THE STRUCTURAL FRAMEWORK AND STRATIGRAPHY OF THE SOUTHEASTERN ADIRONDACKS

by

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INTRODUCTION

The southeastern Adirondacks are herein defined as the topographic highlands (overwhelmingly Precambrian) that lie within a compartment whose corners are situated at: Speculator, Gloversville, Saratoga Springs, and Glens Falls (see fig. 3). The southeastern Adirondacks are part of a regional geologic framework that underlies the map area shown in fig. 1. The lithology and structure of this region is shown in figs. 3 and 4. The purpose of this trip is to show as many examples of this area's representative lithology and structure as time permits.

PREVIOUS WORK

Early mapping within the southeastern Adirondacks was done by William Miller (1911, 1916, 1920, 1921), Cushing and Ruedemann (1914), Bartholome (1956), Thompson (1959), and Hills (1965). Hall (1965) and his students prepared detailed geologic maps along the east flank of the Palmerton Range. In the mid-1960's McLelland (1969) began mapping with the Canada Lake area immediately west of Sacandaga Reservoir. This work was pushed eastward and northward in the early 1970's (McLelland 1974). The contiguous geology to the northwest of the southeastern Adirondacks represents the cumulative work of Cannon (1937), Nelson (1968), de Waard (1965), Lettney (1968), Geraghty (1977), and McLelland (1975, 1976). In addition to these contributors, a great deal of the area was reconnaissanced by Y. Isachsen for the 1961 edition of the N.Y. State Geological Map.

REGIONAL STRUCTURAL GEOLOGY

General Description

Four definite phases of regional folding have been recognized in the southern Adirondacks. A fifth phase of folding may be present as broad, gentle warps. All of these fold sets have large dimensions with the two earliest being of unusually great extent.

The earliest fold event is isoclinal and, overall, recumbent. It is referred to as F_1 and is best represented by the Canada Lake Nappe (fig. 4). F_1 folding is also represented by the Little Moose Mt. Syncline and the Wakeley Mt. Nappe. All F_1 folds have approximately E-W axial

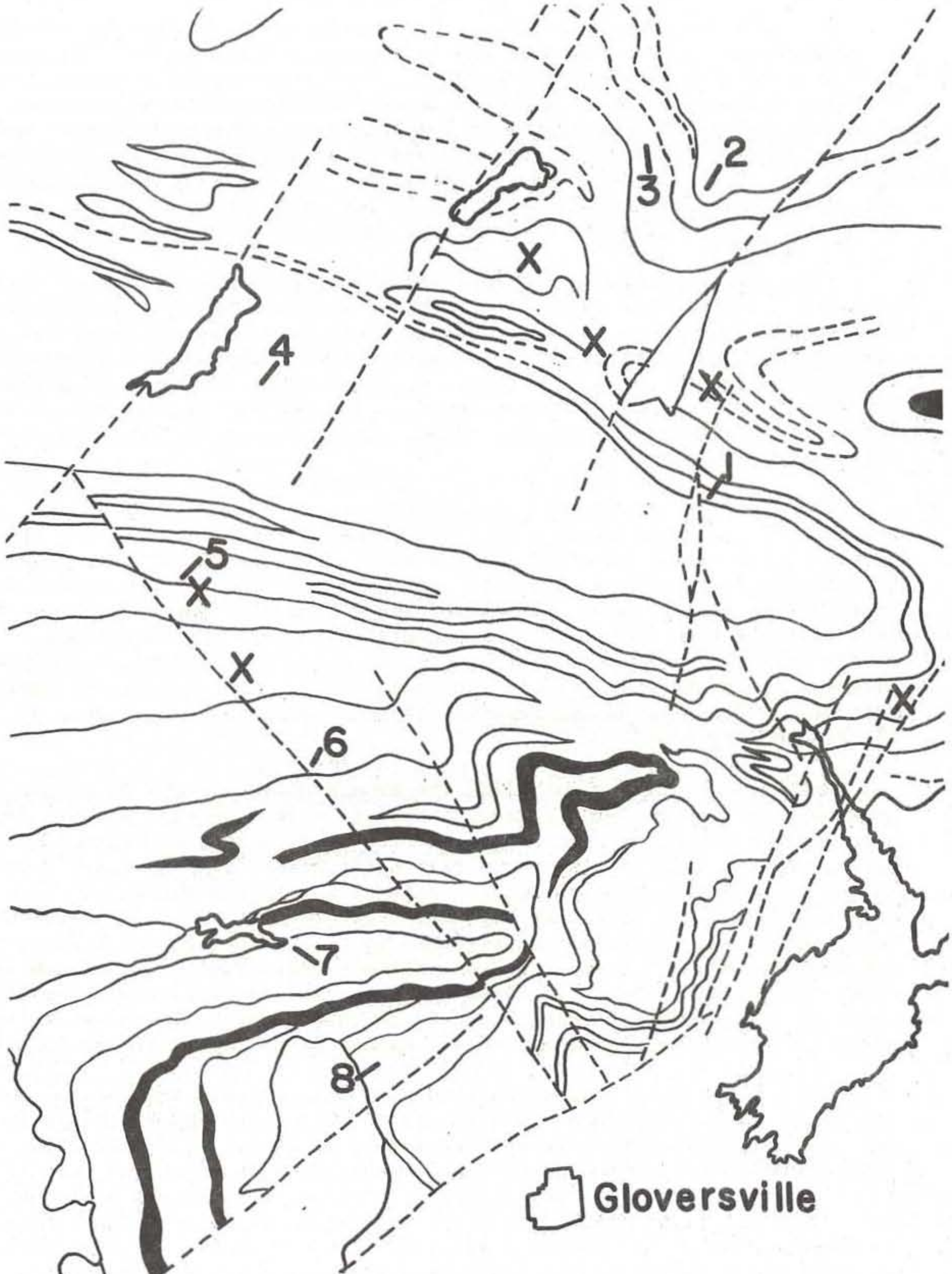

Fig. 10 - Field trip area enlarged from fig. 4. Stop numbers are shown. Large X's locate major anorthositic sills intrusive into de Waard and Walton's (1965) supracrustal sequence.

