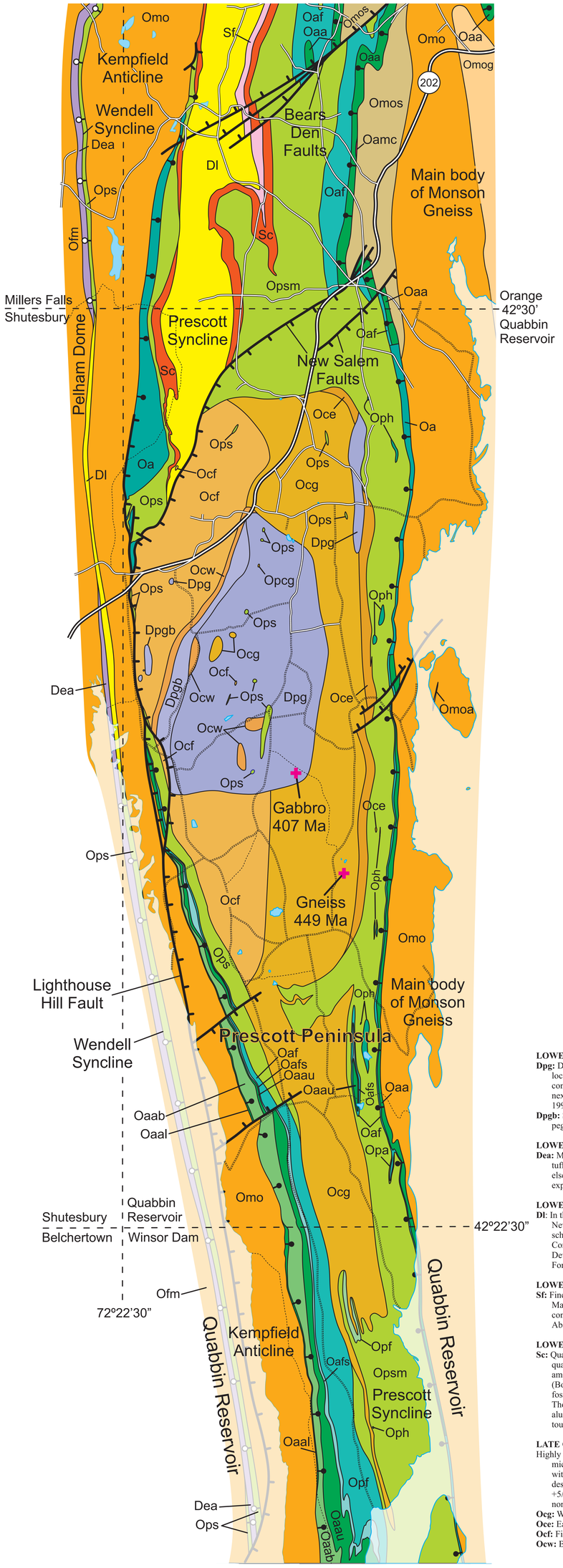
Preliminary Planimetric Bedrock Geologic Map of the Prescott Peninsula and Surroundings, Quabbin Reservoir Area, Massachusetts

Geology by Peter Robinson (1959-2016) and his students, including the M.S. Thesis of Jordan Makower (1964), and results from his Advanced Mapping Classes, 1980-1985.



Dated samples (Tucker and Robinson, 1990)

Mesozoic brittle faults, tics on hanging wall

Late Ordovician or early Silurian detachment faults, tics on hanging wall: Stoneville/Moosehorn faults

Early Devonian Packard Gabbro

Dpgb Dpg

Lower Devonian Erving Formation (Wendell Syncline)

Dea

Lower Devonian Littleton Formation (Prescott Syncline)

Dl

Upper Silurian Fitch Formation (Prescott Syncline)

Sf

Lower Silurian Clough Quartzite (Prescott Syncline)

