THE BEDROCK GEOLOGY OF THE
SOUTHBURY QUADRANGLE
CONNECTICUT

by

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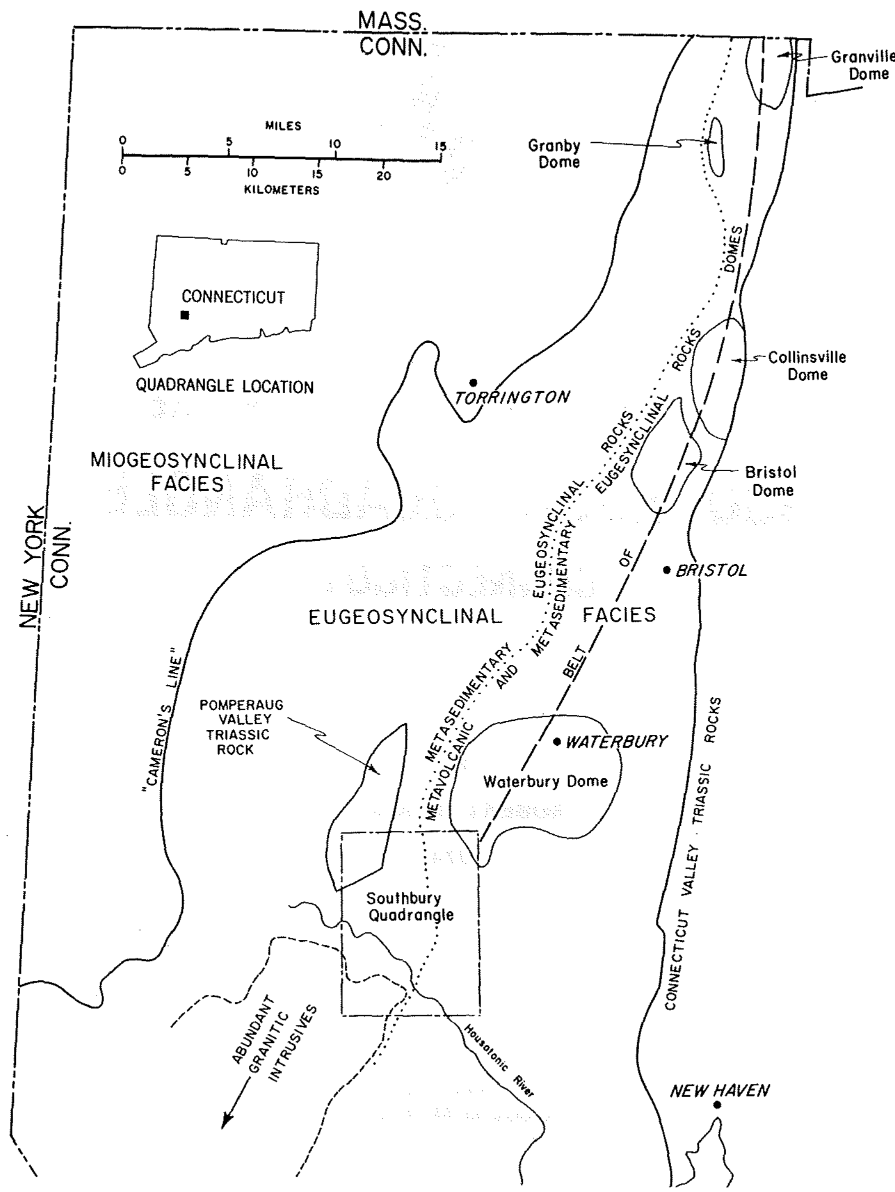


Map delineating belts of major metamorphic rock types and distinctive structural trends. The Collinsville Formation best exhibits the metavolcanic character of the eastern facies and probably marks the site of an island arc active during that part of Cambro-Ordovician time. Hartland Unit I, Hartland Unit II, and the Waterbury Formation are more homogeneous and aluminous on the eastern side and more heterogeneous, micaceous, and quartz rich on the western side of the eugeosyncline. The southern end of the gneiss-dome belt and the northern end of massive granitic intrusive bodies occur within the Southbury quadrangle.

INTRODUCTION

The Southbury quadrangle, located in central-western Connecticut covers an area of 140 sq km (54 sq mi). Topographic elevations in this portion of the crystalline highlands of western Connecticut range from 12 m above sea level at the Housatonic River to 278 m at the top of Woodruff Hill, along the border of the Southbury and Naugatuck quadrangles.

The Southbury quadrangle lies in the Housatonic River drainage basin. Major tributaries to the Housatonic River are the south-flowing Pomperaug River, Kettletown Brook, and Eightmile Brook, and the north-flowing Halfway River and Boys Halfway River. Little River flows eastward into the Naugatuck quadrangle to the Naugatuck River, which in turn flows southward into the Housatonic River.

Two belts of gneiss domes parallel the Connecticut River and are mantled by eugeosynclinal deposits of the western Appalachian fold belt in New England (Rodgers and others, 1959; Thompson and others, 1968); the southern terminus of the western belt of domes lies in the Southbury quadrangle and is marked by the southern end of the Waterbury dome (fig. 2). The units that mantle the gneiss dome include both metasedimentary and metavolcanic rocks; toward the west, the metavolcanic rocks diminish relative to the more micaceous and quartzose clastic-metasedimentary rocks. Still farther west, across the sharp tectonic line known as "Cameron's Line," is a miogeosynclinal belt of carbonate, quartzite, and schist. The best example of a feldspathic metavolcanic eastern facies that grades into a more heterogeneous micaceous and quartzose western facies is the Collinsville Formation. Crowley (1968) also recognized the distinction between eastern and western eugeosynclinal facies by the presence of abundant metavolcanic rocks in the eastern facies. This facies change is slightly different in Cambro-Ordovician units stratigraphically below the Collinsville Formation: a relatively aluminous and homogeneous eastern facies changes to an extremely heterogeneous quartz- and mica-rich western facies.

