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Stratigraphy of the Northwest Limb of the Merrimack Synclinorium in the Kennebago Lake, Rangeley, and Phillips Quadrangles, Western Maine

Moench, R. H.

Boudette, E.L.

TRIP A-1

Stratigraphy of the northwest limb of the Merrimack synclinorium in the Kennebago Lake, Rangeley, and Phillips quadrangles, western Maine[1]

by

R. H. Moench and E. L. Boudette
U.S. Geological Survey
Denver, Colorado and Boston, Massachusetts

Trip A-1 spans a major part of the northwest limb of the Merrimack synclinorium in western Maine. (See fig. 1 of Boone and others, this volume.) Except where faulted, the exposed sequence of Ordovician, Silurian, and Devonian rocks is continuous in most of the trip area, and is far thicker and more varied than any other recognized sequence along the same limb of the synclinorium to the southwest in New England. Despite tight folding and metamorphism to greenschist to amphibolite facies, sedimentary features are well preserved and have permitted detailed stratigraphic subdivisions and geologic mapping (fig. 1). In addition, the discoveries of late Middle Ordovician and Early Silurian fossils at the localities shown in the Cupsuptic and Kennebago Lake quadrangles (fig. 1; Harwood and Berry, 1967; U.S. Geological Survey, 1965, p. A-74) have permitted assignment of tentative ages to most of the exposed sequence in the Rangeley and Phillips quadrangles. The purpose of this trip is to examine the stratigraphic sequence from the Quimby Formation, of Late Ordovician(?) age, to the lower part of the Seboomook(?) Formation, of Devonian age, and to study the basis for correlating fossiliferous Lower Silurian quartz conglomerates in the Kennebago Lake quadrangle with quartz metaconglomerates of the part C of the Rangeley Formation of the Rangeley quadrangle. This correlation, if valid, has an important bearing on the stratigraphy of other parts of the Merrimack synclinorium, particularly in central and southern New England.

Because the purpose of this trip is stratigraphic, the terms metashale, metagraywacke, metasandstone, and so on, for convenience are used instead of their metamorphic equivalents. Metamorphic recrystallization alters primary textures, but primary structures are well preserved, except in calc-silicate rocks. The term "metagraywacke" is used here for unsorted sandstone composed of angular fragments of feldspar, rock fragments, and quartz set in an argillaceous matrix. Metagraywacke within the lowest metamorphic grades displays primary textural features. All the virtually noncalcareous metagraywackes and the more quartzose metasandstones have simple mineral

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[1]Publication authorized by the Director, U.S. Geological Survey.

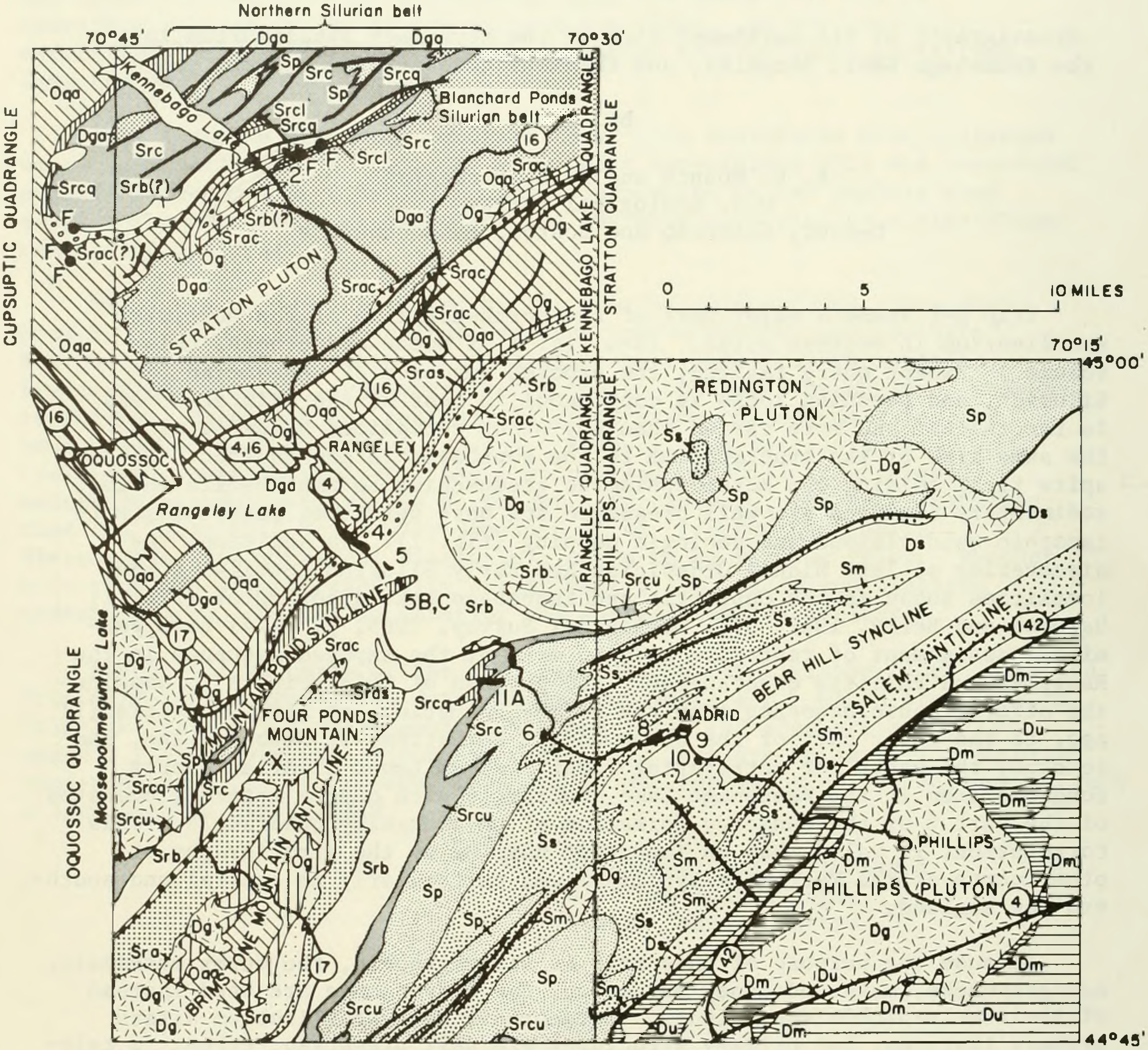


Figure 1.--Geologic map showing stops of trip A-1. Compiled by R.H. Moench and E.L. Boudette from Moench (1970); E.L. Boudette, unpublished mapping; and from modifications of Harwood and Berry (1967, fig. 2) and Harwood (1966).

EXPLANATION

Southern sequence

DEVONIAN

- Dg — Granitic rocks
- Dgo — Gabbro, diorite, and associated reaction hornfels

DEVONIAN(?)

- Du — Upper unit: *Nonsulfidic and sulfidic metashale*
- Dm — Middle unit: *Metasandstone, calc-silicate rock, and marble of Hildreths Formation at top; nonsulfidic and sulfidic metashale*

DEVONIAN (Lower Devonian)

- Ds — Seboomook(?) Formation: *Dominantly gray metashale*

Lower Silurian(?)