Sc

Late Ordovician Shallow Intrusive Cooleyville Gneiss

Ocf Oce
Ocw Ocg

Late Ordovician Partridge Formation

Wendell Syncline | Prescott Syncline

Ops | Opf, Opa, Oph, Opsm

Late Ordovician Ammonoosuc Volcanics Prescott Syncline

Oaf | Oaf | Oa
Oafs
Oaau | Oaa
Oaab | Oaal

Late Ordovician Deep Intrusive Rocks

Fourmile Gneiss Pelham Dome | Monson Gneiss Main Body and Kempfield Anticline

Ofm | Omos, Omoa, Omo, Omog

Paved roads

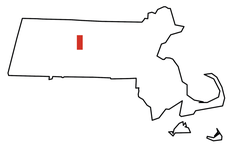
Unpaved roads

Footpaths

Quadrangle boundaries

0 1 2 3 4 5 km
0 1 2 3 miles

N



Prescott Peninsula–Map Explanation

LOWER DEVONIAN PACKARD GABBRO INTRUSION

Dpg: Dark, massive, fine- to coarse-grained, weakly-foliated, faintly,lineated ilmenite–hornblende gabbro, locally pegmatitic. At northeastern contact zone is an isolated lens against Partridge, with a contaminated zone about 1 m thick having garnets up to 4 cm in diameter. Coarse garnets also occur next to some schist xenoliths. A concordant U–Pb zircon age of 407 +3/-2 Ma (Tucker and Robinson, 1990) was obtained from a very coarse gabbro near the southeast corner of the main gabbro body.

Dpgb: Separately mapped western border facies against Cooleyville Gneiss. Very coarse-grained, pegmatoid, mottled dark-green and white hornblende gabbro.

LOWER DEVONIAN ERVING FORMATION (Exposed in Wendell Syncline)

Dea: Massive to well-layered hornblende–epidote amphibolite representing basaltic lava flows and basaltic tuffs. About 600 m thick at Quabbin Hill, south of the map area, probably representing a thick flow, elsewhere thinning to as little as 1 m, probably representing laminated tuff. Thick layers are also exposed in the Wendell and Northfield Syncline, northwest of the map area.

LOWER DEVONIAN LITTLETON FORMATION (Exposed in Wendell and Prescott Synclines)

Dl: In this map area: Gray-weathering mica–chlorite–garnet phyllite with pseudomorphs of staurolite in the New Salem retrograde zone (Hollocher, 1987). Further north: Gray-weathering mica–garnet–staurolite schist (kyanite zone), or mica–garnet–sillimanite schist with or without staurolite (sillimanite zone). Correlative phyllite in the Littleton and Whitefield areas, northern NH, yielded Late Emsian (latest early Devonian) brachiopods and corals (Boucot and Arndt, 1960). Widespread absence of the Fitch Formation along the basal contact indicates a significant unconformity.

LOWER SILURIAN FITCH FORMATION (Exposed in Prescott Syncline)

Sf: Fine-grained calc-silicate granulite and minor pyritic and pyrrhotitic schist. Rare quartz-bearing marble. Marble at nearby Bernardston, MA (Elbert et al., 1988) yielded Lochkovian (earliest Devonian) conodonts, but marble at Littleton, NH (Harris et al., 1983) gave Pridoli (latest Silurian) conodonts. Absence of Middle Silurian strata indicates local non-deposition or erosion.

LOWER SILURIAN CLOUGH QUARTZITE (Exposed in Prescott Syncline)

Sc: Quartzite, quartz-pebble, and quartz-cobble conglomerate, quartz–mica, quartz–muscovite–garnet, and quartz–mica–sillimanite–staurolite schist. Thin layers of calc-silicate granulite and layered hornblende amphibolite at top of formation at a few locations. An upper calcareous quartzite at Bernardston, MA (Boucot et al., 1958) yielded a brachiopod of late Llandovery to early Ludlow age. More abundant fossils in similar rocks at Croydon Mtn., NH, gave a more precise late Llandovery age (Boucot and Thompson, 1963). The base of the formation is a marked regional unconformity, and the abundance of aluminous matrix minerals and the dominance of vein quartz pebbles and cobbles, including veins with tourmaline, indicates the underlying Ordovician strata underwent severe chemical weathering.

LATE ORDOVICIAN INTRUSIVE COOLEYVILLE GNEISS

Highly foliated and lineated felsic gneiss consisting of quartz, oligoclase, and biotite, with variable microcline and minor muscovite, titanite, magnetite, and hornblende. Has apparent intrusive contacts with Partridge Formation and Ammonoosuc Volcanics, and xenoliths of Partridge. First mapped and described in detail by Makower (1964) in the Quabbin Reservoir Quadrangle. A U–Pb zircon age of 449 +5/-3 Ma (Tucker and Robinson, 1990) and a new map interpretation here suggest that the sharp northwestern contact with the Clough Quartzite and Littleton Formation is a Mesozoic fault.