METAMORPHIC STRATIGRAPHY

Most of the mappable units in the Southbury quadrangle have been recognized in adjoining quadrangles. The Straits Schist, the Collinsville Formation, and the Newtown Gneiss extend from the Long Hill quadrangle northward into the Southbury quadrangle (Crowley, 1968). Carr (1960) mapped the Straits Schist to the eastern border of the Southbury quadrangle. In the Roxbury quadrangle (Gates, 1959) and in the Waterbury quadrangle (Gates and Martin, 1967), Gates recognized several rock units that are found in the Southbury quadrangle, including the Straits Schist, the Hitchcock Lake Member, and the Hartland Unit I, the Waterbury Formation within the Waterbury quadrangle; and the Hartland Unit I and Hartland Unit II within the Roxbury quadrangle. R.S. Stanley's (personal communication) mapping in the Newtown quadrangle correlated some of the Roxbury units with Southbury units.

The most distinctive lithologic break in the Southbury quadrangle and the adjacent Waterbury-Naugatuck-Long Hill quadrangle region is the boundary between the quartzo-feldspathic gneissic Collinsville Formation and the overlying muscovite-rich Straits Schist. Unnamed discontinuous lenses of quartzite, marble, calc-silicate, and amphibolite along this boundary suggest that there is a major unconformity at this stratigraphic level. The basal units exposed in the Southbury quadrangle are the Waterbury Formation on the eastern side and Hartland Unit II on the western side of the quadrangle. No Precambrian rocks are recognized in the Southbury quadrangle or adjoining quadrangles. The metamorphic units will be discussed in order from oldest to youngest.

Waterbury Formation

The Waterbury Formation crops out in the northeastern corner of the Southbury quadrangle, where it is continuous with rocks called the Waterbury Formation by Gates and Martin (1967) in the Waterbury quadrangle and with the lower part of a sequence of rocks that Carr (1960) termed the Waterbury Gneiss.

LITHOLOGY

The Waterbury Formation varies from fine-grained, thinly layered (0.5-2 mm) biotite-quartz-kyanite-plagioclase-muscovite-garnet or biotite-quartz-plagioclase-muscovite-garnet-microcline schist and schistose gneiss (with a contorted foliation parallel to the layering) to an extremely contorted, massive rock of the same mineralogical composition. The most distinctive characteristic of both these rocks is a fine-textured patchiness or feltlike appearance on fresh surfaces, particularly on sawed surfaces, due to the presence of very fine-grained kyanite blades (<0.1 mm wide and <1 mm long). Along crumpled layers in some localities these kyanite crystals have grown in knots and patches to 1 mm in diameter. The rock is bluish white where kyanite is abundant. Fresh rock surfaces rich in biotite and kyanite vary between grayish blue and dusky blue. Characteristically the weathered surfaces are rusty. The lighter colored layers in the layered rocks are segregations of feldspar and quartz; the darker layers are predominantly biotite and kyanite.

ORIGIN AND AGE

These schists and schistose gneisses of the Waterbury Formation have lower Si/Al ratios and higher K + Fe + Mg values than do igneous rocks. The extensive rusty weathering and the relatively aluminum-rich composition (10.5 percent Al or 19.8 percent Al_2O_3) of these metasediments indicate that, prior to metamorphism, they probably were uniform, sulfide-bearing clay- and iron-rich shales with few quartz-rich sandy layers.

The age of the Waterbury Formation is not readily determined either by stratigraphic correlation or by radiometric dating. Since the Waterbury Formation on the eastern, and the Hartland Unit II on the western, side of the quadrangle both appear to underlie Hartland Unit I, they may be facies equivalents. The contact between the Waterbury Formation and the overlying Hartland Unit I is probably not a major unconformity nor an abrupt change in sedimentary environment because lenses of a biotite-kyanite-rich member of Hartland Unit I (kyanite-rich member), mineralogically and chemically similar to the Waterbury Formation, are abundant in the eastern facies of the Hartland Unit I, even close to the Collinsville Formation contact.

A similar impasse is reached from radiometric dating. The 465 m.y. rubidium-strontium isochron determined by Clark and Kulp (1968) for the Waterbury Formation can be interpreted in several ways. If the date represents the time of deposition, the Waterbury Formation is an Ordovician metasedimentary unit that was subsequently metamorphosed by the Acadian orogeny between 382 m.y. (Besancon, 1970) and 413 m.y. (Armstrong and

others, 1970). However, if the 465 m.y. isochron represents a complete or partial rehomogenization of the strontium isotopes during metamorphism, the Waterbury Formation may have been a Cambrian or Precambrian sediment or a Precambrian Grenville orogenic product.

The hypothesis favored in this report, that the Waterbury Formation is an eastern facies equivalent of Hartland Unit II, is based on their apparent equality of stratigraphic position, the logical sequence of lateral facies changes which fits a geosynclinal framework, a similar facies change between an eastern and western facies of the overlying Hartland Unit I, and the lack of radiometric evidence to the contrary.

Hartland Unit II

Two members of Hartland Unit II are mapped in the Southbury quadrangle. By far the more abundant is an extremely heterogeneous suite of schist, schistose gneiss, and gneiss, containing amphibolite and calc-silicate layers. This unit is termed the garnetiferous member because of its prominent garnet porphyroblasts.

LITHOLOGY

Garnetiferous member of Hartland Unit II is extremely heterogeneous; the predominant rock is a well foliated, lustrous, quartz-biotite-plagioclase-muscovite-staurolite-garnet schist to schistose gneiss. Other rock types include common biotite-plagioclase-muscovite-quartz-garnet-kyanite schist, rare plagioclase-quartz-staurolite-biotite-muscovite-garnet gneiss, and rare biotite-plagioclase-quartz-garnet schist. Grain sizes vary from medium to coarse. Very coarse porphyroblasts of garnet, staurolite, kyanite, biotite, and magnetite are present in some localities.