- Sm — Madrid Formation: *Calcareous metasandstone, metasiltstone, and calc-silicate rock*
- Ss — Smalls Falls Formation: *Sulfide-rich black metashale and metasandstone; calcareous in upper part; grit abundant in north*
- Sp — Perry Mountain Formation: *Cyclically interbedded commonly cross-laminated quartz-rich metasandstone and muscovite-rich metashale*

Northern sequence

SILURIAN(?) (Lower Silurian(?)) — Rangeley Formation

Part C (Src, Srcl, Srcq, Srcu, F)

- Src, *gray metashale and subordinate feldspathic metasandstone*
- Srcl, *laminated calcareous metasiltstone or silty marble. Absent in Rangeley quadrangle*
- Srcq, *quartzite, quartz conglomerate, and fossiliferous calcareous quartz conglomerate and metasandstone in Kennebago Lake quadrangle; interbedded calcareous quartz conglomerate, feldspathic metasandstone, and gray metashale in Rangeley quadrangle*
- F, *approximate location of fossil localities in Kennebago Lake quadrangle*

Part B (Srb)

Gray metashale interbedded with subordinate feldspathic metasandstone; local quartz-rich polymictic metaconglomerate and conglomeratic mudflow deposits. Thin or absent in Kennebago Lake quadrangle

Part A (Srac, Sras, Sra)

- Srac, *polymictic metaconglomerate*
- Sras, *feldspathic metasandstone*
- Sra, *gray metashale and subordinate feldspathic metasandstone*

ORDOVICIAN(?) (Upper Ordovician(?))

- Og — Greenvale Cove Formation: *Interlaminated feldspathic metasandstone, metasiltstone, and metashale; commonly calcareous*

ORDOVICIAN AND ORDOVICIAN(?) (Middle Ordovician and Upper Ordovician(?))

- Oqa — Quimby, Dixville(?), and Albee Formations

I 5B,C 11A

Field-trip stops
B, C, *bus sections B and C*
A, *bus section A*

OF
Fossil locality

———?——
Contact
Queried where conjectural

———
Fault

assemblages, such as quartz, plagioclase (typically untwinned oligoclase), biotite (or chlorite and white mica at lowest grades), and locally sparse amounts of garnet. The mineralogy of the metashales in the southwestern part of the area is discussed in more detail by Guidotti (trip B-2, this volume). For the sake of simplicity, metamorphic zones are not shown on Figure 1. Stops 1 and 2 are in the contact metamorphic halo of the Stratton pluton; pelitic rocks here contain andalusite and cordierite. Stops 3 and 4 are in the biotite and garnet zones, respectively, and stops 5 through 11 are within a broad zone of staurolite-grade metamorphism. Most of the staurolite, however, has been retrograded to chlorite and sericite.

Because of the importance of the Rangeley Formation, our interpretations of its stratigraphic and facies relationships are briefly reviewed here and are schematically illustrated in Figure 2. Column 1 was constructed from sparse outcrops in the broad, grossly synclinal northern belt of Silurian(?) rocks that is crossed by Kennebago Lake (fig. 1). Silurian rocks of this belt typically have rather gentle dips. At the southwest end of the belt, steeply dipping upper Middle Ordovician graptolite-bearing slate is apparently unconformably overlain by less deformed clastic rocks of the Rangeley Formation (Harwood and Berry, 1967; this report, fig. 1). Column 2, constructed from rocks exposed at stop 2, represents a narrow belt of rocks between the southeast end of Kennebago Lake and the Stratton pluton (fig. 1). For convenience, this belt is called the Blanchard Ponds belt of Silurian(?) rocks. It is separated from the broad belt to the north by a fault of unknown displacement. Rocks of this belt strike northeast and dip nearly vertically. Tops of beds at stop 2 are interpreted to face southeast from sedimentary features. Columns 3, 4, and 5 (fig. 2) represent the main mass of the Rangeley Formation in the Rangeley quadrangle. Column 3 was constructed from data obtained from outcrops at and near stops 4, 5, and 5B, C (for trip sections B and C) southeast of Rangeley Lake, and outcrops north of the small canoe-shaped body of Perry Mountain Formation to the southwest (fig. 1). Column 4 represents a line of outcrops that entends west along a ridge from Four Ponds Mountain to the same canoe-shaped body of Perry Mountain. Column 5 represents several lines of outcrops near the southern border of the Rangeley quadrangle.

Rocks of the main mass of the Rangeley Formation in the Rangeley quadrangle are tightly folded, but are predominantly unfaulted. Correlation among columns 3, 4, and 5 is not a problem because the Rangeley Formation, as a whole, is sandwiched between the distinctive underlying Greenvale Cove and overlying Perry Mountain Formations, and because facies changes were mapped within this coherent mass of the Rangeley Formation. Correlations among columns 1, 2, and the main mass are inferred from similarities of rock types and sequence, which are consistent throughout, despite the obvious thickness changes (Fig. 2). The change in apparent thickness of parts A and B of the Rangeley between the areas of columns 2 and 3 amount to about 1-1/2 miles in a horizontal distance of 10 miles. This abrupt thickening suggest that the limb of the sedimentary basin has been shortened.

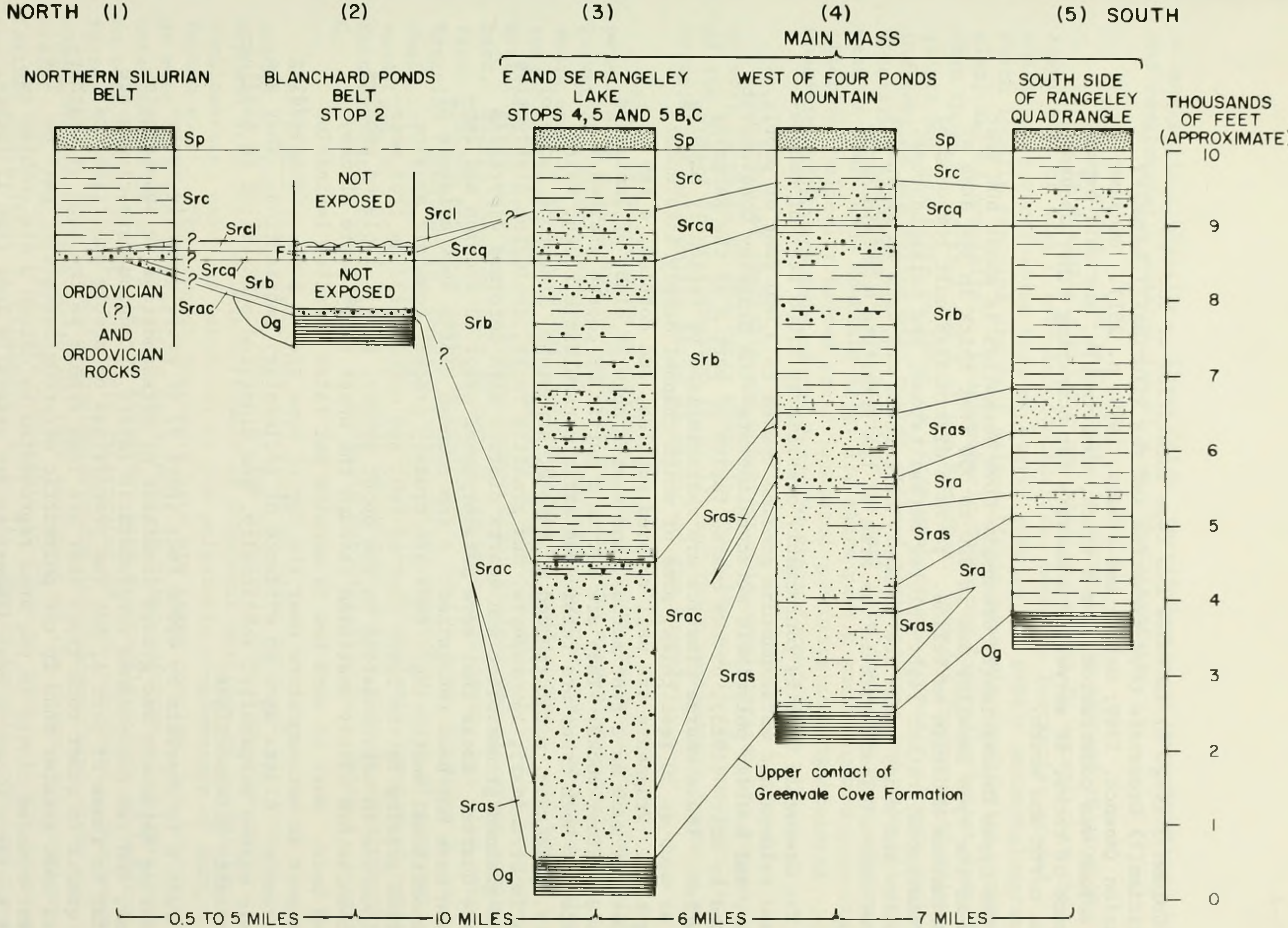


Figure 2.--Stratigraphic columns of the Rangeley Formation, Kennebago Lake (1, 2) and Rangeley (3, 4, 5) quadrangles. Unit symbols and descriptions on Figure 1. F indicates fossiliferous rocks at stop 2, Lower Silurian (upper Llandoverian, C_4-C_5).

