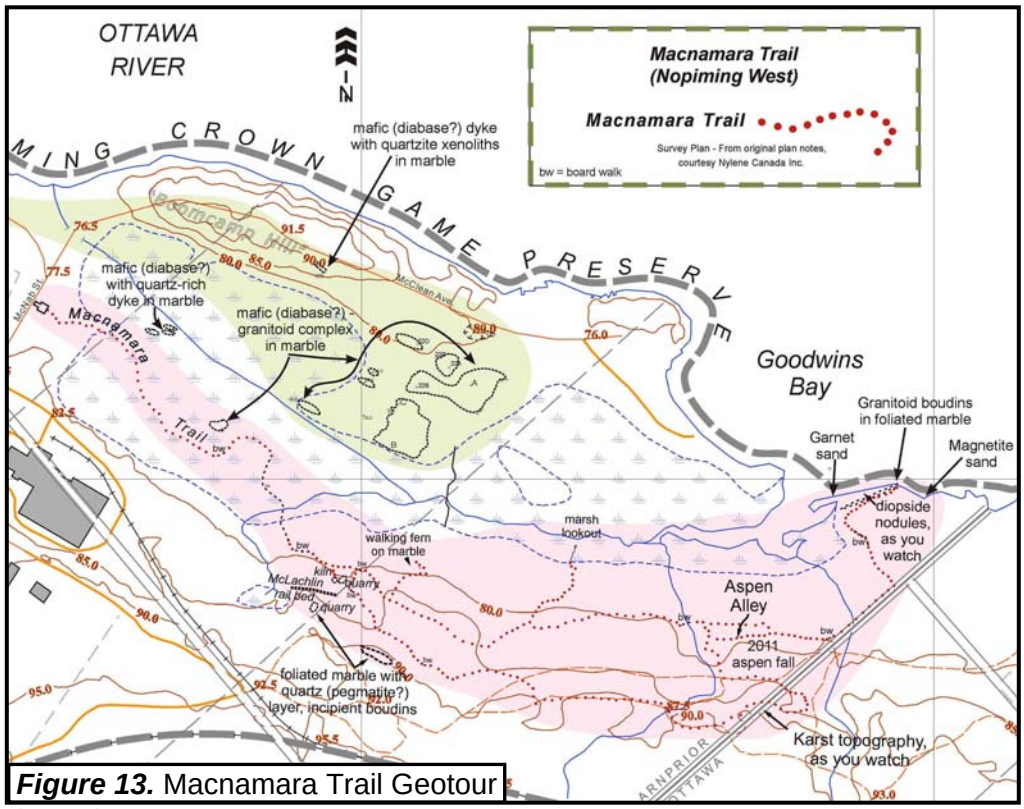


Figure 13. Macnamara Trail Geotour

About 200 meters from the parking lot and a short detour north, a group of white cedar, spruce and balsam fir are keeping their feet dry in the wetland atop east-west trending knobs of mafic rocks,

Figure 14. A quartz-rich pegmatite dyke (**Q)** cuts a mafic body (**M**) in the wetland near the start of the Macnamara Trail.

(possibly diabase) similar to the rocks seen just to the north along McLean Avenue. The central knob is bisected by a meter-wide, quartz-rich peg-matite dyke (Fig. 14). The strike of the pegmatite dyke is N25E.

Crossing the first boardwalk the trail rises along a mafic and granitic bedrock knoll (Fig. 15) wrapped by more recessive marble underlying the surrounding wetlands. The knoll is an outlier of the hills across the marsh to the north in Figure 1. Here, like most of the Ottawa River shoreline, the resistive mafic and silicate rocks are responsible for nearly all of the upland knolls.

Figure 15. Mafic-granitic contact, Macnamara Trail

East of the main boardwalk, marble spiked with quartz-rich granitic layers, has been used to build a kiln (Fig. 16). The kiln may have been used with two quarries, one on either side of a segment of rail bed, all apparent remnants from the McLachlin era (**b** in Figure 16).