The Quartz-rich member of the Hartland Unit II is a lens of quartz-rich rock mapped northeast of Ichabod Hill. For the most part it is a quartz-plagioclase-biotite-muscovite gneiss.

ORIGIN

Most of the rocks in Hartland Unit II are of sedimentary origin. The average composition is close to that of the average marine pelagic sediment but the range of composition extends from subgraywacke to iron-rich shales. Originally the unit must have consisted of interbedded shale, quartz-rich silt and sand, subgraywacke, thin calcareous shale, and limestone. Basalt flows interrupt the sedimentary sequence at several levels. The presence of both volcanics and carbonates suggest a transition between miogeosynclinal and eugeosynclinal deposits (Schwab, 1971).

Hartland Unit I

LITHOLOGY

The eastern and western facies of Hartland Unit I are separated by a strip of Straits Schist and the complete transition is not exposed. On the eastern side, the rocks are divided into an upper laminated member, a lower banded member, and a kyanite-rich member that occurs as lenses within them. The banded member differs from the laminated member in bedding thickness; the mineralogical and chemical compositions of these two members are very similar.

The western facies of Hartland Unit I also includes the laminated member and lenses of the kyanite-rich member, along with a new member, the quartz-rich member. The western facies differs from the eastern in at least seven ways: 1) the banded rocks are absent, 2) a thick quartz-rich gneiss to quartzite is present, 3) the mica content of some beds in the laminated member is significantly higher, 4) the pin-stripe texture of the laminated member is less pronounced, 5) the kyanite-rich member is less abundant, 6) amphibolites are much more common, and 7) gondites (coticules) present in the eastern facies are absent in the western. The western facies is more clastic and heterogeneous, repeating the pattern of the proposed Hartland Unit II-Waterbury Formation facies change described above.

Laminated member. The most abundant rock in Hartland Unit I is a nonrusty-weathering quartz-biotite-plagioclase-muscovite-schistose gneiss characterized by a fine-grained texture and millimeter-scale micaceous laminations separated by slightly thicker quartzose layers. Garnet, kyanite, and microcline are present in many samples but are generally rather minor constituents and microcline and kyanite do not coexist. With few exceptions, biotite is more abundant than muscovite. Most of the rocks have a "salt-and-pepper" speckled surface along the micaceous folia. The eastern facies of this member has many thin gondites, which are distinctive layers of spessartitic garnet and quartz.

Banded member. Mineralogically, the banded member is essentially the same as the laminated member, with the exception that microcline is more abundant and muscovite less abundant. Also, garnet and kyanite are significantly more abundant in the banded rocks. The most common rock type is a nonrusty-weathering fine- to medium-grained quartz-biotite-plagioclase-muscovite-garnet-kyanite schistose gneiss that in most exposures has centimeter-thick bands of alternating quartzose and thinner micaceous layers and in fewer outcrops has millimeter-scale micaceous lamellae separated by slightly thicker quartzose layers. Another abundant schistose gneiss has a somewhat less aluminous assemblage of quartz, plagioclase, microcline, biotite, muscovite, and garnet.

Kyanite-rich member. Isolated lenses of biotite-kyanite-rich rocks are present at all stratigraphic levels in Hartland Unit I, in both laminated and banded members. This rock is a nonrusty- to rusty-weathering, fine-grained biotite-quartz-muscovite-kyanite schist to schistose gneiss that contains subordinate amounts of feldspars, garnet, and sillimanite. The fine kyanite blades have grown in irregular patches, 1-5 mm in diameter, giving the fresh surface a light-bluish appearance and the weathered surface an irregular knobby texture. The massive structure and homogeneous mineralogical character give the rock a poorly defined foliation and bedding. Outcrops are rounded, without the ledgy character of more distinctly bedded units.

Quartz-rich member. In the western-central part of Southbury, a thick continuous band of quartz-rich gneiss and quartzite is interbedded with Hartland I rocks. The mineralogical composition of the quartz-rich band varies from that of the laminated member to almost pure quartzite. Thin calc-silicate bands occur in a few localities. Hillsides underlain by the quartzites have ledgy shoulders where the resistant quartzite crops out; bedding thickness varies from 10 cm to several meters. No relict sedimentary features were recognized. Most of the quartzites have yellowish-gray weathered surfaces and are nonrusty weathering.

ORIGIN

Chemically, all the Hartland Unit I members can be categorized as metasediments. The laminated member and the banded member are chemically similar and are within the composition range of shales and close to that of graywackes. Within the laminated member the average aluminum content increases from west to east, generally reflecting a more clay-rich eastern sedimentary facies and a more quartz-rich western facies. The manganese- and silicon-rich gondites of the eastern facies possibly represent manganiferous cherts thought to be indicative of regions far from sources of clastic continental debris.

The kyanite-rich member is extremely aluminous, with Si/Al ratios only slightly less than 2; probably this rock was a shale with a high clay-mineral content. The greater abundance of the aluminous rock in the eastern facies is thought to be a reflection of increasing distance from the source of clastic debris.

The quartz-rich member varies between a sedimentary quartzite and a subgraywacke.

Collinsville Formation

The Collinsville gneiss was first named by Rice and Gregory (1906). After Stanley (1964) defined the Collinsville Formation in the Collinsville quadrangle report, Crowley (1968) extended the name southward to the Long Hill and Bridgeport quadrangles, where it is continuous with the same rock unit in the Southbury quadrangle. In this quadrangle it borders the strip of Straits Schist and is folded with Hartland Unit I on the western side of the quadrangle.

