Location 1 - between 9 am & 1 pm, Saturday

Canadian Wollastonite (St Lawrence Wollastonite deposit)
6675 Ontario Highway 15, (Seely's Bay) Kingston
Latitude & Longitude: 44°27'57.3"N 76°15'17.1"W
Latitude & Longitude (Decimal Degrees): 44.465923, -76.254750

Dating: Central Metasedimentary Belt, Grenville Province - Meso Proterozoic 1.6 - 1.0 Ga

The Frontenac terrane (regional geology):
- accretionary activity & thrust faulting granulite facies regional metamorphism occurred 1240-1180 Ma,
- regional & contact metamorphism occurred 1150-1175 Ma,
- magmatism occurred 1160-1175 Ma,
- compressional & extensional events (including diabase dykes) occurred 1000-1100 Ma
- Kingston N-S dyke swarm occurred 900 Ma

Geology

Canadian Wollastonite St. Lawrence Deposit (Ontario Ministry of Northern Development and Mines)
& The St. Lawrence Wollastonite Deposit (website)

- The St. Lawrence Wollastonite deposit is composed of calc-silicate and silicate skarn layers interbanded and strongly folded within enveloping quartzite.
- The southern boundary of the skarn is in thermal metamorphic contact with a gabbroic intrusive, which has a syenitic and late pyroxenite phase.
- The deposit has undergone granulite facies metamorphism.
- The average mineral content consistently associated with the wollastonite is:
  - diopside/hedenbergite 40%,
  - feldspar (predominantly albite with relatively minor microcline) 10%,
  - quartz 5%,
  - calcite trace <2%,
  - sulfides (pyrrhotite and pyrite) <1%
  - garnet, graphite, phlogopite trace <1%.
- As wollastonite decreases, feldspar content increases.

St Lawrence Wollastonite Deposit, Pittsburgh Township, Frontenac County, Kingston, Ontario (mindat)
Mineral List: Albite, Calcite, Diopside, 'Garnet', Graphite, Hedenbergite, Microcline, Phlogopite, Pyrite, Pyrrhotite, Quartz, Wollastonite

Geologic Occurrence:
Wollastonite may also be produced in a diffusion reaction in skarn, it develops when limestone within a sandstone is metamorphosed by a dike, which results in the formation of wollastonite in the sandstone as a result of outward migration of Ca. (Wikipedia - Wollastonite)

The St. Lawrence deposit, Seeley's Bay, SE Ontario - A major wollastonite skarn in the Frontenac Terrane; T.A. Grammatikopoulos, A.H. Clark, B. Vasily; Industrial Minerals Bulletin: 2003

The St. Lawrence deposit is a large wollastonite skarn adjoining the gabbroic-to-syenitic Leo Lake pluton in the granulite facies Frontenac Terrane of the Grenville Central Metasedimentary Belt. It occurs within a horseshoe shaped horizon of quartzite, open to the east.
The skarn extends over 1.2 km², and comprises of wollastonite-dominant, wollastonite-clinopyroxene, and diverse quartz-feldspar-sulphide(-titanite) layers, interbanded with, and strongly folded within, the quartzite.
Location 2 - between 1 & 5 pm, Saturday
Grenville Province - Frontenac Lead Mine - occurrence @ 1388 Norway Road

Latitude & Longitude: 44°28'00.2"N 76°30'27.0"W
Latitude & Longitude (Decimal Degrees): 44.466272 -76.507472

**Dating:** Central Metasedimentary Belt, Grenville Province - Meso Proterozoic 1.6 - 1.0 Ga

The Frontenac terrane (regional geology):
- accretionary activity & thrust faulting granulite facies regional metamorphism occurred 1240-1180 Ma,
- regional & contact metamorphism occurred 1150-1175 Ma,
- magmatism occurred 1160-1175 Ma,
- compressional & extensional events (including diabase dykes) occurred 1000-1100 Ma
- Kingston N-S dyke swarm occurred 900 Ma