Ocg: Well lineated medium-grained granite gneiss, tonalite gneiss, and quartz-bearing monzodiorite gneiss.

Oce: Eastern border zone. Coarse-grained, micaceous tonalite gneiss.

Ocf: Fine-grained granodiorite gneiss, granite gneiss, and quartz-bearing monzodiorite gneiss.

Ocw: Border zone west of Packard Gabbro. Coarse-grained micaceous gneiss with plagioclase megacrysts.

UPPER ORDOVICIAN PARTRIDGE FORMATION

Wendell Syncline:

Ops: East limb of Syncline. Well layered, rusty-weathering garnet–biotite–muscovite schist as described by (Halpin, 1965) near Quabbin Hill south of the map area. Can be traced a short distance northward until it passes beneath Quabbin Reservoir, and is then followed discontinuously northward in concept to exposures of the very narrow syncline just beyond the northwest corner of the map area. Regionally it contains minor amphibolite. Interpreted as a sequence of black shales with minor mafic volcanics, deposited in a marine environment. At Bernardston, MA, a quartz-phyric metamorphosed rhyolite bed 10 m above the base of the formation (Tucker and Robinson, 1990) gave a U–Pb zircon age of 449 +3/-2 Ma (early Ashgill). The geochemistry of amphibolites and feldspathic gneisses indicates they are metamorphosed arc and back-arc volcanics similar to the Ammonoosuc Volcanics (Hollocher, 1993).

Prescott Syncline:

Ops: West limb of Syncline and xenoliths in Prescott Complex. Rusty-weathering garnet–biotite–muscovite schist, locally with abundant retrograde chlorite, and usually lacking sillimanite, except in xenoliths.

Opsm: East limb of Syncline and center in extreme south of map. Well-layered, rusty-weathering garnet–biotite–muscovite–sillimanite schist, locally with graphite, ilmenite. These assemblages are typical of the regional sillimanite–muscovite zone (III) of regional metamorphism. Retrograde chlorite is locally present near New Salem and near the south end of the map. Amphibolite and other metamorphosed volcanic rocks are abundant and were subject to detailed geochemical and petrologic study by Hollocher (1985). In his 13 analyses from this belt he identified 10 low-K arc tholeiite basalts, 2 intermediate compositions, and 1 dacite. The section is interpreted as a sequence of black shales with mafic volcanics and subordinate felsic volcanics, deposited in a marine environment.

Opa: Amphibolite, where separately mapped.

Opf: Layered gray- to brown-weathering quartz–feldspar gneiss in a lens adjacent to the Cooleyville Gneiss intrusion on Prescott Peninsula. Interpreted as metamorphosed felsic volcanics.

Oph: Ultramafic hornblendite and interlayered hornblende-rich amphibolite, Prescott Peninsula. Detailed description lacking.

UPPER ORDOVICIAN AMMONOOSUC VOLCANICS

Prescott Syncline West Limb: On Prescott Peninsula the west limb Ammonoosuc has been divided into five members, Oaf, Oafs, Oaau, Oaab, and Oaal. Oaal, Oaab and Oafs pinch out leaving Oaf and Oaa (similar to Oaau) to the north, and subdivision is further dropped to an undivided Oa in the northern part of the map area.

Oaf: Felsic Upper Member. Fine-grained, slabby, typically brown-weathering feldspar–quartz gneiss with or without muscovite and garnet, representing metamorphosed peraluminous rhyolite and dacite (Schumacher, 1988) believed to have melted from a basaltic source. Minor amphibolite. A quartz-phyric metamorphosed rhyolite 30 m below the top of this member at Bernardston, MA (Tucker and Robinson, 1990) yielded a U–Pb zircon age of 453 ±2 Ma (late Caradoc). This felsic unit represents a distinct episode when felsic volcanism dominated over the background of continuing mafic volcanism that predominated in the Lower Ammonoosuc and continued through much of the deposition of the Partridge Formation. It may represent a limited number of major felsic eruptions taking place over a limited time span. Seems to lie mainly in the zone of sillimanite–muscovite grade regional metamorphism, significantly affected by retrograding.