Quarrying appears to have involved a “pin and feather” operation using holes drilled, perhaps by hand, followed by splitting the rock by pounding a metal wedge or “feather” into the hole. The quarry beside the kiln appears to have more and smaller holes drilled at a closer spacing than in the quarry across the rail bed to the south (**d** and **e**, Fig. 16).

A granitic dyke (**G**, Fig. 16) forms much of one wall of the quarry south of the rail bed. While the position of the rail bed coincides closely with maps and 1927 air photographs of the McLachlin yards, the history of the quarries and kiln remains illusive.

Was marble (as opposed to limestone) roasted for lime or were quarries developed mainly as sources for rail bed ballast?

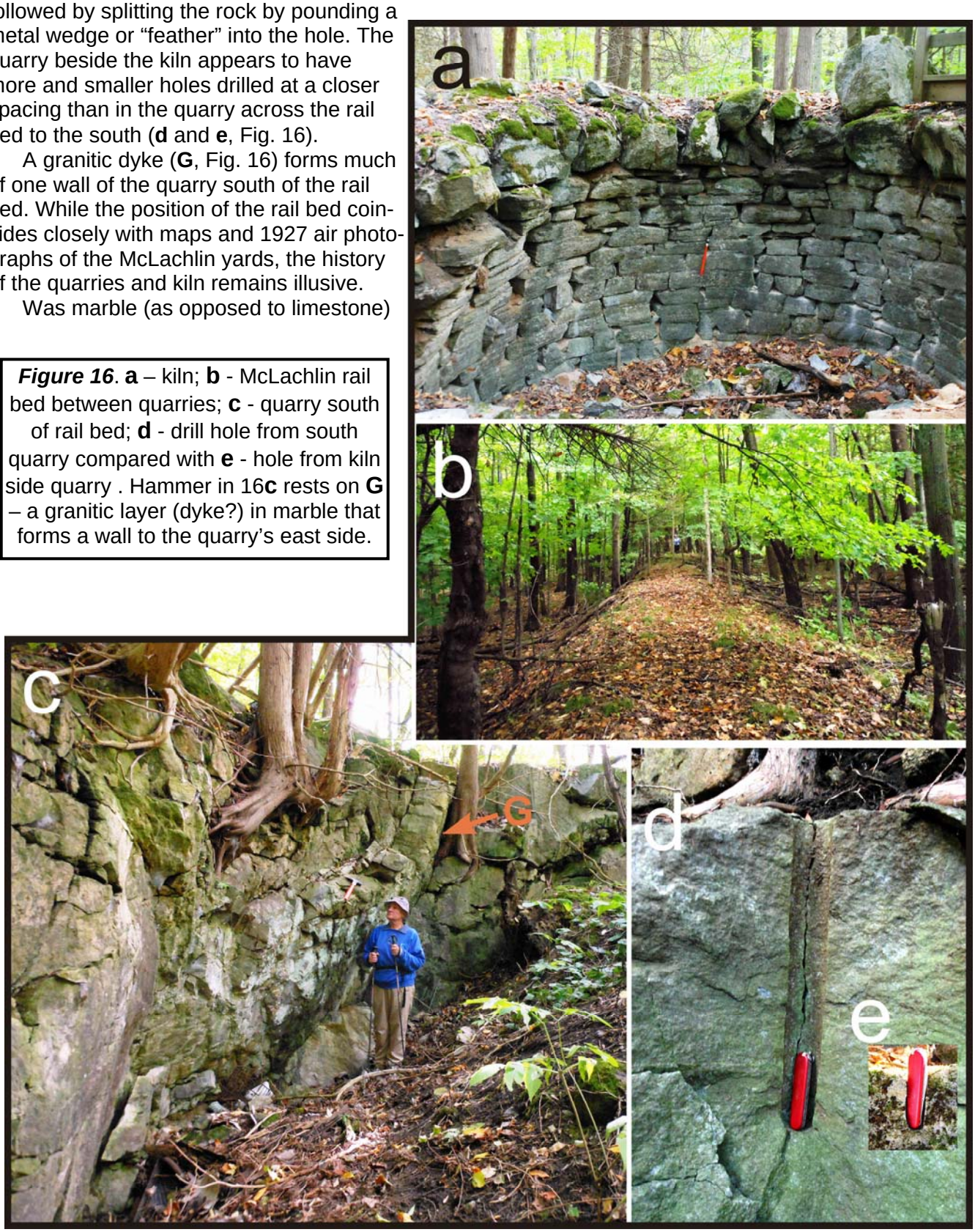


Figure 16. **a** – kiln; **b** - McLachlin rail bed between quarries; **c** - quarry south of rail bed; **d** - drill hole from south quarry compared with **e** - hole from kiln side quarry . Hammer in 16**c** rests on **G** – a granitic layer (dyke?) in marble that forms a wall to the quarry’s east side.

Past the kiln, trail branches extend to the south and to the east. To the south, continuing uphill past the first boardwalk leads to another outcrop with a quartz-rich layer in marble that extends for tens of meters along the brow of the hill (Fig. 17). As the more ductile marble deformed, the weakening support for the

Figure 17. Quartzite layer in marble at hilltop. As the quartzite cracked, the more ductile marble began to deform into the fractures (white arrows) and has completely separated the quartzite blocks at the hammer.

more brittle quartzite produced cracks in the quartzite and has completely separated the layer into blocks at the hammer head in Figure 17. Note the similarity to the stretched diabase blocks in deformed marble in Bell Park. A larger, similar version of a resistant silicate layer also occurs at lower elevation within the 2011 large tooth aspen fall just south of Aspen Alley. The general stepped hillside topography beneath most of the Macnamara Trail appears to result from a thin mantle of glacial till over this bedrock structural fabric.

Farther east, at the hilltop part of the trail loop that extends into Ottawa, deep cavities in marble attest

to ongoing karst development (Fig. 18) and the possibility of paleokarst (older, filled) cavities. Looking back from the bottom of the loop, you can appreciate the cavities extend to at least the height of the hill. Karst and possibly older paleokarst structures may continue much deeper. Apparent Champlain Sea clay has been found in open fractures at depths of about 250 feet in a borehole beneath southwestern Arnprior.