Column 3 (fig. 2) includes the type localities of the Upper Ordovician(?) Greenvale Cove Formation and the Silurian(?) Rangeley Formation (Moench, 1969; Osberg and others, 1968, p. 251). Because this column was constructed from a thick, conformable, and well-exposed sequence of rocks, it serves as a measure for comparing other sequences to the north and south.

The Upper Ordovician(?) Greenvale Cove Formation is about 600 feet thick at the type locality and is 200 to 500 feet thick in the area of the Brimstone Mountain anticline. It is a distinctive unit composed of interlaminated, rather light-colored metasiltstone, and metasandstone. The silty and sandy rocks are commonly calcareous and form an extensive unit of calc-silicate rock in the area of the Brimstone Mountain anticline.

The Greenvale Cove is conformably overlain by 1,000 feet of coarse-grained feldspathic metasandstone grading upward to 3,000 feet of pebble, cobble, and boulder polymictic metaconglomerate--the Rangeley Conglomerate as used by Smith (1923), or the coarse facies of part A of the Rangeley Formation. These coarse clastics are characterized by typically massive beds as much as 30 feet thick, some of which channel deeply into underlying beds. Fragments are well rounded pebbles, and cobbles, a few boulders as much as 2 feet across, and sparse angular slabs of laminated metasedimentary rocks. They are set in a matrix of coarse grained metasandstone. Rock types are felsic and mafic metavolcanic rocks, vein quartz, quartzite, metamorphosed siltstone, sandstone, limestone (some of which is crinoidal), lamprophyre, and granitic rocks, including distinctive medium-grained granodiorite and quartz diorite with deformed dipyramids of blue quartz. Rocks that were metamorphosed prior to erosion and deposition have not been recognized. A few rounded clasts show evidence of predepositional weathering. Beds are crudely graded, commonly showing inverted grading in the lower foot or two, and normal grading from metaconglomerate to metasandstone in the upper several feet. Isolated pebbles and cobbles are widely scattered through the upper sandy parts of many graded beds. Most of each bed is massive but faint parallel lamination is present in metasandstone near the top of some graded beds. Crossbedding is uncommon. Clasts show no evidence of sedimentary imbrication. They are crudely alined subparallel schistosity, and elongated subparallel to bedding-schistosity intersections.

Part A is overlain by 4,000 feet (part B) of gray, commonly rusty-weathering metashale and graded interbeds of metasandstone in subordinate amount, and two conspicuous conglomeratic layers. Conglomerate clasts are similar to those of part A, but the proportions of stable quartzite and vein quartz to other rock types that are less stable in the zone of weathering is much greater than in the polymictic metaconglomerate of part A. The largest rounded clasts in the area represented by column 3 are cobbles and small boulders whose largest dimensions are generally less than 12 inches. Pebbles, cobbles and small boulders are commonly set in a matrix of pelitic on semipelitic phyllite. Slump folds, intraformational unconformities, and conglomeratic mudflow deposits are characteristic.

Part C, about 1,500 feet thick, is incompletely exposed at stop 5B, C. Part C is dominately pelitic and similar to part B, except that the lower half of part C contains distinctive, commonly lenticular graded and locally crossbedded beds of quartz granule and pebble metaconglomerate, which locally contains abundant calc-silicate minerals (amphiboles, grossular, and clinozoisite). Conglomeratic rocks are typically better sorted than those of parts A and B of the Rangeley. Rounded fragments of vein quartz and quartzite as large as large pebbles are commonly closely packed; interstices are filled with coarse grained metasandstone and calc-silicate minerals. Knowledge of the sequence of part C is completed from outcrops west of Four Ponds Mountain (fig. 1), where part C grades upward into distinctive cyclically bedded cross-laminated quartzite and lightcolored muscovite-rich metashale of the Perry Mountain Formation.

Thick-bedded quartzite and quartz-granule conglomerates are present as well in parts of the Perry Mountain Formation and in the northern facies of the Smalls Falls Formation (fig. 1), but their sedimentary features and associations are unlike those of part C of the Rangeley.

South from the area of column 3 (fig.2), the Greenvale Cove Formation persists as a thin but distinctive unit, but the overlying Rangeley Formation changes dramatically. Polymictic conglomerates and feldspathic sandstones of part A become finer grained and less abundant, and they tongue southward into a thick mass of dominantly pelitic rocks. Conglomeratic rocks of part B likewise become finer grained and disappear southward. Quartz conglomerates of part C are more persistent, but also become finer grained and less abundant southward. In the area of column 5, the Rangeley Formation is, thus, a thick, rather monotonous mass of gray metashale interbedded at irregular intervals with subordinate amounts of metasandstone, and in part C with small amounts of quartz granule conglomerate. Farther south, the Rangeley is probably not divisible into parts A, B, and C.

At stop 2 (fig. 2, column 2), about 10 miles north of the area of column 3, rocks similar to those of the Greenvale Cove Formation are exposed less than 50 feet northwest of prominent outcrops of polymictic conglomerate, which is identical to the polymictic conglomerate of part A to the south. The largest fragments here are large cobbles, but boulders as much as 3 feet across have been found in other outcrops of polymictic conglomerate of part A in the Kennebago Lake quadrangle. Tops of bedding in both formations at stop 2 are interpreted to face southeast. Southeast-facing fossiliferous quartz conglomerate and interbedded baked shale and sandstone are exposed about 300 feet southeast of the polymictic conglomerate. The exposed rocks are comparable to those of part C of the Rangeley farther south (fig. 2, columns 2, 3, 4, 5). Shelly fossils, obtained from the localities shown on Figures 1 and 3, indicated a late Llandovery age for these quartz conglomerates. The fossil assemblage, as identified by

A. J. Boucot, includes:

Stricklandia lens ultima

Eocoelia hemispherica

Atrypa reticularis

Protomegastrophia(?)

Eocoelia cf. *E intermedia*

Farther to the southeast a thin unit of metamorphosed laminated argillaceous limestone abuts against intrusive rocks of the Stratton pluton (fig. 1). No comparable unit of metamorphosed impure limestone is present in part C farther south, but a few thin beds of metamorphosed fine-grained calcareous rock were found.

Despite obvious thickness changes in the Rangeley Formation, the exposed sections at stop 2 thus is comparable to the established Greenvale Cove and Rangeley sequence farther south (fig. 2, columns 2 and 3). The Greenvale Cove at stop 2 is much the same as it is farther south. Polymictic conglomerates at stop 2 thicken dramatically southward, become finer grained, and grade farther south to metamorphosed sandstone and then shale. The dominantly pelitic part B is not exposed at stop 2, but may be covered. It is interpreted to thicken southward (fig. 2). The fossiliferous quartz conglomerates and associated metasandstones and metashales at stop 2 may be equated with similar, though nonfossiliferous, rocks that form the lower half of part C farther south. The metamorphosed argillaceous limestone at stop 2 may be a rather restricted near-shore facies that did not extend far to the southeast. The upper half of part C is not exposed at stop 2.