**Geology**
Applies to all 3 sites - Norway Rd occurrence plus:

*Draper Lake Road occurrence* (not visiting)
Latitude & Longitude: 44°27'53.6"N 76°31'39.9"W & Latitude & Longitude (Decimal Degrees): 44.464904, -76.527752

*McFadden Road occurrence* (not visiting)
Latitude & Longitude: 44°27'34.6"N 76°31'22.7"W & Latitude & Longitude (Decimal Degrees): 44.459612, -76.522979

**Ontario Ministry of Northern Development and Mines Number:** MD131C07NE00036

Deposit Name: Frontenac - 1982
Deposit Status: past producing mine with reserves
Primary Commodities: lead
Secondary Commodities: gold, silver, zinc

The property is located approximately 30 km north of the city of Kingston.
Between 1866 and 1905, 9,200 tons of ore were mined.
From 1916 to 1917, 38,527 pounds of lead were recovered.

**Frontenac Lead Mine (Frontenac Draper Lake Mine), Loughborough Township, Frontenac County (mindat)**

Mineral List
- Baryte
- Calcite
- Celestine
- Cerussite
- Chalcopyrite
- Galena

**Frontenac Lead Mine; H G Vennor; Canadian Geological Survey; 1869 (Internet Archive)**

- The country rock consists of grayish and reddish gneiss, interstratified with thick bands of crystalline limestone.
- The average width of veins appear to be about 10 feet (main shaft varies from 13-19 feet).
- The veinstone, which consists of calcspars only, is arranged in bands, more or less coarsely crystalline, and sometimes of a purplish or lilac colour.
- Other minerals observed were very small quantities of iron and copper pyrites and blende.
- Galena is diffused in crystals and bunches throughout the veins.

Because this question was asked - **galena is not toxic** unless you have **prolonged exposure** to mining dust and/or lead-contaminated water. At most we will be at this site for 4 hours - which does not equal prolonged exposure. If you are concerned, please wear a face mask and/or please use bottled water.

https://en.wikipedia.org/wiki/Galena

Health issues: Galena contains lead, a toxic element. **While bound to crystal structure**, the lead content of galena is of minor concern and **the mineral is safe to handle**. However, prolonged exposure via inhalation or ingestion of the pulverized dust is hazardous to one’s health.


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**Please note: The lead occurrence location is “exploratory”**

(meaning that it has never been visited and/or hasn’t been visited in a long time by any of our geology clubs).
Hence, we may be disappointed or we may be “so excited”. Please prepare yourself for both.
Location 3 - between 10 am & 3 pm, Sunday

Cambrian-Ordovician Potsdam Sandstone

@ Lansdowne Quarry site includes:
- Potsdam Sandstone
- Fossil ripple marks & trackways
- Pre-Cambrian unconformity - consisting of marble (chunky) & graphite (slivers)

Latitude & Longitude: 44°28’57.2”N 76°08’58.8”W
Latitude & Longitude (Decimal Degrees): 44.482544, -76.149674

Dating:
Potsdam Sandstone: Cambro-Ordovician - approx 500 Ma (possibly as early as 520 Ma) to 460 Ma - Late Cambrian to Middle Ordovician
Unconformity: approx 1.3 to 1.0 Ga - Central Metasedimentary Belt, Grenville Province - Meso Proterozoic 1.6 - 1.0 Ga

Geology - Potsdam Sandstone

Originally, all of the sandstone formations stretching from Quebec through Ontario and New York State into mid-western states were called the Potsdam Sandstone; however, it now has a swathe of different names. In Ontario, it’s still called the Potsdam Sandstone/Formation (and the Nepean Formation) - and, it generally is sub-divided into Abbey Dawn, Covey Hill, Hannawa Falls, and Chippewa Bay Formations/Members.