Three members of the Collinsville Formation are distinguished in the Southbury quadrángle. One is the Bristol Member, first defined by Stanley (1964); this is the quartzo-feldspathic gneiss and schistose gneiss that envelops Hartland Unit I around the Waterbury dome. A second member, consisting of rocks that are distinctly more aluminous, occurs west of the strip of Straits Schist and is separated laterally from the Bristol Member by a third member, a transitional one consisting of mixed rock types like those of the Bristol Member and the aluminous member.

LITHOLOGY

Bristol Member. The Bristol Member is distinctively uniform; most exposures are homogeneous, nonrusty-weathering, medium-grained quartz-plagioclase-biotite gneiss to schistose gneiss with a medium bedding caused by small changes in biotite content. Outcrops are rounded to slightly ledgy. Muscovite and garnet are minor constituents. Within 2 km of the Newtown Gneiss, Carlsbad-twinned microcline porphyroblasts are found; close to the intrusive body, these crystals increase in size to 3 cm. In addition to the lenses of amphibolite, marble, and quartzite that are found close to the Straits Schist (to be discussed in the next section), the Bristol Member contains isolated pockets of calc-silicate rock with marble cores, lenses of amphibolite, and muscovite-garnet-rich regions very similar to the more extensive aluminous rocks of the transitional member and the aluminous member. The only abundant rock in the Bristol Member is a quartz-plagioclase-biotite gneiss to schistose gneiss.

Aluminous member. Several distinct rock types comprise the aluminous member. The most abundant is a medium-grained nonrusty-weathering quartz-muscovite-biotite-plagioclase schist to schistose gneiss that commonly contains minor garnet and a trace of staurolite, kyanite, and/or sillimanite. Rare muscovite-quartz-biotite-plagioclase schists are interbedded with other rocks.

Although muscovite-rich rocks are the most prevalent type found in the aluminous member, a significant part of this member consists of schistose gneisses less rich in muscovite and of gneisses very similar to those of the Bristol Member. Because these interbedded rocks differ in resistance to erosion, hillsides have ledges of angular, well bedded outcrops. Scattered lenses of amphibolite are present, both within the aluminous member and along its border with Hartland Unit I. These amphibolites vary in thickness from 0.5 m to at least 100 m. Unfortunately, they cannot be traced far enough to define stratigraphic levels within the unit.

Transitional member. The rock types described above for the Bristol Member and the aluminous member are present in the mixed or transitional facies. Boundaries between facies are indistinct but are defined on the basis of the relative abundances of rock types: where the abundance of aluminous rock types is roughly equal to that of Bristol rock types, the transitional member classification is used; where the Bristol or the aluminous rock types distinctly predominate throughout a wide region, the appropriate member name is used. Recognition of a member from observation of one outcrop is impossible because of the great heterogeneity of the rocks, which also makes mapping difficult.

ORIGIN

Except for a few quartz-rich and a few shale-rich examples, most of the compositions of Bristol Member rocks are close to those of igneous rocks. The homogeneity and obviously stratified origin of the Bristol Member and the presences of interbedded amphibolites and a few layers of andesitic composition is suggestive of a volcanic origin. A tuffaceous origin similar to that suggested by Crowley (1968) is probable. The more quartz-rich layers probably represent concentration of quartz by weathering and sedimentary reworking of tuffs. Most probably, the amphibolites represent small, local basalt flows. Such a concentration of silicic, andesitic, and basaltic volcanic products within a eugeosynclinal suite of rocks is likely to have been the product of island-arc volcanism.

The aluminous member appears to have resulted from the metamorphism of an intercalation of tuffaceous units similar to those which made up the Bristol Member, with clay-rich sediments deposited between the volcanic source and the carbonate miogeosyncline. The heterogeneity of the aluminous member is thus in part the result of the intertonguing of material from two distinct sediment sources.

Unnamed amphibolites, quartzites, and marbles

A remarkably distinctive suite of rocks occurs along the boundary between the Straits Schist and the Collinsville Formation; it includes amphibolite, quartzite, and marble in discontinuous lenses. Associated with these rocks is a string of metalliferous sulfide deposits. At most localities these rocks are less than a few tens of meters thick or entirely absent but, regionally, the consistency with which the discontinuous lenses are found is impressive.

Most of the quartzite layers are slightly calcareous and have light-gray to slightly rusty weathering surfaces. One of the thickest quartzites (about 3m) is

well exposed on a hillside a few tens of meters west of Boys Halfway River along the southern boundary of the Southbury quadrangle. The quartzite contains medium-grained crystals of 70 percent quartz, 15 percent plagioclase (An_{92}), 6 percent biotite, 3 percent opaques, 4.5 percent clinozoisite, and about 1 percent sphene. The amphibolite lenses consist largely of hornblende, plagioclase (An_{34-43}) and quartz but locally biotite, anthopyllite, garnet, or pyroxenes are abundant. The marbles have reaction zones on their boundaries similar to those described by Vidale (1968) and in the discussion of Hartland Unit II above.

LITHOLOGY

The lustrous, silver-gray foliation surfaces separated by pod-shaped quartz segregations, the yellowish to rusty-weathered surface, the homogeneous mineralogical and textural character, and the massive, rounded outcrops make the Straits Schist the most distinctive unit in the Southbury quadrangle and in western Connecticut. The average Straits Schist is a medium- to coarse-grained quartz-muscovite-biotite-plagioclase-garnet-graphite-sillimanite-kyanite, schist; garnets and biotite have been partially retrograded to chlorite in some localities. The graphite is concentrated between muscovite folia. Garnets are abundant enough to give surfaces a slightly knotted or knobby appearance. Sillimanite and kyanite coexist in all samples studied; the sillimanite grew in knots, 1 cm in diameter, and on biotite folia; only in a few cases does sillimanite appear to have replaced kyanite. Ilmenite, rather than magnetite, is present.