Polymictic conglomerate that outlines the southern end of the northern belt of Silurian (?) rocks is tentatively correlated by us with the polymictic conglomerate at stop 2 (figs. 1, 2). At least two alternatives, however, are equally viable from present information: polymictic conglomerate of the northern belt is equivalent to (1) quartz-rich polymictic conglomerate in part B of the main mass; or to (2) quartz conglomerates of part C in the Blanchard Ponds belt and in the main mass. The second alternative is compatible with fossil data (Harwood and Berry, 1967, p. D-21), but would require a different source area for the various nonquartzose clasts in the polymictic conglomerate of the northern belt. An additional problem is involved in all three alternatives: Lower Silurian polymictic conglomerate in the Blanchard Ponds belt apparently conformably overlies the thin, but extensive, Upper Ordovician(?) Greenvale Cove Formation. In contrast, at the southwest end of the northern belt, steeply dipping upper Middle Ordovician black slates, which are stratigraphically well below the Greenvale Cove and Quimby Formations, are overlain by less deformed polymictic conglomerate; an angular unconformity is inferred (Harwood and Berry, 1967, p. D-20). These contrasting belts of inferred conformity and unconformity are locally less than half a mile apart, (fig. 1). A sedimentary model that would account for these relationships is difficult to visualize, and conceivably the two belts have been faulted against one another. The northern belt, for example, could be an outlier of a large, nearly flat-lying thrust sheet. Available exposure, however, is inadequate to solve these problems.

Fossiliferous quartz conglomerate of the Blanchard Ponds belt is correlated with massively bedded vitreous-appearing quartzites and quartz conglomerates that outline the northwest side of the northern belt and are exposed on the east shore of Kennebago Lake, about 1 mile north of stop 1 (fig. 1). The quartz conglomerate on the east shore overlies a unit of dominantly pelitic rocks interbedded with two lenticular layers of polymictic conglomerate (fig. 3); this conglomerate is not unlike that of part B of the main mass to the south. Similar polymictic conglomerate is exposed as well in the wedge-shaped unit of part B(?) southwest of Kennebago Lake (fig. 1). Because good quartz conglomerates have not been found at the upper contact of the wedge-shaped unit, this contact is conjectural. This conjectural contact is within a mass of interbedded gray slate and feldspathic metasandstone which conformably overlies both the polymictic and the quartz conglomerates of the northern belt (Harwood and Berry, 1967, p. D-21) and which is similar lithologically to the dominant rocks of parts B and C in the Rangeley quadrangle. At the west edge of the northern belt, quartz conglomerate overlies polymictic conglomerate (Harwood and Berry, 1967, p. D-20), in accord with the established sequence to the southeast, but without the intervening pelitic rocks of part B. All these relationships, thus, tentatively suggest that parts A and B of the Rangeley are overlapped by part C toward the north (fig. 2).

Metamorphosed impure limestone at stop 2 is in turn equated with similar rocks that directly overlie quartz conglomerate to the north, near the southeast end of Kennebago Lake (fig. 1). Similar calcareous rocks are likewise associated with quartzite farther northeast in the northern belt.

Quartz conglomerate of the northern belt is overlain by at least 1,000 feet of irregularly interbedded gray metashale and feldspathic metasandstone. These rocks are characteristic of the upper part of part C of the Rangeley Formation to the south. In addition, at relatively high elevations northeast of Kennebago Lake (fig. 1), rocks correlated with part C of the Rangeley are locally overlain by cyclically interbedded pale-greenish-gray metashale and cross-laminated metasandstones that are remarkably similar to the light-colored Perry Mountain Formation of the Rangeley and Phillips quadrangles. These relationships strengthen the overall correlations that are illustrated on Figure 2.

The vitreous-appearing quartzite and quartz conglomerates of the northern belt typify the widespread upper Llandoverian Clough Quartzite of the Bronson Hill anticline to the southwest in New Hampshire (Billings, 1956; Boucot and Thompson, 1963). Moreover, the local presence of fine-grained calcareous rocks above the quartzite is analogous to relationships between the calcareous Fitch and quartzitic Clough Formations in New Hampshire (Billings, 1956). Correlation of these units is thus extremely tempting, but should be avoided until age relationships among various exposures or belts of quartzite and calcareous rocks are more firmly established. Rocks assigned to the Clough Quartzite in New Hampshire, for example, may be of at least two different ages, according to Boucot (Pavlides and others, 1968, p. 65). The same might be true of the Fitch. In the area of trip A-1, for example, thick-bedded quartzites or quartz conglomerates are exposed in part C of the Rangeley Formation, in the middle and upper parts of the Perry Mountain, and in the northern facies of the Smalls Falls. Moreover, fine-grained calcareous rocks are conspicuous in the Greenvale Cove Formation, in part C of the Rangeley in the Kennebago Lake quadrangle, in the Madrid Formation, and in the Hildreths Formation of the southern sequence (fig. 1). Boudette favors correlation of the calcareous rocks of part C of the Rangeley in the Kennebago Lake quadrangle with the Fitch Formation, whereas Moench favors correlation of the Madrid Formation (which overlies the Smalls Falls and Perry Mountain, as well as part C) with the Fitch. If the Fitch Formation is, in fact, of more than one age, both authors may be correct.

Lower Silurian quartz conglomerates and some polymictic conglomerates are widely distributed in the northern Appalachians (Pavlides and others, 1968, table 5-1), but only in northeastern Newfoundland is there known to be a great thickness of polymictic plutonic-clast conglomerate comparable to part A of the Rangeley Formation. Marshall Kay (written commun., 1970) has called our attention to possible similarities between the Rangeley Formation and the Goldson Group, described by Helwig and Sarpi (1969), some 800 miles to the northeast. The provenance, composition and sedimentology of the Goldson Group is indeed remarkably similar to that of the Rangeley Formation. Both units are of approximately the same age. Although quartz conglomerates are lacking in the upper part of the Goldson, unit J of the Mix Cove Formation in the uppermost unit of the Goldson Group -- is composed of laminated, cross-laminated and convolute-laminated reddish and greenish siltstones (Kay, 1969, table 1; Helwig and Sarpi, 1969, p. 446-447) that are not unlike typical rocks of the Perry Mountain Formation. Environments in these distant areas may thus have been similar at approximately the same time.

Acknowledgments.--We are grateful to H. R. Dixon and R. W. Schnabel for constructive comments on the manuscript.

ROAD LOG FOR TRIP A-1

Assemble at the Rangeley Chamber of Commerce building well before the time of departure of your section. Owing to the added time required for stop 11, section A will leave at 6:00 a.m. Sections B and C will leave at 7:00 a.m., but will travel in opposite directions to stops 1 and 10, respectively. The trip will be by school buses. Owing to parking problems along state highway 4, and logistics at some stops, automobiles will not be permitted.

Participants in section A should be prepared for a 650-foot climb, 2-3/4-mile round trip to stop 11. The transition from part B into part C of the Rangeley Formation and then into the Perry Mountain Formation is will displayed here in extensive pavement outcrops. Participants in sections B and C should be prepared for a somewhat shorter (500-foot climb, 1-1/2-mile round trip) to stop 5B and C, where characteristic features of part C of the Rangeley are exposed in extensive pavements across the troughline of the Mountain Pond syncline.

<u>Mileage</u>

0.0 Start at corner of Pleasant and Main Streets (State Routes 16 and 4, respectively), opposite the Chamber of Commerce building, Rangeley.