Stratigraphic and structural framework of the Potsdam Group in eastern Ontario, western Quebec, and northern New York State; B V Sanford & R W C Arnott; Natural Resources Canada, Geological Survey of Canada; 2010

Potsdam sandstone is varied colouration ranging from grey, white, salmon, red, lilac, yellow, and/or purple - and is present in streaks, bands or mottling. Colouration is due primarily to iron oxides. It is mature sandstone with medium grain size, generally composed of rounded quartz grains cemented by silica or carbonate.

Field Trip Guide: Geology of the Kingston Area; 80th Meeting of Eastern Section of the Seismological Society of America at Queen’s University, Kingston Ontario, Canada; October 5, 2008 (link no longer active)
The Early Paleozoic rocks of the Kingston area, ranging in age from Upper Cambrian to Middle Ordovician, form a nearly flat-lying “sedimentary cover” that unconformably overlies the deeply eroded metamorphic and igneous rocks of the Precambrian basement of the Grenville Province. Parts of two sequences can be recognized. The older sequence is represented by the Cambrian-Ordovician Potsdam Group that dates back to about 500 Ma. It consists of up to thirty metre-thick conglomerates and orthoquartzites that were deposited on an erosion surface of moderate morphologic relief.

The Lansdowne (Ellisville) quarry is located in the Rear of Leeds and Lansdowne Township north of Gananoque. Cream, lilac, and salmon-coloured sandstone is quarried to produce flagstone, blocks and landscape stone. An on-site plant has equipment to cut, guillotine, split and tumble stone to specification.
Potsdam sandstone quarried in Ontario is of varied colouration ranging from grey and white to salmon, red, mottled, lilac, yellow, or purple. Frequently the colouration is present in streaks, bands or mottling. The colour is due primarily to oxides of iron.

The Potsdam formation is mature sandstone of medium grain size and the sandstone is generally composed of rounded quartz grains cemented by silica or carbonate.

The Potsdam (or Nepean) sandstone of Cambrian age outcrops on both sides of the Precambrian Frontenac axis, in Storrington and Pittsburgh townships near Kingston, from Brockville to Westport, in the Perth and Carleton Place areas, and in March and Nepean townships near Ottawa.

The Nepean and Potsdam formations and the sedimentary rocks overlying them show the transgression of a sea from Upper Cambrian to Lower Ordovician time in eastern New York State and eastern Ontario. The sea invaded over rough topography of the Precambrian rocks and, except for an area in the Province of Quebec, there was no break in sedimentation between the Cambrian and the Ordovician.

Potsdam Sandstone is the oldest sedimentary rock in the region, the bottom-most layers that cover the crystalline rocks of New York State and southern Ontario. ...
AGE

ROCK UNIT

Glacial drift, outwash, shoreline deposits, varves, marine clay
unconformity

UTICA SHALE

TRENTON GROUP limestones

BLACK RIVER GROUP limestones
unconformity

BEEKMANTOWN GROUP dolostones

THERESA FORMATION sandy dolostones

POTSDAM SANDSTONE local basal conglomerates
unconformity

GRENVILLE marbles, gneisses, etc.
and PRE-GRENVILLE
Geology - Fossil Ripple Marks & Trackways

*Eolian-Aquatic Deposits and Faunas of the Middle Cambrian Potsdam Group; James W. Hagadorn, Joseph H. Collette, Edward S. Belt; SEPM Society for Sedimentary Geology; 2010*

Exposures of the middle Cambrian Potsdam Group of northern New York, including the type section, represent a suite of inter-fingering eolian dune and aquatic deposits ... Quartz arenites at these exposures are dominantly fine to medium grained, well sorted, and have hematite-coated well-rounded, high-sphericity quartz grains characterized by secondary optically continuous quartz cement overgrowths. ... Paleocurrent analyses imply a coastline in which offshore and mixed-direction winds moved dunes seaward. Considered together, these strata record migration of coastal dunes into aquatic environments and flooding and reworking of distal dune bottom sets. In this setting, the same suite of epifaunal arthropods inhabited dry, damp, and aquatic marine environments.