ORIGIN

Chemically, the Straits Schist resembles a clay-rich shale with a low quartz content. The presence of graphite in the unit, the high aluminum content, and the homogeneous composition suggest a deep, quiet deposition of clays in an oxygen-poor environment that allowed the preservation of organic carbon.

PRE-TRIASSIC IGNEOUS ROCKS

Newtown Gneiss

GENERAL DISCUSSION

The southwestern corner of the Southbury quadrangle is underlain by a weakly foliated and bedded granitic to granodioritic gneiss characterized by large euhedral to subhedral microcline porphyroblasts. In the Long Hill quadrangle, Crowley (1968) called this unit the Newtown Gneiss; this terminology is extended to the Southbury quadrangle. R.S. Stanley (personal communication) also found this rock in the adjacent Newtown quadrangle. The cross-cutting relationships seen on the map indicate an igneous plutonic origin, rather than the metasedimentary one suggested by Crowley (1968). On a local outcrop scale cross-cutting features at the margins of the body of gneiss and xenoliths of country rock within the gneiss (both Hartland Unit I and Collinsville Formation) clearly require an intrusive origin for the Newtown Gneiss. A weak but penetrative deformation has created a pervasive, indistinct foliation of the feldspar porphyroblasts. The attitude of this indistinct foliation is essentially parallel to the NW strike of more distinct foliation in the country rock, indicating that intrusion was followed by a later phase of deformation related to the doming (period-4 folding). The microcline porphyroblasts in the Newtown Gneiss also occur in adjacent country rocks, both Hartland Unit I and the Collinsville Formation, but not in the Straits Schist. In fact, the absence of intrusive cross-cutting relationships with the Straits Schist can be considered as negative evidence of a pre-Silurian age of the Newtown Gneiss. The abundance and size of the porphyroblasts in the country rock decrease with increasing distance from the Newtown Gneiss border. Collinsville and Hartland Unit I rocks do not abruptly terminate against the Newtown Gneiss in most regions; there is a gradational boundary, with the abundance of country-rock xenoliths decreasing inward. The lithologic character of these xenoliths is preserved well enough to extend the original outcrop pattern of the country rocks into the intrusive body. Such relationships can best be explained by a combination of intrusion and widespread potassium metasomation, resulting in growth of porphyroblasts during a period of deformation and recrystallization.

GRANITIC BODY

The largest area of the Newtown Gneiss is underlain by medium- to coarse-grained quartz-plagioclase-microcline-biotite-muscovite gneiss of granitic composition that contains microcline porphyroblasts 1-5 cm long. The gneiss has a nearly isotropic fabric, with only a weak alignment of porphyroblasts. Weathered outcrops are rounded and massive. The biotite folia are contorted about the porphyroblasts to such an extent that only slight micaceous foliation has been produced.

GRANODIORITIC BODY

A part of the Newtown Gneiss, considerably more mafic than the granitic body, is found on either side of the Pomperaug fault along the western quadrangle boundary. The one sample studies in thin section is a hornblende-rich granodiorite; other areas in the granodiorite body appear to have less microcline than the hornblende-rich granodiorite and to more nearly approach the composition of quartz diorite. As in the granitic part of the Newtown Gneiss, the small micaceous content and the abundant porphyroblasts of the more mafic phase produce an indistinct fabric—outcrops are massive and rounded. Microcline porphyroblasts are less abundant than in the granitic part of the gneiss and smaller (0.25-2 cm in length).

An isolated outcrop of rock lithologically similar to the Newtown Gneiss was found on the eastern cliffs of Horse Hill along the western border of Southbury quadrangle. The western extent of this small outcrop is unknown but is of interest because it lies about 2 km outside the perimeter of intermixed Newtown Gneiss and country rocks.

The Newtown Gneiss intrudes the Collinsville Formation and Hartland Unit I east of the Pomperaug fault, and on the western side of the fault, the gneiss intrudes Hartland Unit II. Pegmatites and nonporphyritic medium-grained granitic rocks intrude the Newtown Gneiss.

Nonporphyritic granites and granodiorites

Cross-cutting features record several periods of granitic intrusion in the Southbury region. Relatively large bodies are indicated on the map; they are not exclusively igneous rock; abundant country-rock xenoliths are included. With the exception of numerous pegmatites, relatively few granitic rocks intrude the

Straits Schist; most granites are restricted to lower stratigraphic units. This restriction may indicate that most granites predate the Straits Schist, or it may indicate a relative stratigraphic level to which granitic rock intruded, or it may indicate a physical behavior of the Straits Schist that was not conducive to granitic intrusion. At this stage of study it is not clear which explanation is correct.

Although there is considerable spread in the mineralogical and chemical composition of these granitic rocks, no change in composition with apparent time of intrusion is obvious. Muscovite-rich granites are in a minority; most contain more biotite than muscovite. Only a few rocks lack potassium feldspar and these have high contents of muscovite or biotite than may reflect metamorphic replacement of potassium feldspar by hydrous potassic phases.

Post-orogenic Paleozoic igneous rocks

A small undeformed mesocratic syenite stock and a biotite lamprophyre dike cut the metamorphosed units of the Southbury quadrangle. The stock is about 150 x 70 m and is located about 300 m west of the dam at Southford Falls State Park. A biotite lamprophyre (minette), 1 m in width, is exposed along Interstate 84 roadcuts on the western side of the junction with State Route 188. The lamprophyre dike (biotite K-Ar date of 334 m.y.) has an age that is comparable with K-Ar dates related to regional metamorphism; although the undeformed dike postdates Acadian metamorphism, it cooled to argon-retention temperatures at the same time as the surrounding metamorphic rocks (Clark and Kulp, 1968; Zartman and others, 1965). The stock intruded at a distinctly later period (whole rock K-Ar date of 263 m.y. and biotite K-Ar date of 277 m.y.), after the country rock has cooled to argon-retention temperatures.