THE BASEMENT CONTROVERSY

In the early 1960's Walton and de Waard (1963) proposed an intriguing new hypothesis concerning Adirondack geology. They postulated that, together with associated charnockitic lithologies, the anorthositic rocks of the Adirondacks constituted a pre-Grenvillian basement complex. Prior to the Grenville Orogeny (~1.1 b.y.), this basement complex had been folded, metamorphosed, and eroded. Sometime during the Proterozoic the basement was unconformably overlain by the section of rocks that begins with the Lower Marble Fm. and is referred to as the supracrustal sequence. During the Grenville Orogeny, both basement and supracrustal sequence were folded together and metamorphosed. Subsequent erosion has left the basement exposed in the cores of domes, while the supracrustal rocks are preserved in synclinal keels.

The Walton-de Waard basement hypothesis was originally based upon the observation that the Lower Marble Fm. seems to overlie a number of different lithologies and appears, therefore, to be separated from these rocks by an unconformity. Presumably the unconformity was initially angular, but as in many other instances, the angular discordance has been erased by subsequent deformation.

There are several problems inherent in the basement hypothesis. The first is that a number of the so-called "older paragneisses" assigned to the basement complex are identical to lithologies lying above the marble. In this writer's opinion most of these should be included within the Lower Marble Fm. The fact that these units may often be discontinuous does not necessarily prove the existence of an erosional disconformity. The same affect could be produced by original variations in shallow water sedimentation. Equally probable is that boudinaging with the marble rich units would result in similar phenomena. It is widely recognized boudinage structures are common in this horizon (Stop 3). In places the marbles have been almost completely squeezed out, and the Lake Durant Fm. lies directly on quartzo-feldspathic gneisses of type "a", yet it is widely agreed that this sort of discordance is tectonic in origin.

A second point of importance concerns the status of the anorthositic gneisses as candidates for a pre-Grenvillian basement. Field work in the southern Adirondacks has resulted in the recognition of a large number of anorthositic sills that intrude at stratigraphic horizons lying far up into the supracrustal sequence. The locations of some of these are shown in fig. 10. One of these bodies will be visited at Stop 5. The existence of these sills represents serious negative information with regard to the hypothesis that the anorthosites of the Adirondacks are part of a pre-Grenvillian basement. It is possible, of course, to suppose that there was more than one episode of anorthosite intrusion in the Adirondacks. However, even the principle bodies of anorthosite to the north contain inclusions of lithologies identical to the Lower Marble Fm. and appear to cause what may be high temperature contact metamorphism in the latter, e.g. garnet-wollastonite deposits at

Willsboro Point.* Thus, all anorthosite bodies appear to post-date the Lower Marble Fm.

If we conclude that the anorthositic gneisses of the Adirondacks cannot be part of a Pre-Grenvillian basement, then it is still possible to hypothesize that the associated quartzo-feldspathic gneisses of type "a" constitute such a basement. Absolute age dating does not corroborate this hypothesis, and these gneisses may simply represent the next layer down in a continuous stratigraphy (Isachsen, McLelland and Whitney 1975). However, the status of the type "a" gneisses remains unresolved, and the identification of a pre-Grenvillian basement constitutes a major problem in Adirondack research.

IMPLICATION FOR ADIRONDACKS IN GENERAL

It is believed that the structural framework developed here for the southern Adirondacks may be extended to the entire mountain range. Figure 11 shows the manner in which fold sets F_1-F_4 can account for the outcrop pattern of the Adirondacks. Within the Northwest Lowlands Foose and Carl (1976) have already demonstrated that the alaskitic gneisses once thought to occur in phacoliths is actually exposed in the cores of structural culminations lying at the intersections of NNE and NW fold axes (F_3 and F_4 of this paper). Fishook terminations in these outcrops appear due to earlier fold noses.

In Fig. 11 the Arab Mt. Anticline has been extrapolated across the entire northern section of the Adirondacks. This, like many other extrapolations in fig. 11, is speculative and based upon a synthesis of data from earlier reports, aeromagnetics, etc. Nonetheless, the picture that emerges is not unreasonable and may serve as a working model for further research. It does appear likely that salients and re-entrants in the Marcy Massif (Saranac Basin, etc.) lie at the intersections of F_2 and F_3 fold axes. Similar interpretations appear likely for structural basins such as that mapped by Buddington and Leonard (1962) near Sabbatis, New York.

Fig. 11 suggests that the southern Adirondacks represents a large domical structure due principally to large F_2 and F_3 intersections, and underlain by extremely large F_1 nappes (Canada Lake-Little Moose Mt. Syncline and Wakeley Mt. nappes). Erosion has cut a window through this dome providing an excellent exposure through great, recumbent flaps of rock deformed and metamorphosed at some 20-25 km depth and 600-800°C (McLelland and Whitney 1977). Since the present Moho beneath the Adirondacks appears to be located near 35 km (Katz, personal communication), it seems likely that the Grenvillian orogeny represented by these P,T conditions may have been associated with events resulting in a double continental thickness.

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* It should be noted that Essene et al (1977) have proposed that the development of wollastonite may be due to lowering of the partial pressure of CO_2 by influx of H_2O in a two component vapor phase.