*Sedimentary Structures and Depositional Environments, Potsdam Formation, Upper Cambrian; Ervin G Otvos; American Geological Institute AAPG Bulletin; 2004*

The Upper Cambrian Potsdam Formation (orthoquartzitic sandstone and conglomerate) in eastern Ontario, southwestern Quebec, and northern New York State, was deposited during an early Paleozoic transgression over the Precambrian surface of the Canadian Shield. Rock types and sedimentary structures indicate three distinct environments:
1) terrestrial, talus sheet wash fan (quartzite breccia), Frontenac arch, Thousand Islands region; 2) marine and (or) fluvial channel (cross laminated sandstone), Ontario and northern New York; and 3) low-energy, littoral to nearshore (laminated sandstone and some siltstone) Quebec and New York State.

*Stepping out. An artist's rendition (right) of the explorer that left the first known tracks on dry land. Tracks Found of Earliest Steps on Land, Kathleen Wong; Science Mag; 2002*

It was one small step for arthropods, one giant leap for land animals. Scientists taking a closer look at ancient arthropod footprints say that sandstone quarries of southern Ontario, Canada, mark a momentous event in the history of life - the first known steps on dry land. Five hundred million years ago, Earth’s oceans teemed with life, including a number of large, armored arthropods. These many-legged ancestors of today's insects and millipedes scurried along the muddy bottom of a sea that covered much of eastern North America. Yet the rock and soil just a few meters past the surf remained an open frontier, a moonscape that supported nothing more complex than mats of algae. Scientists have long assumed that the Ontario trackways were merely prints left behind by animals moving underwater.

But upon closer inspection, a team led by Robert MacNaughton of the Geological Survey of Canada found evidence that the sandstone slabs started out as terra firma. The surfaces bear ripples from wind as well as warty marks characteristic of sand blown across a slightly damp surface. The tracks consist of mirror-image lines of dimples, some separated by a midline groove. This symmetry shows
that the animals placed both limbs of an opposing pair on the ground at the same time. Such a gait is most common among aquatic animals, but the mounds of sand displaced by each step suggests that the creatures were not buoyed by water at the time.

The scientists suspect that the trackways were made by lobster-sized arthropods known as euthycarcinoids, animals that walked on eight legs and dragged a spiked tail. The trackways capture their forays into a dune field on the shore of an ancient sea, the team concludes in the May issue of Geology. That pushes back the date of the first beach footfall by as many as 40 million years. Paleontologist and arthropod trackway expert Ken McNamara of the Western Australian Museum in Perth says that researchers had been mystified about why, according to earlier estimates, arthropods took so long to venture onto land. "They were so common back then, they're beautifully adapted to [being terrestrial], with armor, bodies that can support their weight on land, and internal gills. Maybe the reality is, they didn't take long after all."

**Posted in** Paleontology

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*Tracks Found of Earliest Steps on Land; Kathleen Wong ; 2002*

... But upon closer inspection, a team led by Robert MacNaughton of the Geological Survey of Canada found evidence that the sandstone slabs started out as terra firma. The surfaces bear ripples from wind as well as warty marks characteristic of sand blown across a slightly damp surface. ... The trackways capture their forays into a dune field on the shore of an ancient sea.

*First steps on land: Arthropod trackways in Cambrian-Ordovician eolian sandstone, southeastern Ontario, Canada; Robert B. MacNaughton, Jennifer M. Cole, Robert W. Dalrymple, Simon J. Braddy, Derek E.G. Briggs, Terrence D. Lukie; GSA Publications; 2002*

Basal terrestrial deposits in the Cambrian-Ordovician Nepean Formation (Potsdam Group) near Kingston, Ontario, contain arthropod-produced trackways that extend the record of the first arthropod landfall back by as much as 40 million years. The presence of large, simple cross-beds and of wind-produced structures, including adhesion ripples and wind-ripple laminations, indicates that the host strata were deposited in an eolian dune field, probably in a marginal-marine setting. The trackways were preserved mainly as undertracks and record the activities of large, amphibious arthropods, possibly euthycarcinoids.