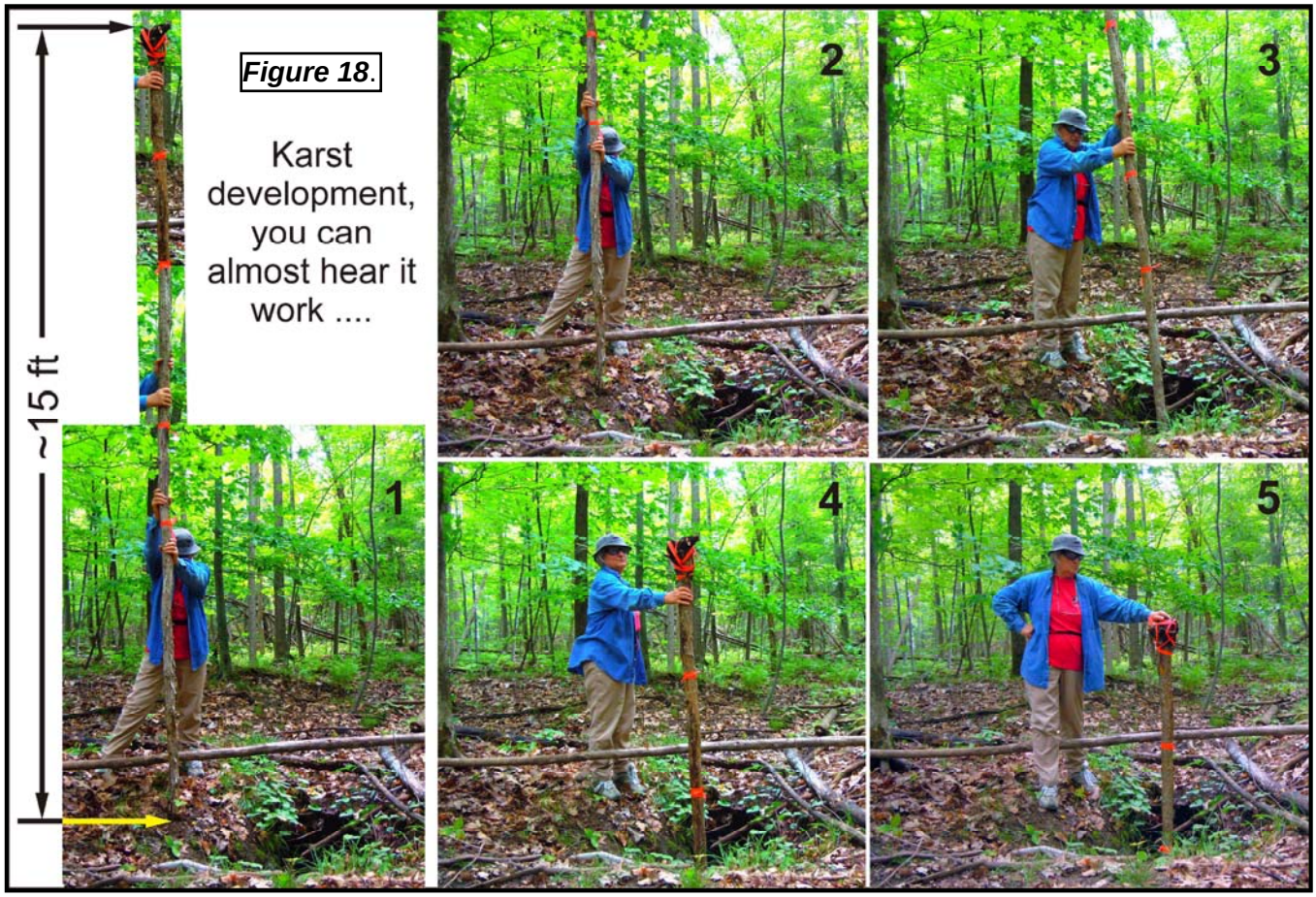


Figure 18.

Back at the kiln, the trail also branches to the east. Taking the path to the walking ferns, you will note that the rounded blocks beneath the calciphilic ferns is marble while the immediately adjacent, sharply angular block is mainly quartz (Fig. 19). The ferns know.

Figure 19. Note that the walking fern is growing on rounded outcrops of marble while the adjacent sharply angular block (under hammer) is composed mainly of quartz.

At the beach areas along the Ottawa River, several features await you. Near the entrance to the marsh, distinct purple layers characterize the nearshore sand. Hand lens study reveals the layers are formed by grains of pure garnet. This contrasts with the black layers in sand from the bay beyond the east end of the Macnamara Trail from which your magnet will lift conspicuous trains of magnetite grains.

Along the rocky shoreline with no beach, bands of small crystals of probable tremolite mark the foliation structure. The grains act as studs that make walking on the rather steep shoreline easier than expected. Locally nodules rich in tremolite, diopside and pyrite are emerging from the marble dissolving (Fig. 20) with each wave and storm – effectively as you watch.