Oafs: White schist member. A distinctive zone of quartz–white-mica schist and gneiss, with origin obscured by extensive retrograde metamorphism. It is likely that these rocks are equivalent to local layers found elsewhere containing abundant kyanite, sillimanite, or staurolite interpreted as metamorphosed hydrothermally altered felsic volcanics. They may also be related to felsic gneisses with weathering-resistant quartz–sillimanite nodules that are common in the upper part of the Ammonoosuc elsewhere (Robinson, 1963; Schumacher, 1988). Their consistent stratigraphic position just below Oaf, may indicate they represent a major outfall of easily altered glassy ash preceding the major felsic eruption of Oaf.

Mafic lower member in general–Oaau, Oaab, Oaal, Oaa: Hornblende amphibolite, former coarse anthophyllite amphibolite extensively retrograded to chlorite, and various more felsic gneisses. Based on extensive analyses from areas mainly further north (Schumacher, 1988), these rocks are interpreted as arc- or back-arc-related tholeiitic basalts and rare andesites and metamorphosed hydrothermally altered equivalents. Locally pillows, graded tuffs, agglomerates and other features are preserved even at sillimanite grade. They are older than the overlying felsic member dated at 453 ±2 Ma, but the exact age is presently unknown. Similar rocks in northern New Hampshire (Moench and Aleinikoff, 2002; Rankin et al., 2007) are cut by the Joslin Turn pluton with an age of 469 ±2 Ma (late Arenig). More recent U–Pb dating of felsic volcanics in the same area (Aleinikoff et al., 2015) suggests ages in the ranges 480–462 and 458–445 Ma. U–Pb ages from 7 intrusions and 1 volcanic rock in west-central New Hampshire (Valley et al., 2015) were the following. The Plainfield and Lebanon tonalites, both cutting Ammonoosuc Volcanics, gave 475 ±5 Ma and 466 ±8 respectively. The Sugar River granodiorite intruded the Ammonoosuc at 460 ±3 Ma at the same time as extrusion of a felsic lapilli tuff at 460 ±2 Ma.

Oaau: Uppermost part of the mafic lower member. Hornblende amphibolite and former coarse anthophyllite amphibolite extensively retrograded to chlorite. Some of these rocks, especially near the top of the unit, contain significant magnetite, and these were followed through a series of folds across the channel west of Little Quabbin Island, based on a ground-magnetic survey on the ice in February 1965. They also relate to a distinctive positive aeromagnetic anomaly in the southwest part of the map area.

Oaab: Biotite gneiss in middle of mafic lower member. A complex mix of felsic biotite gneisses and retrograded gedrite–feldspar gneisses now dominated by chlorite, with subordinate amphibolite. These rocks resemble extensive sections of felsic rocks in the lower part of the Ammonoosuc on the east and west limbs of the Warwick Dome in northern Massachusetts, including rocks described as "patch rock." Such rocks were interpreted as intermediate felsic volcanics invaded by hydrothermal chlorite veins, subsequently prograded to gedrite, then here retrograded back to chlorite. Despite some similarities to Monson Gneiss, abundance of secondary chlorite makes these rocks distinctive.

Oaal: Lowermost part of the mafic lower member. A thin unit of rather uniform hornblende-rich amphibolite exposed only in the extreme northwest of the belt and in sharp and easily mapped contact with the underlying Monson Gneiss. At one place a narrow belt of this unit surrounded by Monson Gneiss is confirmed as a narrow syncline of Ammonoosuc and not a xenolith in Monson Gneiss. However, along this contact there are several special localities not mapped here. At several locations the uppermost several feet of the Monson Gneiss, are tan-, yellow- or brown-weathering and contain abundant muscovite, atypical of Monson Gneiss in general. At one location, the east edge of a Monson outcrop against the basal amphibolite appears to be a conglomerate of quartz grains in a feldspar matrix. At another location a coarse quartzite occurs at the contact, of which as much as 30 cm may be conglomerate. Though lithically different from the Moosehorn Conglomerate on the east limb of the Syncline in the northern part of the map area, the similar stratigraphic–structural position of the apparent conglomerates lends further intrigue to the question of how to interpret the basal contact of the Ammonoosuc Volcanics against the Monson Gneiss, intrusive or an extensional fault. Our new interpretation of the Cooleyville Gneiss as the shallow intrusive equivalent of Monson Gneiss provide added fuel to this controversy.