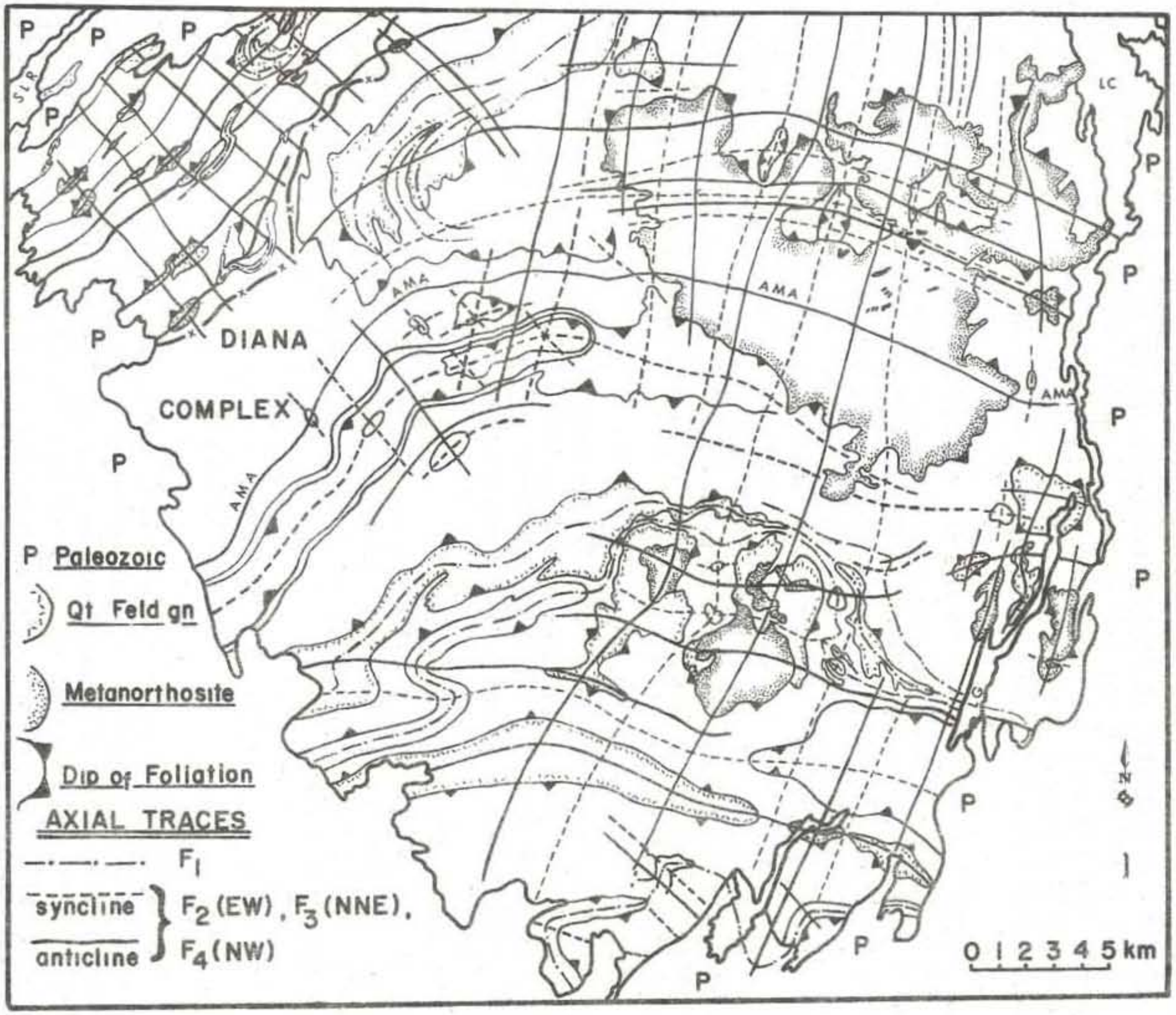

Fig. 11 - Hypothetical structural framework for the Adirondacks. AMA-Arab Mt. Anticline.

FAULTS

Three main systems of faults affect the Adirondacks. All are normal faults and many formed during the PreCambrian and were reactivated in Paleozoic time. The best defined topographically is the NNE trending set that has been further accentuated by glacial scouring. A great many lakes are oriented parallel to this fault set, e.g. Indian Lake, Lake George. The NNE faults are important in determining the eastern and southeastern margins of the Adirondacks where they have "stepped-down" the Paleozoic section to the east. A number of grabens also exist. Such grabens are present at the Sacandaga Reservoir area, the Lake George Graben which continues southward to the northwest of Saratoga Springs, and at the Paleozoic inliers in the vicinity of Wells, New York.

The NNE faults often have extensive breccias developed along them. An outstanding example exists at, and just south of, the junction of Rts. 8 and 30. Many of these faults must have substantial offset along them, but, thus far, mapping of the PreCambrian has failed to establish precise quantitative values for this displacement. The reason is that most of the larger NNE faults have major valleys associated with them, and it is difficult to extrapolate folded stratigraphy across these. A minimum offset is obtainable at the town of Wells where the Paleozoic inlier lies 1500 feet below the tops of the surrounding PreCambrian hills. The offset must have been at least this much with the downthrown side being to the east.

Offset along the NW faults has been easier to ascertain because they are less affected by glacial scouring and resultant valleys. Near Canada Lake the offset on the western NW fault shown on fig. 3 is approximately 2000' with the east side being downthrown.

Slickensides, breccia, closely spaced fracturing, and stratigraphic discontinuities indicate that the region has been affected by an almost E-W set of high angle faults. Offset along these has not been measured. The E-W fault system shows up well on ERTS imagery and appears to extend into the Paleozoics.

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REFERENCES CITED

Balk, Robert, 1936, Structural and petrologic studies in Dutchess County, N.Y., Part I: Geol. Soc. Am. Bull., v. 47, p. 684-774.