Sequence of Paleozoic igneous events

Amphibolites and other metavolcanic rocks within the metamorphosed strata of the Southbury quadrangle are undoubtedly the oldest igneous rocks of the region. It is more difficult to determine the relative ages of granitic plutons that intruded the orogenic belt during phases of deformation. Obviously, the porphyroblastic Newtown Gneiss is older than pegmatites and nonporphyroblastic granites that intrude it; in turn, the Newtown Gneiss cuts period-3 lineations and folds but period-4 schistosities penetrate the gneiss. Relative ages of the smaller nonporphyroblastic granitic bodies are more difficult to ascertain because the large scale of the structures, the limited outcrops, and the indistinct foliations of many granite bodies introduce ambiguous evidence or give none. Some highly deformed, well foliated, and folded granitic bodies appear to have been deformed during folding-periods 2, 3, and 4. Other plutons seem to have been only slightly affected by deformation and their only foliations are close to boundaries; these may have been intruded after period-3 folding and before that of period 4. Although some pegmatites have been deformed, the vast majority show no evidence of deformation and clearly cut across the latest fabrics and thus are probably the youngest igneous event directly related to metamorphism and orogenesis. The 344-m.y. lamprophyre dike intruded the belt after the last deformation but before the argon-retention temperature was reached in the cooling metamorphic country rock; thus the dike has a K-Ar date compatible with the K-Ar dates of the country rock. A still later alkalic event was marked by the intrusion of mesocratic, alkali-amphibole syenites (263-277 m.y. K-Ar dates). Only one body was mapped but erratics of this distinctive lithology were found northwest of the known body; glaciers that moved southeastward undoubtedly carried the erratics from one or more identical plutons.

TRIASSIC ROCKS

Although detailed discussion of the Triassic rocks of the Pomperaug Valley is beyond the scope of this report, a short summary of previous studies of these rocks and observations made during mapping for this report are included.

Percival's (1842) mapping first outlined the regions underlain by basalt and arkose in the Pomperaug Valley. The block-fault theory of Davis (1888) was based largely on his observations in this region. Shortly thereafter, Hovey (1890) reported on the rocks encountered in a dry hole drilled for oil and later (1899) Hobbs made the first comprehensive report of the Pomperaug Triassic region. Davis and Hobbs established the stratigraphic sequence at the base of the Triassic, where outcrops are adequate on the hills and slopes north and east of South Britain.

The sequence consists of covered arkosic sediments (?) west of South Britain, overlain sequentially by shale, arkosic conglomerate, and sandstone, a distinctive amygdaloidal basalt, a thin shale, more conglomerate, a thick columnar-jointed basalt, reddish and greenish shale, a pillow basalt, and more arkosic sediments found north and east of South Britain. The thickness of the covered arkosic sediments below the base of the amygdaloidal basalt can be estimated from the width of the Pomperaug River valley west of South Britain and from the drilling record from the dry well 0.5 km. west of Middleground Cemetery; Hovey (1890) noted that two trap sheets were encountered in arkosic sediments before the crystalline basement was encountered at 1,235 ft (380 m) and Hobbs (1899) reported that the two traps were found near the top of the dry hole. Even the thickness of well exposed beds is difficult to measure because of variations in bed attitude.

STRUCTURAL GEOLOGY

General discussion

A complex Paleozoic fold history is required for the outcrop pattern of the Straits Schist in southwestern Connecticut. Stanley (1964, 1968) proposed that the complex fold history in northwestern Connecticut in the Collinsville quadrangle consisted of nappe formation followed by doming. Dieterich (1968a, b) also recognized this requirement on a regional scale in southwestern Connecticut and developed a series of folding events that are compatible with the local and regional stratigraphic and structural schemes. Crowley (1968) also constructed a complex sequence of nappe formation to explain structural relations in the Long Hill and Bridgeport quadrangles. This report uses the Dieterich scheme with minor changes and additions to fit local problems.

The most conspicuous structural feature of the metamorphosed units in the quadrangle is the long strip of the Straits Schist that extends from the southern border northward to Southford Falls and then northwestward to the Triassic Pomperaug fault. The southwestern corner of the Waterbury dome dominates the structure in the northeastern part of the quadrangle. West of the strip of the Straits Schist, a series of folds in Hartland Unit I and the Collinsville Formation has been bent into an arc parallel to the arched strip of Straits.

High-angle faults

The Pomperaug fault is both the best exposed normal fault and the major post-Paleozoic structure in the Southbury quadrangle. The fault can be traced readily, by the juxtaposition of Triassic basalts and pre-Triassic metamorphic rocks, northward into the Woodbury quadrangle. Along the western border of the Southbury quadrangle, the Pomperaug fault cuts the Newtown Gneiss with an apparent right-lateral offset.

GEOLOGIC HISTORY

The oldest rocks in the Southbury quadrangle are Cambro-Ordovician eugeosynclinal metasediments; the original sedimentary-rock pattern consisted of an eastern facies of aluminous pyritiferous shale (Waterbury Formation) and a more heterogeneous western facies of interbedded shale, quartz-rich siltstone and sandstone, subgraywacke, and thin calcareous shale and limestone (Hartland Unit II). The western facies may represent continental-slope or continental-rise sedimentary rocks that are transitional between the eastern eugeosynclinal facies and the western miogeosynclinal shelf facies. These basal rocks may lie on Precambrian crust, as indicated by the isotopic ages of many gneiss domes in New England but there is no evidence that the rocks in the gneiss-dome belt west of the Connecticut Triassic Valley are Precambrian. Then, in Cambro-Ordovician time, interbedded aluminous shale, shale, and subgraywacke (Hartland Unit I) were deposited on the oldest units. In the east the sedimentary rocks were more highly aluminous than those to the west and were most prevalent, whereas in the west quartz-rich sedimentary rocks were more commonly interbedded with shales and graywackes. The sedimentary pattern is similar to that of the basal units. A distinctly different sedimentary pattern was established in the uppermost Cambro-Ordovician rocks: in the west, aluminous shales were intercalated with subordinate tuff (Aluminous member of the Collinsville Formation) but in the east, abundant basaltic, andesitic, and rhyolitic rocks had few interbeds of shale, sandstone, and thin limestone (Bristol Member of the Collinsville Formation). The eastern facies may represent island-arc deposits. A major unconformity was developed above this stratigraphic level. No evidence of Taconic deformation was recognized in the Southbury quadrangle.