Drive west on Main Street.

0.6 Turn right on Loon Lake Road and drive north.

1.2-1.4 Quimby Formation (Or) crops out on right side of road.

2.3 Pavement ends at Rangeley Airport on left.

2.4 Road intersection--drive straight ahead on right fork of gravelled roads.

2.8 Garnet-bearing reaction hornfels (included in Dga) in roof zone of Devonian gabbro crops out on right.

3.3 <u>Caution</u>: Sharp bend to right in road.

4.1 Ridge of Spotted Mountain (reaction hornfels) visible to northwest.

4.7 Borrow pit in spheroidally weathered gabbro (Dga) in pre-Pleistocene weathering zone.

5.3 Road junction: bear right from Loon Lake Road onto Kennebago Lake Club access road.

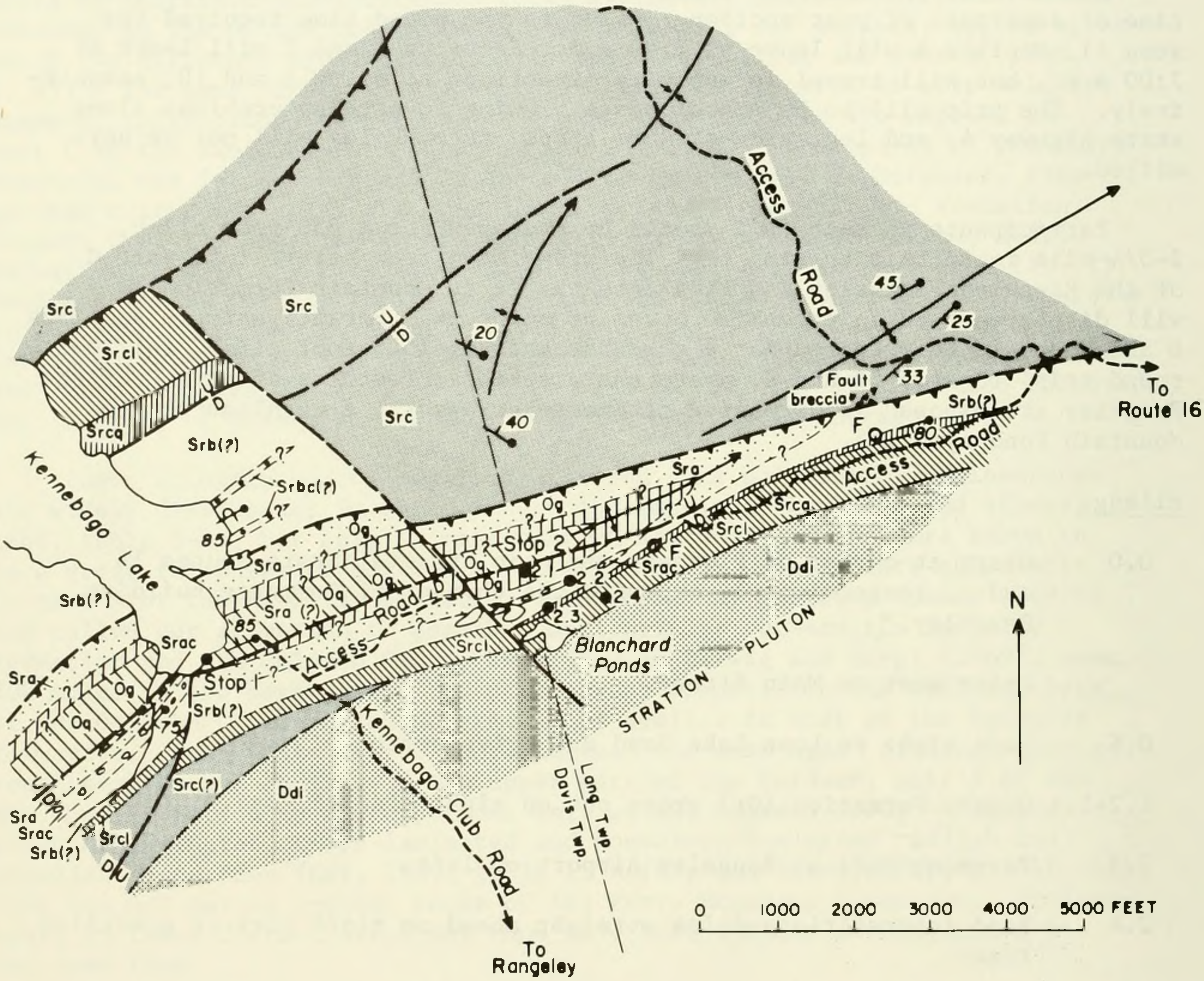


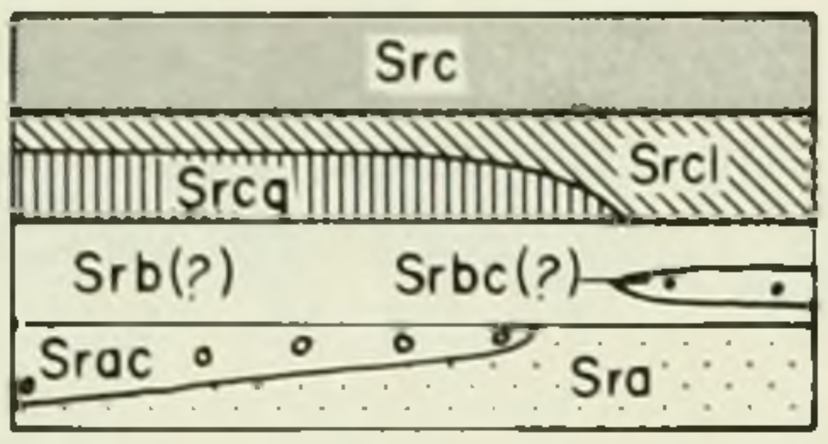
Figure 3.--Detailed geologic map of the Kennebago Lake area, Kennebago Lake quadrangle, showing location of stops 1 and 2. Planimetric base from unrectified aerial photograph (U.S. Geol. Survey Series GS-VBKX no. 1-66, 5/24/66, approx. scale 1:26,000). Geology by E.L. Boudette, assisted by D.S. Harwood, Jay Murray, and Woodrow Thompson, 1962-68.

EXPLANATION

Medium- to coarse-grained hornblende diorite

DEVONIAN

Lower Silurian(?)



Rangeley Formation

Part C:

Src, *pelitic andalusite-cordierite hornfels with thick- and thin-bedded arkosic metasandstone; may be part B* (Srb) *in part*

Srcl, *thin-bedded and laminated calc-silicate rock and metamorphosed silty limestone*

Srcq, *fossiliferous quartz pebble conglomerate and metasandstone east of Blanchard Ponds; vitreous-appearing, locally conglomeratic quartzite on north side of Kennebago Lake*

Part B:

Srb, *pelitic andalusite-cordierite hornfels with thick- and thin-bedded arkosic metasandstone; possibly same as part C* (Src)

Srbc, *polymictic conglomerate; possibly same as part A* (Srac)

Part A:

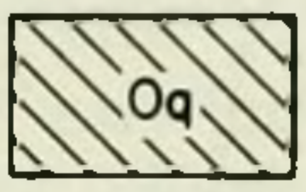
Srac, *polymictic conglomerate*

Sra, *thick- and thin-bedded metasandstone, possibly with some pelitic rocks*

SILURIAN(?)

Upper Ordovician(?)

Greenvale Cove Formation



Quimby Formation

ORDOVICIAN(?)