Bartholome, Paul, 1956, Structural geology and petrological studies in Hamilton County, N.Y.: Princeton University, doctoral thesis.

Buddington, A.E., 1939, Metamorphism of Adirondack igneous rocks: Geol. Soc. America, Mem. 7.

Buddington, A.E. and Leonard, B.F., 1962, Regional geology of the St. Lawrence County Magnetite District: N.W. Adirondacks USGS Prof. Paper 376.

Cannon, R.D., Jr., 1937, Geology of the Piseco Lake quadrangle: N.Y. State Mus. Bull. 312.

Cushing, H.P. and Ruedemann, R., 1941, Geology of Saratoga Springs and vicinity: N.Y. State Mus. Bull. 169.

Essene, E.J., Bohlen, S.R., and Valley, J.W., 1977, Regional metamorphism in the Adirondacks (abs.): GAAPBC, v. 9, n. 3, p. 260.

Foose, M. and Carl, T., 1976, Setting of Alaskite bodies in the NW Adirondacks: Geology, v. 5, n. 2, p. 77-81.

de Waard, D., 1962, Structural analysis of a preCambrian fold: the Little Moose Mt. Syncline in the southwestern Adirondacks: Proc. Kon. Ned. Akad. Wetensch., Amsterdam, v. B, n. 65, p. 404-417.

de Waard, D., 1965, The occurrence of garnet in the granulite-facies terrain of the Adirondack highlands: Jour. Petrology, v. 6, no. 1, p. 165-191.

Geraghty, E., 1977, Structure, stratigraphy, and petrology of part of the Blue Mt. 15' quadrangle, central Adirondacks: Ph.D. Thesis, Syracuse University.

Hall, Leo, e.al., 1965, Northeastern edge of the Saratoga quadrangle: N.Y. State Mus. and Science Service, open-file maps.

Hills, Alan, 1965, The preCambrian geology of the Glens Falls and Fort Ann quadrangles: Yale University, Doctoral thesis.

Husch, J., Kleinspehn, K., McLelland, J., 1975, Anorthositic rocks in the Adirondacks: basement or non-basement? (abs.): GAAPBC, v. 7, n. 1, p. 78.

Isachsen, Y., 1968, Crane Mt. area, North Creek quadrangle: N.Y. State Mus. and Science Service, open-file maps.

Isachsen, Y., McLelland, J. and Whitney, P., 1975, Anorthosite contact relationship in the Adirondacks and their implications for geologic history (abs.): GAAPBC, v. 7, n. 1, p. 78.

Lettney, C., 1968, The anorthosite-charnockite-norite series of the Thirteenth Lake Dome, south-central Adirondacks, in Isachsen, Y., ed., Origin of anorthosite and related rocks: N.Y. State Mus. and Science Service, Mem. 18.

Miller, W.J., 1911, Geology of the Broadalbin quadrangle: N.Y. State Mus. Bull., 153.

Miller, W.J., 1916, Geology of the Lake Pleasant quadrangle: N.Y. State Mus. Bull., 182.

Miller, W.J., 1920, Geology of the Goversville quadrangle: N.Y. State Mus. and Science Service, open-file maps.

Miller, W.J., 1923, Geology of the Luzerne quadrangle: N.Y. State Mus. Bull., 245-46.

McLelland, J., 1969, Geology of the southernmost Adirondacks: NEIGC Guidebook, v. 61, p. 11-1 - 11-34.

McLelland, J., 1972, Stratigraphy and structure of the Canada Lake Nappe: NYSGA Guidebook, v. 44, p. E1-E27.

McLelland, J., 1973, Structural framework of the southern Adirondacks (abs.): GAAPBC, v. 5, n. 1, p. 54.

McLelland, J., 1974, Structure and stratigraphy of the southern Adirondacks (abs.): GAAPBC, v. 6, n. 7, p. 865.

McLelland, J. and Whitney, P., 1977, Origin of garnet coronas in the anorthosite-charnockite suite of the Adirondacks: Contr. Min. and Petrol., v. 60, p. 161-181.

Nelson, A.E., 1968, Geology of the Ohio quadrangle: U.S. Geol. Survey Bull., 1251-F.

Silver, L.T., 1969, A geochronologic investigation of the Anorthosite Complex, Adirondack Mts., N.Y.: N.Y. Mus. and Sci. Bull. 18.

Thompson, B., Jr., 1959, Geology of the Harrisburg quadrangle: N.Y. State Mus. and Science Service, open-file maps.

Walton and de Waard, 1963, Orogenic evolution of the preCambrian in the Adirondack highlands: a new synthesis: Proc. Kon. Ned. Akad. Wetensch., Amsterdam, v. B, n. 66, p. 98-106.

Whitney, P. and McLelland, J., 1973, Origin of coronas in Adirondack metagabbros: Contr. Min. and Petrol., v. 39, p. 81-98.

ROAD LOG

Mileage

0.0 West side of bridge leading from Rt. 30A into Northville, N.Y. Assembly point will be in boat launching area miles north of bridge.

3.9 Cross the Sacandaga River. For the next 3.5 miles all exposures have been within the Sacandaga Fm. The large hills immediately to the south are underlain by vertically dipping paragneisses and metagabbros situated on the hinge line of the Canada Lake Nappe. Note the southerly dips of the Sacandaga Fm.; these define the southern limb of the Piseco Anticline.

7.4 Leaving Sacandaga Fm.; enter quartzo-feldspathic gneisses "a" of the Piseco Anticline. For the next 4 miles all exposures lie within these gneisses.