Discontinuous lenses of quartz sandstone, limestone, and calcareous shale, together with basalt flows of probable Silurian age were deposited on the unconformity, (southern equivalents of the Russell Mountain Formation of Massachusetts). Above these heterogeneous rocks a homogeneous, organic black shale of Siluro-Devonian age was deposited (the Straits Schist); this unit is the youngest Paleozoic rock exposed in the Southbury quadrangle.

The 334-m.y. K-Ar date of an undeformed lamprophyre dike restricts the metamorphism and complex deformation of the region to the Acadian orogeny. The sequence of deformation consists of an initial western thrusting and/or folding of moderate-scale nappes, followed by a major east-facing nappe that was subsequently domed by rising gneiss bodies. Four periods of Acadian folding can be recognized. The first deformation, the west-facies nappes, produced fold noses that can be seen on regional maps but no schistosity or lineations related to this deformation were seen. The second period of folding produced the major E-facing nappe, low-angle isoclinal folds, and a strong schistosity. The third period of folding produced folds nearly coaxial with those of period 2 but period-3 folds are not as highly isoclinal and have more nearly vertical axial planes and a less pronounced schistosity. Period-3 folding possible was formed during an E-W compression of the E-facing nappes. All three fold periods have NS to NE-SW trends. The fourth period of folding has a W to NW axial trace that is approximately tangential to the Waterbury Gneiss dome; therefore it is postulated that this last period of deformation was caused by draping of folds off the sides of the rising dome. The axial-plane schistosity of period-4 folding is well developed only locally.

The large granitic body (Newtown Gneiss) intruded metasedimentary units in the southwestern part of the Southbury quadrangle prior to period-4 folding and was subsequently deformed by that folding, producing a weak foliation. Smaller granitic bodies predate the Newtown pluton but are difficult to place exactly in a time sequence. Abundant late-stage pegmatites cut all periods of deformation.

Snowball structures in garnets with post-rotational overgrowths, large unoriented poikiloblasts of staurolites, unoriented porphyroblasts of biotite and kyanite, and unoriented sillimanite fibers suggest that the highest temperature period of metamorphism to the almandine-amphibolite facies occurred after the last period of deformation.

NW-trending high-angle faults may be related to the Alleghany orogeny, in which metamorphism and plutonism affected eastern Connecticut and southern Rhode Island.

A prolonged period of erosion exposed kyanite-staurolite-bearing metamorphic rocks in the Southbury region prior to deposition of Triassic arkoses and basalts. Then Triassic faulting downdropped the arkosic sediments and basalt flows in fault basins (arkoses and basalts) of the Pomperaug valley. Erosion followed this deformation.

The topography was smoothed by the scraping of topographic highs by Pleistocene glaciers and the filling of lows with glacial debris. Renewed stream erosion has only partially modified the glacial landscape.

REFERENCES CITED

Armstrong, R. L., Barton, J. M., Carmalt, S. W., and Crowley, W. P., 1970, Geochronologic studies of the Prospect, Ansonia, and Milford Formations, southern Connecticut: Connecticut Geol. Nat. History Survey Rept. Invest. 5, 19-27.

Besancon, J. R., 1970, A Rb-Sr isochron for the Nonewaug Granite: Connecticut Geol. Nat. History Survey Rep. Invest. 5, p. 1-9.

Carr, M. H., 1960, The bedrock geology of the Naugatuck quadrangle: Connecticut Geol. Nat. History Survey Quad, Rept. 9, 25 p.

Clark, G. S., and Kulp, J. L., 1968, Isotopic age study of metamorphism and intrusion in western Connecticut and southeastern New York: Am. Jour. Sci., v. 266, p. 865-894.

Crowley, W. P., 1968, The bedrock geology of Long Hill and Bridgeport quadrangles: Connecticut Geol. Nat. History Survey Quad. Rept. 24, 81 p.

Davis, W. M., 1888, The Triassic formation of the Connecticut Valley: 7th Ann. Rept. U. S. Geol. Survey, p. 468-490.

Gates, R. M., 1959, The bedrock geology of the Roxbury quadrangle, Connecticut: U. S. Geol. Survey Geol. Quad. Map GQ-121.

Gates, R. M., and Martin, C. W., 1967, The bedrock geology of the Waterbury quadrangle: Connecticut Geol. Nat. History Survey Quad. Rept. 22, 36 p.

Hobbs, W. H., 1899, The Newark System of the Pomperaug Valley: U. S. Geol. Survey 21st Ann. Rept., pt. 111, p. 7-160.

Hovey, E. O., 1890, The oil well of Southbury, Conn.: Sci. Am., v. 62, p. 275.

Percival, J. G., 1842, Report on the geology of the state of Connecticut: New Haven, Osborn and Baldwin, 495 p.

Rice, W. N., and Gregory, H. E., 1906, Manual of the geology of Connecticut: Connecticut Geol. Nat. History Survey Bull. 6, 273 p.

