

The Franklin quadrangle is located in southeastern Sussex County, northwestern Morris County, and western Passaic County, where it straddles the boundary between the New Jersey Highlands and Valley and Ridge physiographic provinces, but it is predominantly in the Highlands. The area is characterized by rugged uplands with ridge top elevations of as much as 1,410 ft. above sea level, separated by broad, generally northeast-striking stream valleys. The valleys are drained by the Wallkill River in the west, the Pequannock River in the northeast, and the Rockaway River in the southeast.

Previous work on the bedrock geology of the guadrangle includes that of Spencer and others (1908), Hague and others (1956), Baker and Buddington (1970), and Drake and others (1996). The bedrock lithologies and structures depicted on these maps lacks conformity with more recent detailed mapping of adjacent areas. Moreover, new interpretations of bedrock geologic relationships, based in part on detailed bedrock mapping, major and trace element geochemistry, stable isotope analysis, and uranium-lead (U-Pb) geochronology, have updated much of the previous work.

> STRATIGRAPHY Paleozoic rocks

Paleozoic rocks in the map area range in age from Cambrian through Devonian and are subdivided into the Middle Paleozoic rocks of the Green Pond Mountain Region and Lower Paleozoic rocks of the Kittatinny Valley sequence. Middle Paleozoic rocks crop out in the Green Pond Mountain Region, a northeast-trending block of downfaulted and folded sedimentary rock in the southeast part of the area. They include the Green Pond Conglomerate, Longwood Shale, Poxino Island, and Berkshire Valley Formations of Silurian age, and the Connelly Conglomerate, Esopus Formation, Kanouse Sandstone, Cornwall Shale, and Bellvale Sandstone of Devonian age. The stratigraphic relationships of the Middle Paleozoic rocks were discussed by Darton (1894), Kümmel and Weller (1902), Barnett (1970), and

Herman and Mitchell (1991).

regarded as Cambrian in age.

Formations of Cambrian through Ordovician age of the Kittatinny Valley sequence crop out in the lowland areas of the Wallkill Valley, Wildcat Brook, and Big Springs, where they unconformably overlie, or are in fault contact with, Mesoproterozoic rocks. The Kittatinny Valley sequence was previously considered part of the Lehigh Valley sequence of MacLachlan (1979) but was reassigned by Drake and others (1996). It includes the Kittatinny Supergroup, of which the Leithsville Formation and Allentown Dolomite are exposed in the quadrangle. Based on the final acceptance of the Global Stratotype Section and Point base (GSSP) for the Ordovician at Green Point, Newfoundland (Cooper and others, 2001), the Cambrian-Ordovician boundary in New Jersey is now accepted as occurring within the lower third of the Epler Formation, at the top of the Cordylodus lindstromi zone, within conodont fauna B as used in Karklins and Repetski (1989). Therefore, the Allentown Dolomite is now

North of Franklin Pond, northwest-striking lamprophyre dikes of Lower Silurian to Upper Ordovician age of the Beemerville Intrusive Suite (Drake and Monteverde, 1992) intrude he Franklin Marble of Mesoproterozoic age, and the west limb of the zinc orebody at the Franklin mine. Elsewhere regionally, titanite from nepheline syenite at Beemerville yields a TIMS U-Pb crystallization age of 447 ± 2 Ma (Ratcliffe and others, 2012), a K-Ar cooling age from biotite of 435 ± 20 Ma (Zartman and others, 1967), and a fission-track age from titanite of 422 ± 14 Ma (Eby and others, 1992).

Neoproterozoic rocks Mesoproterozoic rocks along the eastern side of the Wallkill Valley, north of Morris Lake. and along the southwestern part of Bowling Green Mountain, are unconformably overlain by unmetamorphosed rocks of the Neoproterozoic Chestnut Hill Formation (Drake, 1984; Gates and Volkert, 2004). Elsewhere regionally, the Chestnut Hill Formation is unconformably overlain by the Lower Cambrian Hardyston Quartzite. Rocks of the Chestnut Hill Formation were formed from alluvial, fluvial, and lacustrine sediments, and possible volcanic rocks of felsic composition, that were deposited in a series of small sub-basins along the rifted margin of eastern Laurentia at about 600 Ma during breakup of the supercontinent Rodinia (Volkert and others, 2010a).

Mesoproterozoic rocks in the map area, but not the Cambrian or younger Paleozoic rocks, are intruded by east or northeast-striking diabase dikes of Neoproterozoic age (Volkert and Puffer, 1995). The dikes are characterized by sharp, mainly discordant contacts against enclosing country rocks, aphanitic chill margins, and they contain xenoliths of Mesoproterozoic rocks. Some dikes have columnar joints along their margins, suggesting that the magma may locally have broken the surface as flows that are now eroded. Dikes have geochemical compositions that are high in TiO₂, P₂O₅, Zr, and light rare-earth elements, indicating they were formed from an Ocean Island Basalt-like mantle source in a rift-related, within-plate, tectonic setting (Volkert, 2004a). Contacts between diabase dikes and the Chestnut Hill Formation are not known to be exposed in the Highlands, so the temporal

Mesoproterozoic rocks

relationship between them remains unknown.

commonly, southeast.