11.4 Stop 1 - Pumpkin Hollow. Large roadcuts on the east side of Rt. 30 expose excellent examples of the Sacandaga Fm. At the northern end of the outcrop typical two pyroxene-plagioclase granulites can be seen. The central part of the outcrop contains good light colored sillimanite-garnet-microcline-quartz gneisses (leucogneisses). Although the weathered surface of these rocks are often dark due to staining, fresh samples display the typical light color of the Sacandaga Fm. The characteristic excellent layering of the Sacandaga Fm. is clearly developed. Note the strong flattening parallel to layering.

Towards the southern end of the outcrop calc-silicates and marbles make their entrance into the section. At one fresh surface a thin layer of diopsidic marble is exposed. NO HAMMERING, PLEASE. Many "punky" weathering layers in the outcrop contain calc-silicates and carbonates.

At the far southern end of the roadcut there exists an exposure. Here there is exposed the contact between the quartzo-feldspathic "a" gneisses of the Piseco Anticline and the overlying Sacandaga Fm. The hills to the south are composed of homogeneous quartzo-feldspathic type "a" gneisses coring the Piseco Anticline (note how ruggedly this massive unit weathers). The Sacandaga Fm. at Stop 1 has a northerly dip off the northern flank of the Piseco Anticline and begins its descent into the southern limb of the Glens Falls Syncline.

No angular discordance or metamorphosed soil profile can be discerned at the base of the Sacandaga Fm. However, this does not preclude the prior existence of an angular discordance. Intense deformation often erases all traces of earlier angular discordance (Balk 1936).

Along most of the roadcut there can be found excellent examples of faults and associated pegmatite veins. Note that the drag on several of the faults gives conflicting senses of displacement. The cause of this is not known to the author. Also note the drag folds which indicate tectonic transport towards the hinge line of the Piseco Anticline.

13.7 Entrance to Sacandaga Public Campsite. On the north side of the road are quartzo-feldspathic gneisses and calc-silicates. These are probably within the Lower Lake Durant Fm. Anorthositic and gabbroic rocks have intruded here and locally steep dips may be related to this.

15.7 Enter town of Wells. Silver Bells Ski are to east. The slopes of the ski hill are composed of excellent gabbroic anorthosite and anorthositic gabbro. These appear to be intrusive into the Upper Marble Fm. These intrusives may be related to the Speculator Mt. anorthosite sheet and can be traced eastward into anorthositic rocks of the Tenantville Complex which is exposed in the region near Tenantville in the large saddle of the Piseco Anticline several miles to the east.

The town of Wells in underlain by Lower Paleozoic sediments which have been down dropped by a set of steep N20E faults that result in a local dome and graben complex. The mapped offset of PreCambrian stratigraphy across these faults indicates that, if the displacement vectors were vertical, the throw is of the order of 3500 ft.

19.2 Junction with Gilmantown Road. Continue north on Rt. 30. We are now near the hinge line of the Glens Falls Syncline.

21.5 Parking area on east side of highway. To the west are charnockitic gneisses assigned to the Blue Mt. Fm. Note the southerly dips as we are located here on the north flank of the Glens Falls Syncline.

22.2 Junction of Rts. 8 and 30. Continue north on Rt. 30. Beginning at the intersection are good exposures of garnetiferous leucogneisses of the Upper Marble Fm. Lithologically these are similar to the leucogneisses seen in the Sacandaga Fm. at Stop 1, however, they lack the good layering that characterizes the Sacandaga.

At the junction itself there are good exposures of fault breccia associated with one of the NNE faults responsible for the Paleozoic inlier at Wells.

For the next mile the highway passes just above the contact of the metastratified sequences and anorthositic rocks of the Oregon Dome. These anorthosites form the large hills across the stream valley to the northeast.

23.2 Leaving the Upper Marble Fm. On the north side of the highway are cuts through garnetiferous amphibolite, calc-silicates, marbles, and quartzites of this unit.

24.7 Small outcrop of quartzo-feldspathic gneiss in the Lake Durant Formation.

25.1 Stop 2. One half mile south of southern intersection of old Rt. 30 with new Rt. 30.

On the west side of the road small roadcut exposes a splendid example of Adirondack anorthositic gneisses that are intermediate in character between the so-called Marcy type (uncrushed) and the Whiteface type (crushed). About 50% of the rock consists of partially crushed crystals of andesine plagioclase. Some of these crystals appear to have measured from 6-8" prior to cataclasis. Excellent moonstone sheen can be seen in most crystals. In places ophitic to subophitic texture has been preserved with the mafic phase being represented by orthopyroxene.

In addition to the coarse grained anorthosite there exists a fine grained phase and a clearly crosscutting set of late orthopyroxene rich dikes. The latter may represent a late mafic differentiate related to cotetic liquids responsible for the ophitic intracrystalline rest magma. This would be consistent with the iron enrichment trend characteristic of Adirondack igneous differentiation. The fine grained phase may have intruded early in the sequence, but this is uncertain.

Near road level there can be found several inclusions of calc-silicate within the anorthositic rocks. These are believed to have been derived from the Lower Marble Fm. and are consistent with a non-basement status for the anorthosite.

The upper, weathered surface of the outcrop affords the best vantage point for studying the textures and mineralogy of the anorthositic rocks. In several places there can be seen excellent examples of garnet coronas of the type that are common throughout Adirondack anorthosites. These coronas are characterized by garnet rims developed around iron-titanium oxides and pryoxenes. Recently McLelland Whitney (1977) have succeeded in describing the development of these coronas according to the following generalized reaction:

Orthopyroxene + Plagioclase + Fe-bearing oxide + quartz =
garnet + clinopyroxene

This reaction is similar to one proposed by de Waard (1965) but includes Fe-oxide and quartz as necessary reactant phases. The products are typomorphic of the garnet-clinopyroxene subfacies of the granulite facies (de Waard 1965). The application of various geothermometers to the phases present suggests that the P,T conditions of metamorphism were approximately 8 Kb and 650-700^{o} C respectively.