Contact

Long dashed where approximately located; short dashed where inferred or gradational; queried where conjectural

Thrust

Teeth on upper plate

Normal

U, *upthrown side;*
D, *downthrown side*

Faults

Approximately located

Anticline

Syncline

Folds

Showing trace of axial surfaces and direction of plunge of axes. Approximately located

25 Upright

85 Overturned

Strike and dip of beds

Tops determined from sedimentary features

1 2.1

Location of outcrops at stops 1 and 2

F

Fossil locality

5.8 Garnet-bearing reaction hornfels in roof zone of Devonian gabbro crops out on right.

6.0 Borrow pit in till.

6.7 Outlet of Cow Pond (Note: Erratics along the road represent fairly well the underlying lithologies; they include reaction hornfels, gabbro, and diorite.)

10.4 Blanchard Ponds trail on right side of road.

10.6 Kennebago Lake Club--turn to left on service road and park in service area.

10.7 STOP 1. Outcrop on Lake shore to the west of the small stream which runs behind the service area.

Rocks exposed here are assigned to the upper part of the Quimby Formation, perhaps within 600 feet of the base of the Greenvale Cove Formation. This assignment is based on lithologic similarity to rocks in the type area of the Quimby (Moench, 1969) exposed at stop 3, and on the proximity of outcrops of the Greenvale Cove and Rangeley Formations at stop 2, about 4,000 ft east-northeast of stop 1, and of the Rangeley Formation about 800 ft southwest and 2,000 ft north of stop 1. (See fig. 3.) The dominant rock at stop 1 is dark, thin-bedded sulfidic slate, and lighter colored metagraywacke composed of quartz, plagioclase, subordinate amounts of biotite, and sparse magnetite and pyrite. The metagraywacke beds display fair to good graded bedding and poor cross laminations. Bedding strikes northeast, dips steeply, and faces northwest.

The rock at stop 1 is inferred to occur on the northwest limb of an isoclinal fold that trends about N. 70° E., and plunges at a low angle to the east (fig. 3). The Quimby on the southeast limb is interpreted to have been truncated by a normal strike fault along which the Rangeley Formation and perhaps a small amount of the Greenvale Cove have been downfaulted on the southeast against the Quimby. The Quimby Formation at stop 1 may be overlain to the north by the Greenvale Cove Formation; no exposures exist to confirm its presence. Farther north, along the east shore of Kennebago Lake (fig. 3) a succession is exposed, grading well up into the Rangeley Formation.

Rocks at stop 1 are within the contact metamorphic halo of the Stratton pluton. They contain biotite. More pelitic overlying rocks of the Rangeley and Greenvale Cove Formations exposed nearby contain andalusite and cordierite.

Return to buses.

10.7 Turn around, begin retracing rout back toward Rangeley, and park at woods access road on left 0.2 mile from Kennebago Lake Club.

0.2 STOP 2. Walk 0.7 mile to northeast along woods access road (fig. 3) to the limit of vehicle travel.

Borrow pits occur along road in valley train deposits probably associated with a large glacial lake in the Dead River and Sandy River drainages. Proceed about 1,200 feet, azimuth S. 81° E., from the end of the usable part of the road to an area of several scattered outcrops north of the largest Blanchard Pond (fig. 3).

A succession of four principal exposures occurs in apparently conformable normal stratigraphic order at stop 2 (fig. 3). In ascending stratigraphic order they represent: stop 2.1, the Greenvale Cove Formation; stop 2.2, polymictic Rangeley Conglomerate as used by Smith (1923) or the conglomeratic facies of part A of the Rangeley Formation; stop 2.3, fossiliferous quartz metaconglomerate and metasandstone correlated with the lower part of part C of the Rangeley (fig. 2); stop 2.4, calc-silicate rock, considered to be a local calcareous facies of part C of the Rangeley Formation (fig. 2). Dominantly pelitic rocks of part B of the Rangeley are not exposed, but may occur between stops 2.2 and 2.3. The calc-silicate rock is in contact on the southeast with mafic rocks of the Devonian Stratton pluton (fig. 1).

The Greenvale Cove Formation (Og) at stop 2.1 is exposed in small outcrops on the forest floor. Abundant angular rubble of Greenvale Cove is present nearby. The rock is laminated metasiltstone and fine- to medium-grained metasandstone, composed of quartz, plagioclase, and biotite. This rock is similar to the upper part of the Greenvale Cove at stop 4 (fig. 1).

Polymictic conglomerate (Srac) at stop 2.2 is exposed in an unusual series of 3-dimensional outcrops. Clasts are rounded, pebble-and cobble-sized fragments of granitic rocks, diorite, felsic and mafic volcanics, quartzite, quartz, and chert. They are set in a matrix of feldspathic metasandstone. Most of the clasts can be correlated with known pre-Silurian rock types exposed in the core of the Boundary Mountain anticlinorium to the northwest. The distinctive quartz diorite with blue quartz is exposed on Round Mountain in the Chain Lakes quadrangle to the north, and occurs in the metaconglomerate at stop 4 as well. Tabular clasts tend to be imbricate at stop 2.2. Most clasts, however, tend to be elongated parallel to the strike of bedding. Individual conglomerate beds here are lenticular.

Fossiliferous rocks at stop 2.3 are thick bedded faintly laminated quartzose metasandstone and quartz-pebble metaconglomerate (Srcq). Individual beds commonly grade from quartz-pebble metaconglomerate at the base to metasandstone at the top. Shelly fossils, listed previously, occur in the conglomeratic, calcareous lower parts of the graded beds, and they are probably allochthonous. This fossiliferous unit is about 150 feet thick. It extends discontinuously along strike to the northeast almost to the eastern edge of the Kennebago Lake quadrangle, where it is cut by intrusive rocks. Efforts to trace it to the southwest have failed.

Calc-silicate rock (Srcl) exposed at stop 2.4 is believed to be metamorphosed silty to sandy limestone. The rock is distinctly laminated and is composed of various combinations of quartz, diopside, hornblende, garnet,epidote, chlorite, and small amounts of calcite. Mafic diorite of the Stratton pluton is exposed a few feet to the southeast.

Return to buses.

Return to Chamber of Commerce building in Rangeley.

0.0 Drive south along State route 4 from Chamber of Commerce building in Rangeley.

1.7 STOP 3. The shale member of the Quimby Formation (Or) exposed along Nile Brook. The rock is dark-gray pyrrhotite-bearing metashale (about 70 percent) with thin interbeds of metagraywacke and sparse thin beds of calc-silicate rock. Metagraywacke beds are graded, commonly parallel laminated, less commonly cross laminated; some have load casts. Tops of beds face northwest, on the northwest limb of an anticline whose axis is exposed on the east shore of Rangeley Lake.

Return to buses.

2.3 STOP 4. Starting at "The Terraces" cabins, walk south on left-hand side of road 1/2 mile past outcrops of Greenvale Cove Formation (Og) and part A of the Rangeley Formation (Sras and Srac).

First outcrops on the left are thinly interlaminated metashale and metasiltstone of the Greenvale Cove Formation (Og). Farther southeast, at a higher stratigraphic level in the Greenvale Cove, is a prominent zone of thinly laminated metasiltstone and metasandstone with abundant thin beds of calc-silicate rock. Metasiltstone and metasandstone laminations are commonly graded, but unequivocal tops are difficult to read in this lithology. Tops of rather sparse well-graded beds are interpreted to face southeast.

Basal feldspathic metasandstones of the Rangeley Formation (Sras) are exposed next to a telephone pole on the left. The basal 25 feet of the Rangeley is composed largely of coarse-grained light-colored metasandstone in graded beds facing southeast that range in thickness from a few inches to several feet. The metasandstone beds are separated by thin partings of gray metashale. The lower contact of the Rangeley is not exposed here in the roadside outcrops, but it is exposed on the hillside about 2,000 feet to the northeast. Features exposed there indicate that the basal Rangeley sands were deposited on unconsolidated shaly sediments of the Greenvale Cove Formation.