Mesoproterozoic rocks in the map area consist of an assemblage of granites, gneisses, and marble. Most Mesoproterozoic rocks were metamorphosed to granulite facies during the Ottawan phase of the Grenville orogenic cycle at 1045 to 1024 Ma (Volkert and others, 2010b). The temperature for this high-grade metamorphism is constrained from regional calcite-graphite geothermometry to 769°C (Peck and others, 2006).

Among the oldest Mesoproterozoic rocks in the area are the Losee Suite that formed

in a magmatic arc, and a thick assemblage of supracrustal metavolcanic and metasedi-

mentary rocks formed in a back-arc basin inboard of the Losee arc (Volkert, 2004b). Rocks of the Losee Suite are calc-alkaline in composition and include various quartz-plagioclase aneisses and amphibolite formed from plutonic and volcanic protoliths (Volkert and Drake. 1999). Rocks of the Losee Suite yield sensitive high-resolution ion microprobe (SHRIMP) U-Pb zircon ages of 1282 to 1248 Ma (Volkert and others, 2010b). Spatially and temporally associated with the Losee Suite are supracrustal rocks that include microcline gneiss and amphibolite formed from felsic and mafic volcanic protoliths,

respectively, and quartzofeldspathic gneisses, calc-silicate rocks, and marble formed from

sedimentary protoliths. Microcline gneiss yields U-Pb SHRIMP zircon ages of 1299 to 1251

Ma (Volkert and others, 2010b) that closely overlap the age of rocks of the Losee Suite. Granite and related rocks of the Byram and Lake Hopatcong Intrusive Suites, that together comprise the Vernon Supersuite (Volkert and Drake, 1998), are abundantly exposed in the map area where they intrude Losee Suite and supracrustal rocks. Byram and Lake Hopatcong rocks form a complete differentiation series that includes monzonite, quartz monzonite, granite, and alaskite, all of which have a distinctive A-type geochemical composition (Volkert and others, 2000). Granite of both suites yields similar U-Pb SHRIMP zircon ages of 1188 to 1182 Ma (Volkert and others, 2010b).

The youngest Mesoproterozoic rocks are postorogenic potassic granites and granite pegmatites that are undeformed, contain xenoliths of foliated gneiss or marble, and intrude other Mesoproterozoic rocks in the map area as small, tabular to irregular bodies that are discordant to the metamorphic foliation. Pegmatite known locally as Double Rock, that intrudes marble and the west limb of the zinc orebody at the Franklin mine, has a U-Pb zircon age of 986 Ma, and other regional postorogenic bodies of granite and pegmatite yield U-Pb zircon ages of 1004 to 990 Ma (Volkert and others, 2005).

Paleozoic bedding and cleavage Bedding in the Paleozoic rocks is fairly uniform and strikes northeast except in the hinge areas of folds at Bowling Green Mountain. The average strike of bedding in Middle Paleozoic rocks of the Green Pond Mountain Region is N.39°E. Beds range in dip from 22° to 90° and average 60°. Most beds are upright and dip northwest and, less commonly, southeast, although locally in the Longwood Valley they are overturned. The average strike of bedding in Lower Paleozoic rocks of the Kittatinny Valley sequence is N.46°E. (fig. 1). Beds range in dip from 11° to 90° and average 44°. They dip mainly northwest and, less

Cleavage (closely spaced parallel partings) is present in most of the Paleozoic rocks but is best developed in shale and other fine-grained rocks. Cleavage in rocks of the Green Pond Mountain Region strikes about N.43°E. and in rocks of the Kittatinny Valley sequence about N.53°E., nearly parallel to the strike of bedding in both the Middle and Lower Paleozoic rocks. Cleavage dips mainly southeast at an average of 75° in Middle Paleozoic rocks, and toward the northwest or southeast at an average of 43° in the Lower Paleozoic

Proterozoic foliation Crystallization foliation, formed by the parallel alignment of mineral grains in the Mesoproterozoic rocks, defines the trend of the bedrock. It is an inherited feature from compressional stresses during granulite-facies metamorphism that deformed the rocks between 1045 and 1024 Ma (Volkert and others, 2010b). Foliation strikes mainly northeast at an average of N.34°E. (fig. 2), but locally, in the hinges of folds, it strikes northwest because of deformation of the rocks during folding. Foliation dips southeast and, less commonly, northwest at 30° to 90° and averages 65°. Northwest-striking foliation dips gently to moderately

Folds in the Paleozoic rocks were formed during the Taconian and Alleghanian orogenies at about 450 Ma and 250 Ma, respectively. Folds in the Green Pond Mountain Region are northeast, open to tight, upright to locally overturned, and gently inclined to recumbent anticlines and synclines (Barnett, 1976; Herman and Mitchell, 1991). Most folds plunge gently southwest. Taconic-age folds here are cut by younger Alleghanian faults (Herman and Monteverde, 1989; Herman and others, 1997). Folds in rocks of the Kittatinny Valley sequence are northeast, open, upright, and form gently north-plunging anticlines and synclines that continue from Lake Mohawk to the south (Drake and Volkert, 1993).