26.2 Long roadcuts parallel to strike through the lower porition of the Lake Durant Fm. These are characteristically composed of well layered pink quartzo-feldspathic gneisses, thin amphibolites, and calc-silicates. The quartzo-feldspathic lithologies are dominant and become increasingly so proceeding up from the basal units. At this locality the increase in quartzo-feldspathic material is accompanied by the development of K-feldspar megacrysts.

26.7 On west side of road are extensive cuts in the Upper Marble Fm. Quartzite, calc-silicate, and sillimanite-garnet-quartz-feldspar leucogneisses are especially well developed here. Some marble and charnockite are present. The large hills to the southeast consist of anorthositic gneisses in the Oregon Dome. The rocks exposed along the highway dip off the dome.

27.2 Stop 3. Northern intersection of old Rt. 30 and new Rt. 30, 3.3 miles east of Speculator. New York.

The Upper Marble Fm. is exposed in roadcuts on both sides of the highway. These exposures show typical examples of the extreme ductility of the carbonate rich units. The south wall of the roadcut is particularly striking, for here relatively brittle layers of garnetiferous amphibolite have been intensely boudinaged and broken. The marbles, on the other hand, have yielded plastically and flowed with ease during the deformation. As a result the marble-amphibolite relationships are similar to those that would be expected between magma and country rock. Numerous rotated, angular blocks of amphibolite are scattered throughout the marble in the fashion of xenoliths in igneous intrusions. At the eastern end of the outcrop tight isoclinal folds of amphibolite and metapelitic gneisses have been broken apart and rotated. The isolated fold noses that remain "floating" in the marbles have been aptly termed "tectonic fish".

Features such as those seen within this roadcut have led this writer to question the appropriateness of assigning an unconformity to the base of the Lower Marble Fm. Tectonic phenomena in rocks of high viscosity contrast can account for the fact that the marbles are able to come into contact with a variety of lithologies.

A variety of interesting lithologies are present in this roadcut. The marble itself contains diopside (now serpentinized), tourmaline, graphite, chondrodite, phlogopite, and a variety of pyrites. Interesting reaction rims, or selvages, exist between the marbles and quartz rich boudins. Presumably these selvages reflect the influence of compositional gradients during metamorphism.

Most of the amphibolites in the outcrop are highly garnetiferous and some layers appear to contain 60-70% garnet. The garnets are almandine rich and are similar to those at Gore Mt. However, it is not known whether these amphibolites represent metamorphosed sedimentary or igneous rocks. Note that a number of the garnets are separated from surrounding hornblende by narrow light colored rims. These consist of calcic plagioclase and orthopyroxene and represent products of the reaction:

Garnet + Hornblende = Orthopyroxene + Calcic Plagioclase + Water

This reaction is characteristic of the granulite facies wherein the association garnet plus hornblende is unstable (de Waard 1965).

Also present in the outcrop are various layers rich in calc-silicates. One of these contains coarse, pale diopside crystals several inches across. Others consist almost entirely of green diopside. Tremolite has also been found in some layers. Rusty weathering, metapelitic units are rich in graphite, calc-silicates, and pyrite. Grossularite, scapolite, and wollastonite, and sphene have been recognized in thin section.

Near the west end of the outcrop a deformed layer of charnockite is well exposed. In other places the charnockite-marble interlayering occurs on the scale of one to two inches.

Exposed at several places in the roadcut are striking, cross-cutting veins of tourmaline and quartz displaying a symplectic type of intergrowth. Other veins include hornblende and sphene bearing pegmatites.

Commonly included in the Upper Marble, but not exposed here, are quartzites, kinzigites; sillimanite rich, garnetiferous, quartz-microcline gneisses; and fine grained garnetiferous leucogneisses identical to those characterizing the Sacandaga Fm. These lithologies may be seen in roadcuts .5 mile to the south.

Almost certainly these marbles are of inorganic origin. No calcium carbonate secreting organisms appear to have existed during the time in which these carbonates were deposited (1.1 b.y. ago). Presumably the graphite represents remains of stromatolite-like binding algae that operated in shallow water, intertidal zones. If so, the other roadcut lithologies formed in this environment as well. This seems reasonable enough for the clearly metasedimentary units such as the quartzites and kinzigites. The shallow water environment is much more interesting when applied to the charnockitic and amphibolite layers. The fine scale layering, and ubiquitous conformity of these, strongly suggests that they do not have an intrusive origin. Perhaps they represent the metamorphosed products of volcanic material in a shelf like environment. Such intercalation is now occurring in many island arc areas where shallow water sediments cover, and in turn are covered by, ash and lava. Alternatively they may represent metasediments.

30.5 Junction of Rt. 8, 28, and 30 in village of Speculator. Head southwest on Rt. 8.

For the next 14 miles exposures are limited. For the most part, however, we shall be passing through the quartzo-feldspathic gneisses "a" that cover the Piseco Anticline.

44.5 Stop 4. Hinge line of Piseco Anticline near domical culmination at Piseco Lake. The rocks here are typical quartzo-feldspathic gneisses "a" such as occur in the Piseco Anticline and in other large anticlinal structures, e.g. Snowy Mt. Dome, Oregon Dome.

The pink "granitic" gneisses of the Piseco Anticline do not exhibit marked lithologic variation. Locally grain size is variable and in places megacrysts of K-feldspar may be seen. In the present outcrop these megacrysts appear to have been largely granulated and only a few small remnants of cores are seen. The open folds at this locaity are minor folds of the F_2 event. Their axes trend N70W and plunge 10-15^o SE parallel to the Piseco Anticline.