The lower 1,000 feet of the Rangeley--the sandstone facies of part A (Sras)--is abundantly exposed in the woods a few tens of feet east of Route 4. The dominant rock exposed here is massive feldspathic metasandstone in a succession of graded beds facing southeast. Single beds range in thickness from a few feet to 30 feet and tend to be thickest in the upper part of the sequence. Conglomeratic rocks are absent from the lower 250 feet of the sandstone facies. Small amounts of granule-pebble conglomerate first appear about 250 feet above the base and thence become gradually more abundant and coarser grained to the southeast toward the top of the sandstone facies.

Spectacular outcrops of conglomerate (Srac) begin opposite "The Birchwood" cabins and extend several hundreds of feet to the south along Route 4. The most impressive features of these rocks are the great thickness of individual beds (as much as 30 feet), their crudely graded, poorly sorted, and internally massive character, and the great variety of generally well rounded rock fragments. Unlike typical fluvial gravels, the largest clasts are not at the base of each bed, but instead are a foot or two above the base. Similar examples of inverted graded bedding have been noted by Fisher and Mattinson (1968) in turbidite-conglomerates at Wheeler Gorge, California.

Return to buses.

3.5 STOP 5. Turn left to Greenvale Cove School and park behind schoolhouse. Walk 100 yards northeast up gravel road to riprap quarry.

On northwest side of quarry are large blocks and outcrops of conglomerate, representing the lower of two prominent conglomeratic layers in part B of the Rangeley (Srb). The conglomerate is polymictic, but clasts of vein quartz and quartzite are much more abundant than in conglomerates of part A. In some rocks, interpreted as pebbly mudflow deposits, clasts are widely spaced in a matrix of pelitic phyllite.

Overlying rocks in the quarry and along the brook to the southeast are dominantly gray metashale and irregularly interbedded feldspathic metasandstone. Pebbly mudflow deposits, slump folds, and intraformational unconformities are exposed along the brook. Bedding tops face southeast, except on the northwest limbs of the slump folds. Pelitic rocks contain euhedral pseudomorphs of chlorite and sericite after staurolite, which are locally alined subparallel to the plane of northwest-striking slip cleavage.

STOP 5B and 5C, for sections B and C only. Follow blazed trail (not shown on fig. 1) leading southeast from brook to pavement outcrops on hillside.

Part C of the Rangeley Formation (Srcq) is displayed in pavements that extend nearly 1,000 feet across strike. Rocks in the highest and farthest outcrops on the southeast are complexly folded in the axial zone of the Mountain Pond syncline. Fold axes plunge gently northeast to steeply southwest. Rocks in nearer and lower outcrops face southeast.

The dominant rock is gray metashale, which is irregularly interbedded with thin to very thick graded beds of feldspathic quartzite, and lenticular graded beds of closely packed quartz granule and pebble metaconglomerate. Beds of metaconglomerate range in thickness from a few inches to about 10 feet. Clasts are vein quartz and quartzite. Pebbly mudflow deposits are less common than in part B of the Rangeley.

Return to buses.

5.3 Long Pond on right.

6.0-6.1 Roadcuts of rusty-weathering dominantly pelitic rocks of part B of the Rangeley Formation (Srb).

6.4 Large road cut of rusty-weathering dominantly pelitic rocks. Dominant attitude of bedding is about N. 25° W., 25° NE, right side up, just southeast of the crestline of the Brimstone Mountain anticline. In contrast to the southwest plunge of the Mountain Pond syncline, the anticline plunges northeast.

6.7 South end of Long Pond.

7.1 Roadcut on right. Dominantly pelitic rocks of part B of Rangeley Formation (Srb).

9.2-9.5 Outcrops on right. Dominantly pelitic rocks of part C (Src). Rangeley Formation infolded with a small amount of the Perry Mountain Formation (Sp). Quartz pebble metaconglomerate of part C is exposed on the nose of an anticline that plunges steeply northeast.

9.8 Low outcrops on right. Uppermost part C of Rangeley Formation (Src).

10.6-10.8 Large outcrops on right. Perry Mountain Formation (Sp). Cyclically thin-bedded quartzite and light-colored muscovite-rich metashale and a few quartzite beds several feet thick. Bedding tops face northwest to the axis of a syncline at the extreme northwest end of the outcrops.

11.1 Bridge over Sandy River.

11.7-12.0 STOP 6. Watch traffic! Walk south on left-hand side of road past outcrops of uppermost Perry Mountain Formation (Sp) and lowermost rocks of Smalls Falls Formation (Ss). Tops of all beds face southeast.

Rocks of the Perry Mountain (Sp) are cyclically interbedded white quartzite and light-colored muscovite-rich metashale. Graded bedding is ubiquitous; cross lamination and convolute lamination are abundant.

Rocks of Smalls Falls Formation (Ss) are cyclically interbedded sulfide-rich rusty-weathering carbonaceous metashale and quartzite. Bedding features in lower part are similar to those of Perry Mountain.

Return to buses.

12.2-12.4 Outcrops on left; Smalls Falls Formation (Ss).

12.7 STOP 7. Smalls Falls picnic area; type locality of the Smalls Falls Formation (Ss). The formation is well exposed in cascades and pavements along the Sandy River above the falls and along the tributary Chandler Mill Stream a short distance to the west. Bedding features are best exposed along the Chandler Mill Stream.

The dominant rock type is rusty-weathering cyclically interbedded metashale and slightly subordinate quartzite. The metashale is dark-gray and carbonaceous and contains a few percent of pyrrhotite. The beds of quartzite, typically 1 inch thick, are well graded and commonly display a rather wispy cross lamination. The large altered and partly altered andalusite porphyroblasts tend to be alined subparallel to the plane of a pervasive slip cleavage that strikes northwest.

Return to buses.

13.0 Outcrop on left; Smalls Falls Formation (Ss).

13.4 Harvey Pond on left.

13.6-13.8 Large roadcuts on left. Smalls Falls Formation (Ss).

14.4 Bridge over Sandy River. Madrid Formation (Sm) exposed in stream bed; it is fine-grained light-colored metasandstone that contains abundant pods of calc-silicate rock.

15.2 STOP 8. Descend steep bank to outcrops along Sandy River. Contact between the Smalls Falls (Ss) and Madrid (Sm) Formations exposed on both sides of small island in center of stream. Tops of bedding face southeast.

Uppermost 500 feet of Smalls Falls (Ss, upstream) is a thin- to medium-bedded assemblage of sulfide-bearing calcareous metasandstones and metasiltstones, and a subordinate number of beds of noncalcareous metashale. Probably owing to their greater primary permeability, the coarser grained sediments of the original rock tend to be the most calcareous and contain various assemblages of calc-silicate minerals. The silty and shaly rocks are less calcareous, more carbonaceous, and darker colored. Some shaly beds contain as much as 75 percent almandine-spessartite garnet. Tops of beds near the upper contact of the Smalls Falls are indicated by graded bedding. The coarser clastics are lighter colored than the more carbonaceous finer clastics, but they are commonly softer than the finer clastics, owing to abundant calcite cement.

The contact between the Smalls Falls (Ss) and Madrid (Sm) Formations is sharp. It is marked by the abrupt appearance of coarser grained, lenticular-bedded, and crossbedded calcareous Madrid metasandstone. The abundance of sulfides diminishes gradually upward from the contact. The basal coarse clastic zone of the Madrid is about 35 feet thick. It is overlain by about 170 feet of interlaminated noncalcareous metasiltstone and metashale and some thin-bedded calc-silicate rock. The top of this shaly zone and younger rocks of the Madrid will be seen at stop 9.

Return to buses.