*Potsdam Public Museum - Rock Structures and Fossils*

The Potsdam Sandstone consists of sand-rich, river-transported sediment that interfingers with the sandy sediments of a marine shoreline. There are places in the basal part of the sandstone, however, where sand gives way to pockets of coarse conglomerate—to boulders and cobbles of gneisses, quartzites and other crystalline rocks. Called talus, the debris accumulated at the base of low hills and ridges that once protruded as islands in the shallow Cambrian sea.

The sandstone displays cross-bedding where the layers are inclined to the horizontal. Cross beds indicate the presence of currents, such as the flow of a river across a delta or the ebb and flow of strong tidal currents. ... Most cross beds are small-scale features, but some are comparable in size with the cross bedding observed in large desert sand dunes.

Mudcracks and ripple marks also occur in Potsdam Sandstone. Ripple marks with vertical crests were formed by the gentle, back-and-forth oscillation of water, whereas the inclined crests were produced by waves and tidal currents. The preservation of mudcracks in the rock points to the former presence of tidal flats where shallow water alternated with mudflats.

Beds of quartz sand are ill suited for the preservation of organisms, and fossils are scarce in the Potsdam Sandstone. ... Trace fossils, however, are locally abundant. They are sedimentary structures left by organisms - they consist of trails, tracks, burrows or tunnels left at the time of sediment deposition.
**Geology - Pre-Cambrian Unconformity**

*Field Tripping: Geology of the Kingston Area; H.H. Helmstaedt, W.A. Gorman & S.L. McBride; Department of Geological Sciences, Queen’s University, Kingston, Ontario; 1987*

Stop 3 Sunbury Road & Highway #15

“... The coarse-grained marble contains small flakes of biotite and graphite ...”

(Though this is a different location, it does describe the same marble found at Lansdowne Quarry.)

**Geological Notes for Maps Nos. 2053 and 2054 Madoc-Gananoque Area; D. F. Hewitt; Geological Circular No. 12, Ontario Ministry of Natural Resources; 1964**

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**TABLE OF FORMATIONS**

**CENOZOIC**

**PLEISTOCENE**

Till, moraine, drumlins, eskers, kames, etc.

**Unconformity**

**PALEOZOIC**

**Ordovician**

Black River and Trenton Groups: Limestone.

Beekmantown Group: Dolomite and sandstone.

**LOWER ORDOVICIAN OR CAMBRIAN**

Potsdam or Nepean Formation: Sandstone.

**Unconformity**

**PRECAMBRIAN**

**Plutonic Rocks**

Diabase and porphyritic andesite dikes.

Granite gneiss, migmatite, granitized gneiss, hybrid granite gneiss, granite pegmatite.

Granite and syenite.

Grey granite, granite gneiss, granodiorite, tonalite.

Diorite, gabbro, metagabbro, anorthosite, amphibolite.

**Intrusive Contact**

**Metasedimentary Rocks**

Quartzite, quartzo-feldspathic rocks.

Paragneiss, pelitic and psammo-pelitic schists and gneisses.

Marble, lime silicate rocks, skarn.

Para-amphibolite, biotite-amphibole schists and gneisses.

**Metavolcanic Rocks**

Basic volcanic rocks, greenstone, pillow lava, amphibolite.

Rhyolite and associated acid volcanic rocks.

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**Potsdam Public Museum - Bedrock Geology**

The Potsdam Sandstone overlies an ancient erosion surface, now seen as an unconformity between Cambrian and Precambrian rocks at the base of the column. The sandstone is of Late Cambrian age (ca. 520 million years old), whereas the age of underlying crystalline rocks varies from nearly 1000 million to more than 1300 million years (1 to 1.3 billion years).