Oaa: Mafic lower member undivided.

Oa: Ammonoosuc too thin or too poorly exposed to divide into members.

Prescott Syncline East Limb:

Oa: Amphibolite and quartz–feldspar gneiss, too thin to subdivide at 1/24,000 scale occurs on the east limb of the Syncline. This is well exposed on Little Quabbin Island, where it is about 25 m thick between Monson Gneiss and Partridge schist and amphibolite. It consists of laminated amphibolite, some with diopside, a characteristic coarse garnet–cummingtonite gneiss, and very minor felsic gneiss at the top. Further north on Prescott Peninsula it has been possible to map a lower amphibolite member **(Oaa)** and an upper felsic gneiss member **(Oaf)**, and this subdivision has been continued with some breaks through the Quabbin Reservoir Quadrangle and to the Orange Quadrangle, where the Ammonoosuc thickens greatly with several mappable members, including a basal Moosehorn Conglomerate, before finally pinching out between Partridge and Monson several kilometers north of Orange Village. There is also an isolated fold near the east limb showing the upper three members as mapped on the west limb.

Oamc: Moosehorn Conglomerate Member. Thin quartz-grit to fine quartz-pebble conglomerate with a matrix of epidote, diopside and calcite. Occurs at the basal contact of the Ammonoosuc with the Monson Gneiss in the northern part of the map area. Classification as metamorphosed conglomerate is uncertain.

UPPER ORDOVICIAN DEEP INTRUSIVE IGNEOUS ROCKS

This group of rocks, with the exception of 2–3 outcrops, is interpreted to be intrusive. Strong layering in many locations, once thought to be evidence of some volcanic protoliths (Robinson, 1963), is now interpreted to be the result of strong deformation of varied intrusive rocks and xenoliths along with a few mafic dikes (Robinson et al., 1989; Robinson and Mabee, 2016). The group as a whole is comparable to calc-alkaline plutons in magmatic arcs (Hollocher et al., 2002). U–Pb zircon ages in the range 455–442 Ma (late Caradoc to early Llandovery) show that these rocks cannot be a basement beneath the Ammonoosuc Volcanics and Partridge Formation. The ages would permit an intrusive relationship, that is not supported by field relations in Massachusetts and southern New Hampshire. Present interpretation is that a terrane of tholeiitic arc or back-arc volcanics and overlying marine shales with volcanics has been emplaced against a terrane of calc-alkaline arc-related intrusions along a major extensional detachment of probable early Silurian age. Our new finding that the Cooleyville Gneiss represents geochemically-related late Ordovician hypabyssal intrusions into the Partridge Formation and Ammonoosuc Volcanics, provides a new insight into this problem.

FOURMILE GNEISS (Exposed in Pelham Dome)

Ofm: Coarse- to fine-grained massive to weakly-layered, light-gray to yellow-weathering feldspar–quartz gneiss with minor amphibolite grading locally to fine- to medium-grained hornblende gneiss with locally abundant garnet. A sample from the Northfield Quadrangle (Tucker and Robinson, 1991) yielded a U–Pb age of 454 +3/-2 Ma (late Caradoc) on igneous zircon.

MONSON GNEISS (Exposed in Kempfield Anticline and Main Body). The belt exposed in the Kempfield Anticline was assigned to Fourmile Gneiss by Robinson (1963, 2007), but is here reassigned to Monson Gneiss as a result of known continuity with the type locality at the Quarry, Monson, Massachusetts.

Omo: Coarse-grained, layered to massive feldspar–quartz gneiss and hornblende amphibolite. Amphibolites occur as both xenoliths within felsic intrusions and as cross-cutting dikes, with contact relations obscured by great strain. The Main Body east of the map area (Tucker and Robinson, 1990) yielded U–Pb igneous zircon ages of 454 +3/-2 Ma, 445 +3/-2 Ma, 442 +3/-2 Ma and 442 +3/-2 Ma (late Cardoc to early Llandovery).

Omoa: Interlayered amphibolite and minor feldspar–quartz gneiss where separately mapped.

Omos: Mapped area of rusty-weathering gneiss containing pyrite, muscovite, and rare sillimanite, indicating pre-metamorphic hydrothermal alteration (Sioui, 1990).

Omog: Mapped areas where massive granitoid gneiss predominates.

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