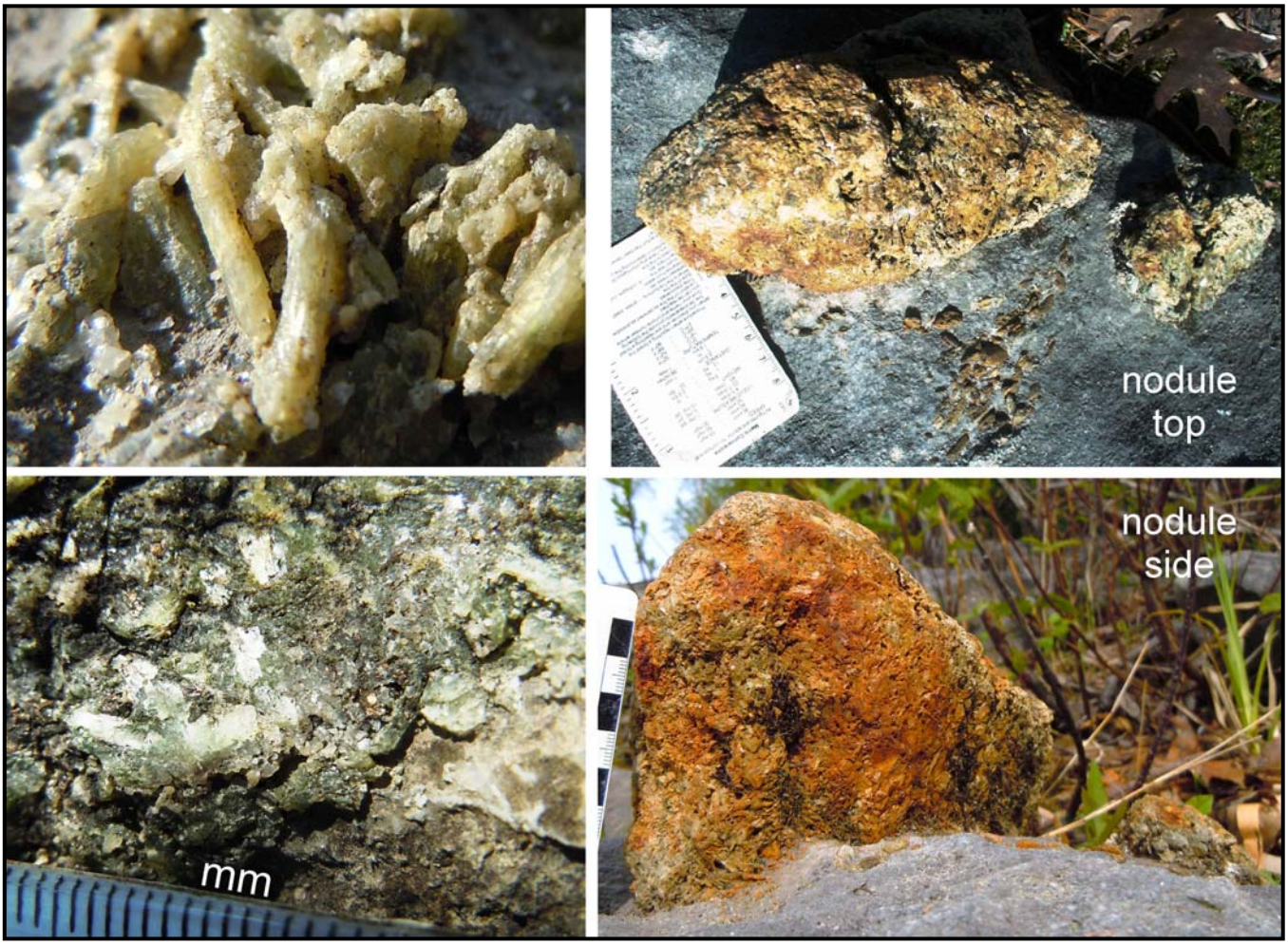


Figure 20. Left: tremolite, diopside, pyrite are among several minerals in the suite making up the mainly silicate nodules (Right) emerging from the dissolving marble.

At the eastern end of the Macnamara Trail, more dramatic evidence of silicate incorporation into the more ductile marble appears. Large pinch and swell forms of deformed marble wrap around more brittle, meter-scale, granitic fragments (Fig. 21). The structures form a string of boudins (French culinary term for sausage) extending west to the mouth of the marsh. The present coastline elevation is determined by the water level set at the Chats Falls hydro dam near Fitzroy Harbour. The granitic boudins extend along this erosional contour for over 100 meters and effectively control the present shoreline.

Locally near the boudin boundary and in fractures within the boudins, reactions have produced a variety of classic crystals including quartz, slender, triangular, black tourmaline and green minerals, possibly diopside or apatite, growing within a mud coloured calcite crystal matrix (Fig. 22).

Figure 21. Close to the shoreline, a chain of meter-scale granite boudins in marble extends for over 100 meters at the end of the Macnamara Trail.

Figure 22. Crystals from reactions at the boudin boundary include quartz, black tourmaline and green minerals (apatite?) within mud coloured calcite.