The most striking aspect of the gneisses in the Piseco Anticline is their well developed lineation. This is expressed by rod, or pencil-like structures. Often these consist of alternating ribbons of quartzite, quartzo-feldspathic gneiss, and biotite rich layers. In many instances these ribbons represent transposed layering on the highly attenuated limbs of F_1 minor folds. Near the northeast end of the roadcut such F_1 minor folds are highly visible because the presence of quartzites in the stratigraphy enhances their visibility. Slabbed and polished specimens from this and similar outcrops demonstrates that these F_1 folds are exceedingly common in the Piseco Anticline. Examination of these F_1 folds shows that the dominant foliation in the rock is axial planar to them. Similarly, layer transposition is related to flattening parallel to the axial planes of F_1 folds. The intersection of F_1 axial plane foliation and earlier compositional surfaces helps to define the strong lineation in the outcrop. In addition to this a number of rod-like lineations are probably the hinge line regions of F_1 minor folds which are difficult to recognize because of apparent lithologic homogeneity. Lineation in the outcrop is further intensified by the fact the upright and relatively open F_2 folds are coaxial with F_1. Thus the intersection of the F_1 and F_2 axial planar foliations results in a lineation parallel to the two fold axes. Moreover, F_2 minor folds are often of the crenulation variety and their sharp hinge lines define a marked lineation in the F_1 foliation.

As described above, a number of parallel elements combine to produce an extremely strong lineation in the Piseco Anticline. Past observers have sometimes remarked that the lineation appears to be the result of stretching parallel to the long axis of the Piseco Dome. However, the lineation is probably unrelated to "stretching" and is more realistically explained as an intersection lineation of So, Si, and S_2 elements. Moreover, the intensity of the lineation is more the result of the early F_1 recumbent folding and flattening than it is of the later, coaxial F_2 Piseco Anticline.

46.5 Junction of Rt. 8 and Rt. 10. Turn south towards Canada Lake.

47.0 On both sides of Rt. 10 are red stained quartzo-feldspathic gneisses "a" that have been cataclastized by a large N20E fault zone. For the next 5.5 miles we shall pass through a number of road-curves as Rt. 10 makes its way through the core rocks on the south limb of the Piseco Anticline.

50.5 Cross into the Sacandaga Fm.

52.5 Parking area on east side of highway. The rocks here are quartzo-feldspathic gneisses believed to be part of the Sacandaga Fm.

52.8 Stop 5 - Shaker Place. The northernmost roadcut consists of a variety of metasedimentary rocks. These lie directly above the Piseco Anticline and are believed to be stratigraphically equivalent to the Sacandaga Formation. The outcrop displays at least two phases of folding and their related fabric elements. Thsse are believed to be F_1 and F_2. Both axial plane foliations are well developed here. Several examples of folded F_1 closures are present and F_1 foliations (parallel to layering) can be seen being folded about upright F_2 axial planes.

Further to the south, and overlooking a bend in the west branch of the Sacandaga River, there occurs a long roadcut consisting principally of pink and light green quartzo-feldspathic gneisses. About half-way down this roadcut there occurs a very large and impressive boudin of amphibolite and iopsidic gneiss. To the north of this boudin the quartzo-feldspathic gneisses are pervasively intruded by anorthositic gabbros, gabbroic anorthosites, and various other related igneous varieties. At the north end of the cut and prior to the metasoratified sequences these intrusives can be seen folded by upright F_2 axes. They are crosscut by quartzo-feldspathic material.

Three important conclusions emerge from study of this outcrop. The first is that the anorthositic suite is intrusive into rocks at, and above, the stratigraphic level of the Lower Marble or Sacandaga Fm. In the second place, while the anorthositic rocks are clearly involved in F_2 folding, they do not show, and in fact transect, F_1 foliation. Thirdly, the quartzo-feldspathic rocks intruded by the anorthosites appear to have undergone substantial anatexis in the vicinity of the intrusion. This is suggested by the cross-cutting quartzo-feldspathic material and by the overall appearance of the gneisses along the roadcut.

53.9 Roadcut on west side of highway shows excellent examples of anorthositic gabbros intrusive into layered pink and light green quartzo-feldspathic gneisses. The presence of pegmatites and cross-cutting granitic veins is attributed to anatexis of the quartzo-feldspathic gneisses by the anorthositic rocks.

54.2 Fine grained metagabbro on west side Rt. 10.

54.6 Excellent roadcut in coarse anorthositic gabbro. Ophitic to subophitic texture well preserved. Garnets are sporadically developed and tend to be associated with coarse gabbroic pegamtites showing mineral grwoth perpendicular to contacts. Compositional layering may be primary.

55.1 Small cut in megacrystic granitic gneiss on east side of highway.

55.3 Begin half-mile of roadcuts exhibiting intrusion of quartzo-feldspathic gneisses by members of the anorthositic gabbro suite, several phases of which appear to be present and in cross-cutting relationships. Source metasedimentary areas may be xenoliths. Pods of megacrystic gneiss may be anatectic in origin.

55.9 Kennels Pond - Avery's Fishing Site

56.0 Lake Catherine to east of highway; metasediments intruded by anorthositic gabbros in roadcut on west.

56.8 Avery's Hotel on west of highway at top of hill.

56.9 Steeply dipping kinzigites with white, anatectic layers.

57.7 On west side of highway at sharp bend are excellent examples of anorthositic gabbros intrusive into kinzigites. The gabbroic rock transect the principal foliation (F_1) and are folded by upright folds of the F_2 event.

57.9 Extremely garnetiferous kinzigites. Here the rocks dip gently to the north due to the presence of a mesoscopic F_2 synform.