16.0 STOP 9, Madrid village. Type locality of the Madrid Formation (Sm) exposed along the Sandy River and the tributary Saddleback Stream. (See topographic map of Phillips quadrangle.). Walk south from the bridge over Saddleback Stream and along the east bank of the Sandy River.

The top of the shaly zone in the Madrid (described above in stop 8) is exposed north of the bridge over the Saddleback Stream. It is overlain to the southeast by 70 feet of thin-bedded light-gray, white, and pale-bluish-green calcareous metasiltstone and metasandstone. Note the distinctive cross lamination in the white beds. These rocks are overlain by 5 to 10 feet of sulfidic carbonaceous metasiltstone and metashale, followed by about 550 feet of thick-bedded light-gray to light-brownish-gray calcareous metasandstone with subordinate partings of medium-gray metashale. The beds of metasandstone are as much as 10 feet thick; they are graded, commonly crossbedded, and they commonly contain pods of calc-silicate rock. Gray metashale is most abundant in the southernmost outcrops along the Sandy River where the Madrid (Sm) grades upward into the Seboomook(?) Formation (Ds). All beds face southeast.

Return to buses.

17.0 STOP 10. Seboomook(?) Formation (Ds) is exposed along the Sandy River under the bridge and downstream.

The rock is dominantly gray faintly bedded to well bedded metashale with greatly subordinate amounts of light-colored metasiltstone and fine-grained metasandstone. Tops of beds face northwest toward the trough of the Bear Hill syncline (fig. 1). Typical graded bedding is expressed by continuous gradations from sandy or silty rock into metashale. It is unlike graded bedding in the Rangeley or Perry Mountain Formation, for example, in which the contact between each graded bed of metasandstone and the next overlying bed of metashale tends to be sharp or sharply gradational. Where silty or sandy material is absent from the Seboomook(?), graded bedding is expressed by subtle gradations in staurolite content, which reflect changes of original alumina (or clay) content within each graded bed.

Return to buses.

STOP 11. Park near bridge over Sandy River (elevation 1,447 ft; see topographic map, Rangeley quadrangle). Extensive pavement outcrops are 5,000-6,000 feet, azimuth N. 85° W., from the bridge and at an elevation of about 2,100 feet. Their approximate location is shown on the geologic quadrangle map (Moench, 1970). Figure 4 illustrates stratigraphic and structural relationships of the upper part of the Rangeley Formation and the lower part of the Perry Mountain Formation.

The most important stratigraphic features at stop 11 are the distinctive beds of quartz metaconglomerate in part C of the Rangeley, and the gradational contact between the Rangeley Formation and the overlying Perry Mountain Formation. The quartz metaconglomerates are equated approximately with the fossiliferous quartz conglomerate at stop 2 in the Kennebago Lake quadrangle. At stop 11 (fig. 4) quartz metaconglomerates crop out at three stratigraphic levels and are separated by typical gray Rangeley metashales. The metashales are irregularly interbedded with generally greatly subordinate amounts of metasandstone. The metaconglomerates, together with associated coarse-grained metasandstone, form thick, commonly lenticular graded beds. Some of these coarse clastic rocks contain abundant clinozoisite, grossular, and amphibole, suggesting that the original cement was a mixture of carbonate and clay minerals. Pebbly mudflow deposits, composed of conglomerate clasts rather widely spaced through a matrix of metashale, are present but not abundant.

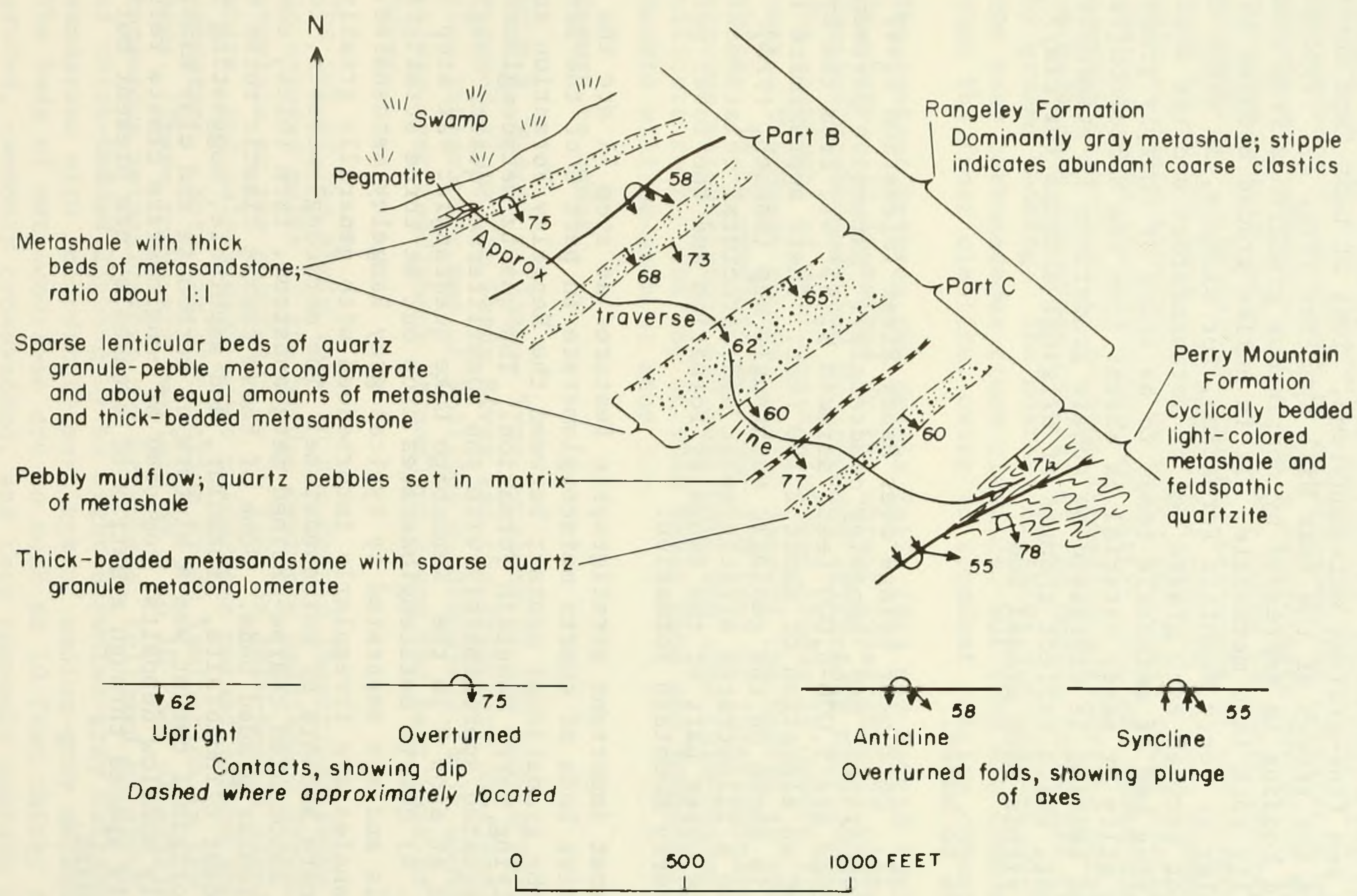


Figure 4.--Pace and compass sketch map of pavement outcrop at stop 11.

Gray Rangeley metashale that is rather irregularly interbedded with typically massively graded beds of feldspathic metasandstone grade upward into light-colored muscovite-rich Perry Mountain metashale that is cyclically interbedded with distinctively cross laminated, graded beds of more quartzose metasandstone.

The overturned folds shown on Figure 4 plunge steeply, locally directly down the dip of the phyllitic axial surface cleavage. The pelitic rocks are phyllites with porphyroblasts of staurolite, altered to chlorite and white mica.

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