Summary

A good geology map of the northwest corner of Nopiming was published in 1919 and available to Charles Macnamara. As part of the marble-rich Sharbot Lake Terrane, the Madawaska to Macnamara Trail area displays many of the deformational features seen along the southwest margin of the Composite Arc Belt – a major tectonic subdivision of the Grenville Province.

The Ottawa shoreline from Bell Park to the end of the Macnamara Trail is underlain by ~billion year old, metamorphosed, folded, Grenville marble laced with silicate crystals, inclusions and intrusions. The ductile difference between the two rock types provides dramatic contrasts in deformation that is very apparent in outcrop. A banded fabric of harder metamorphic, particularly silica-rich minerals, protrude from the surface of the softer marble host. Intrusion and inclusion has left folded dykes, granitic boudins and deformed diabase masses. Thin hilltop caps of Ordovician mudstones from an equatorial coastal habitat some 460 million years ago suggest that erosion has locally paused near the Precambrian-Paleozoic nonconformity.

The harder elements in the Grenville structure may have guided glacial and post-glacial erosion to leave northwest-southeast trends to hills and shoreline geography. Many of the topographic steps in the Macnamara Trail area coincide with quartz-rich bands in the marble host rock. Clear ice contact features such as glacial striations, chatter marks and crescent gouges have not yet been documented in the tour areas, but do exist to the south and west within Nopiming and Arnprior. In the relatively soft marble, these surficial forms may have been erased by the large water flows in the ancestral Ottawa and Madawaska rivers. Some mafic cored hills suggest a roche moutonnée shape with steeper westerly faces and gradual slopes to the east. These forms are not in obvious agreement with observed striations a few km to the south.

Karst development is underway along the Macnamara Trail. Paleokarst structures may also exist.

The present habitat is evolving from a legacy of forestry and industrial development. Data on the kiln, quarries and rail bed would fill gaps in the history of this part of Nopiming.

The walking ferns on marble illustrate a relationship between biosphere and geosphere. More detailed observation, both along shorelines and within the forested areas, will clearly add significantly to the Nopiming story. Charles Macnamara might not be surprised.

***Acknowledgements*:**

Mr. G. Vogg, Dr. J. A. Donaldson, Dr. G.R. Dix, Dr. R. Rainbird, Dr. A. LeCheminant, and Mr. S. Watters for instructive insight and discussions during field trips to Arnprior area sites.

Further Reading*:*

Arnprior Archives**,** Charles Macnamara fonds, **J9.1 - J12.9**

Dix, G.R. and Rodhan, Z.A. 2006. A new geological framework for the Middle Ordovician Carillon formation (uppermost Beekmantown Group, Ottawa Embayment): onset of Taconic foreland deposition and tectonism within the Laurentian platform interior. Canadian Journal of Earth Sciences, 43, p.1367-1387.

Dix, G.R. and Robinson, G.W. 2003. The geochemical record of hydrothermal mineralization and tectonism inboard of the Appalachian Orogen: the Ottawa Embayment. Chemical Geology, 197, p. 29– 53.

Goodwin-Bell, J.S. 2008. Delineation of isograds in siliceous dolomitic marbles along the Sharbot Lake – Frontenac terrane boundary of the Grenville Province, southeastern Ontario. Canadian Journal of Earth Sciences, 45, p. 669-691.

White, D.J., Forsyth, D.A., Asudeh, I., Carr S.D., Wu, H., Easton, R.M. and Mereu, R.F. 2000. A seismic-based cross-section of the Grenville Orogen in southern Ontario and western Quebec. Canadian Journal of Earth Sciences, 37 p.183–192.

M.E. Wilson, 1919. Geological Survey of Canada map 1739. Portions of Bristol, Onslow, McNab, Fitzroy and Torbolton Townships, Quebec and Ontario. Map to accompany GSC Memoir 136 by M.E. Wilson. Scale 1 inch: 1 mile.

See http://www.turnstone.ca/lampro.htm for more on the nature and significance of Lamprophyres.