58.5 Road sign: Canada Lake - 10 miles

59.0 Crossing Swamp

59.7 Crossing swamp that marks contact between the Sacandaga Fm. and megacrystic gneisses of the Rooster Hill Fm.

60.0 Megacrystic gneisses of Rooster Hill Fm.

60.1 Megacrystic gneisses of Rooster Hill Rm.

60.5 Kinzigite in Rooster Hill Fm.

61.2 Stop 6 - North end of Stoner Lake. Type locality of Rooster Hill Fm. The Rooster Hill Formation is characteristic of a wide spread lithology throughout the Adirondacks. Its most characteristic feature is the presence of striking 1-4" megacrysts of K-feldspar. These are almost always falttened within the plane of foliation. Nonetheless, a number of these megacrysts preserve evidence of approximately euhedral crystal outline.

Compositionally the Rooster Hill megacrystic gneisses consist of orthopyroxene, garnet, hornblende, biotite, perthitic microcline, some plagioclase (oligoclase), and quartz. An igneous analogue would be quartz monzonite.

The parentage of the Rooster Hill megacrystic gneisses is obscure. It is not known whether the megacrysts are phenocrysts or porphyroblasts. The fact these lithologies are conformable with the enclosing stratigraphy over broad areas is consistent with a metastratified origin but does not rule out intrusion as sills. The lack of substantial banding across units thousands of feet thick is less consistent with a metasedimentary origin than with an igneous one. However, the problem remains unresolved and requires further research.

Regardless of parentage, the Rooster Hill Fm. appears to correlate with the Lake Durant.

62.0 Crossing contact of Rooster Hill Fm. and kinzigites of the Peck Lake Fm. Near the contact the Rooster Hill megacrystic gneisses become equigranular. This is probably due to cataclasis.

62.9 Kinzigites in the Peck Lake Fm.

63.8 Junction of Rt. 10 and Rt. 29A. Continue east on Rt. 29A-10.

64.8 Small roadcut of kinzite.

65.5 Canada Lake Store and Post Office Ledges on north side of highway consist of pyroxene-quartz-plagioclase gneisses (enderbites) assigned to Royal Mt. member of the Green Lake Fm. Scarce amphibolite layers are boudinaged, and near east end of the outcrop amphibolite pods have been broken and rotated by intrusive material. This material is of the same pyroxene-quartz-plagioclase composition as the enderbite and grades into it.

65.7 Crossing Green Lake on Rt. 10-29A. At east end of bridge and in woods are exposures of quartzites and leucogneisses of the Green Lake Fm.

66.2 Cross contact into charnockites of the Canada Lake Fm. These form large roadcuts along the highway.

66.8 Stop 7. Irving Pond Fm. in the Core of the Canada Lake Nappe. The units to be examined occur along the east side of the road.

The Irving Pond Fm. consists of some 2500' of quartzite and less abundant quartzo-feldspathic gneisses and calc-silicates. It has been folded back on itself in the core of the nappe, and its apparent thickness is therefore doubled. At this particular locality we will examine the Irving Pond near its lower contact with the Canada Lake Fm. In the outer 100-200' near this contact the Irving Pond becomes "dirty" and clean massive quartzites give way to garnetiferous biotite-quartz-feldspar gneisses (kinzigites). Both of these lithologies are well developed at this locality. Also present near the contact is an excellent set of F_1 minor folds showing axial plane foliation. These folds do not appear to fold an earlier tectonic foliation. Their axes parallel the Canada Lake Nappe.

67.7 Passing Nick Stoners Inn and Golf Course.

68.8 Passing Vroman's Hotel in town of Caroga Lake.

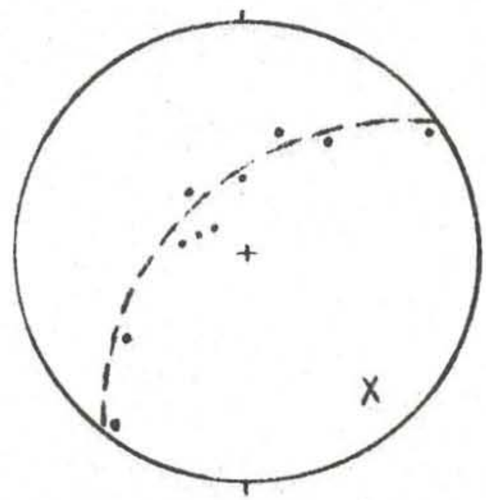
69.2 Junction Rt. 29A and Rt. 10. Continue south on Rt. 29A.

70.8 Enderbites and related gneisses of the Royal Mt. Member of the Green Lake Fm. The repetition of stratigraphy from the Canada Lake Store is due to recumbent, isoclinal folding about the Canada Lake Nappe.

71.7 Stop 8 - The Peck Lake Formation.

Roadcut of garnetiferous quartz-biotite-oligoclase gneiss with minor amphibolite and calc-silicate bands. These gneisses are the dominant lithology of the Peck Lake formation which is exposed here on the south limb of the F_1 fold. Needles of sillimanite can be seen in some specimens. White porphyroblasts are K-feldspars and pods of white quartzo-feldspathic material are probably anatectic.

In a little overhang near ground level there is an F_2 minor fold with an axial trend of N50W, plunging 15 SE. Axial plane cleavage and lineation cut across the compositional layering and earlier foliation of this fold. It appears that such folding and cleavage are prevalent throughout outcrops of Peck Lake gneiss. Often these features are obscurred by poorly developed compositional banding. Polishing and staining reveal both folds and cleavage in many specimens and, therefore, suggest that their abundance vastly exceeds their recognition.



The entire outcrop is a "large minor" fold. Note the change of dip from one end to the other. The accompanying equal area plot is for poles of foliation in this roadcut and in outcrops directly NE of the road.

The lithologies and structures represented in this cut are typical of the Peck Lake formation. It is the structural complexities that make the Peck Lake formation difficult to work with and subdivide. It is, by far, the least competent unit in the sequence.

72.5 Peck Lake

End Road Log