Rodgers, John, Gates, R. M., and Rosenfeld, J. L., 1959, Explanatory text for preliminary geological map of Connecticut, 1956: Connecticut Geol. Nat. History Survey Bull. 84, 64 p.

Schwab, F. L., 1971, Geosynclinal compositions and the new global tectonics: Jour. Sed. Petrology, v. 41, p. 928-938.

Stanley, R. S., 1964, The bedrock geology of the Collinsville quadrangle: Connecticut Geol. Nat. History Survey Quad. Rept. 16, 99 p.

Thompson, J. B., Robinson, P., Clifford, T. N., and Trask, N. J., 1968, Nappes and gneiss domes in west-central New England, in Studies of Appalachian geology, northern and maritime, Zen, E-An, White, W. S., and Hadley, J. B., eds.: New York, Wiley, p. 203-218.

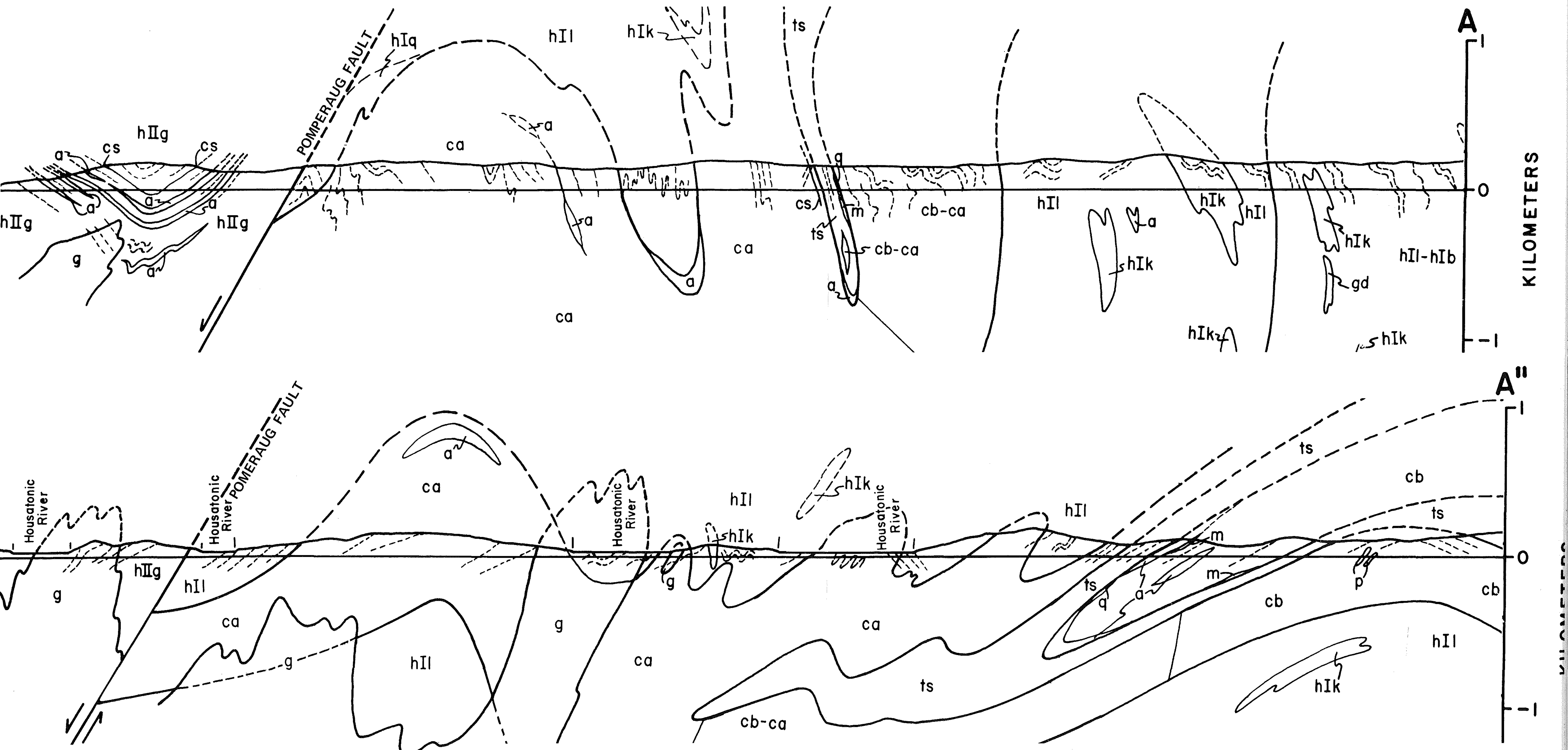
Vidale, R. J., 1968, Calc-silicate bands and metasomatism in a chemical gradient: unpub. Ph.D. dissertation, Yale Univ., 79 p.

Zartman, R., Snyder, G., Stern, T. W., Marvin, R. F., and Bucknam, R. C., 1965, Implications of new radiometric ages in eastern Connecticut and Massachusetts: U. S. Geol. Survey Prof. Paper 525-D, p. 1-100.

CROSS SECTION FOR THE SOUTHBURY QUADRANGLE

Major formation boundaries are hypothetically projected below the ground surface and dashed above the surface. The lighter discontinuous dashed lines below the surface indicate the generalized attitudes of foliations and styles of folds. Zero marks sea level. The lithologic abbreviations are the same as on the map. No vertical exaggeration.

Note that the plunges on fold axes shown on the map are not consistent, particularly west of the strip of the Straits Schist; some plunge NW, some SE, and some SW, and others are essentially horizontal. Therefore, the interpretation of fold geometry in cross section is somewhat speculative in detail because the measured attitudes of minor fold axes of one generation in many cases bear little resemblance to the attitude of major fold axes of a different generation related to the map-scale outcrop pattern. These difficulties are inherent to regions with multifold histories.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