Folds that deform Mesoproterozoic rocks originated during the Ottawan phase of the Grenville orogeny. They deform earlier-formed planar metamorphic fabrics and, therefore. postdate the development of crystallization foliation. Characteristic fold patterns are broad, open, northwest-verging to locally upright, northeast-plunging antiforms and synforms. Mineral lineations plunge parallel to the axes of major folds. Plunges range from 13° to 53° and

that deform Mesoproterozoic and Paleozoic rocks. Most faults are characterized by brittle deformation features that include brecciation, recrystallization and low-temperature retrogression of mafic minerals, chlorite or epidote-coated slickensides, and close-spaced fracture cleavage. The Zero and Reservoir faults are characterized by ductile deformation features that include mylonite, shear band foliation, and boudinage, overprinted by brittle deformation features. The Tranquility thrust fault strikes northeast and dips gently to moderately southeast at an average of 35°. The fault places Mesoproterozoic and Paleozoic rocks on the hanging

wall against Paleozoic dolomite on the footwall. It extends through the northwest corner of the map area, and is also known to the southwest, in the Tranquility quadrangle, where it was encountered in drill core by New Jersey Zinc Company geologists (Baum, 1967), and in the Newton East quadrangle, where the fault was inferred by Drake and Volkert (1993), and later confirmed through drilling in 2009 at the Limecrest quarry (Volkert, 2010). The fault is characterized by early ductile deformation that is strongly overprinted by brittle deformation

The structural geology of the bedrock units is dominated by northeast-trending faults

The Hamburg fault strikes northeast and dips southeast at about 75°. It places Mesoproterozoic rocks on the footwall against Paleozoic rocks on the hanging wall along most of its length. The latest movement appears to have been normal. The fault is characterized by brittle deformation features along its entire length.

The Zero fault strikes northeast and dips steeply southeast to vertically. It bounds the west side of the Wallkill River Valley where it places Mesoproterozoic rocks on the footwall against Paleozoic rocks on the hanging wall. The fault is characterized by ductile deformation features of Proterozoic age that are overprinted by brittle deformation fabric of probable Paleozoic age (Metsger, 2001). The fault has a protracted history of movement through geologic time, but the latest movement sense appears to be normal. The Zero fault terminates in a series of splays in the northern part of the map area where it is cut off by the East

The Sparta thrust fault strikes northeast and dips nearly horizontally to about 35° southeast. To the south, in the Newton East quadrangle, it was interpreted as a northwest-dipping back thrust (Drake and Volkert, 1993), but it is here reinterpreted as a folded thrust fault based on movement indicators in Allentown Dolomite near Sparta. The fault is cut off on both ends by the Zero fault. The Sparta thrust fault has Paleozoic rocks along most of its length, but in the map area it extends along the east side of the Wallkill River Valley, where it has Paleozoic rocks on the footwall and Mesoproterozoic rocks on the hanging wall. The fault is characterized by brittle deformation fabric along its entire length.

The East fault strikes northeast and dips southeast about 80°. It borders the east side

of the Wallkill River Valley, where it has Mesoproterozoic rocks along most of its length, but

in the map area it places Paleozoic rocks on the footwall against Mesoproterozoic rocks on the hanging wall. The latest movement on the fault appears to have been reverse. The fault is characterized by brittle deformation fabric along its entire length. The Reservoir fault strikes northeast and ranges in dip from steeply northwest to steeply southeast. It places Mesoproterozoic rocks on the footwall against Paleozoic rocks on the hanging wall along most of its length. The fault has undergone multiple reactivations dating from the Proterozoic that indicate normal, right-lateral strike slip, and reverse movement, with latest movement having been normal. The fault is characterized by ductile deformation features in the center of the fault zone that are overprinted by a zone of brittle deformation

as much as 1,000 feet wide.

The Russia fault (Herman and Mitchell, 1991) strikes N.50°E., closely paralleling the adjacent Reservoir fault, and dips southeast at about 80°. It is bounded by Paleozoic rocks on both sides. South of the map area the fate of the fault is unknown, and to the north, in the Newfoundland quadrangle, it merges with, or is cut off by, the Reservoir fault. Latest movement on the fault appears to have been normal. The fault is characterized by brittle

The Longwood Valley fault strikes about N.45°E. and dips steeply northwest to verti-

cally. It has Mesoproterozoic rocks on the footwall and Paleozoic rocks on the hanging wall

than a few thousand feet long. These faults are characterized mainly by brittle deformation

features. Latest movement is varied and ranges from normal, to right-lateral or left-lateral

along most of its length. Kinematic indicators suggest the latest movement on the fault was reverse, although dip-slip normal movement is predominant south of the map area. The fault is characterized by brittle deformation fabric. Mesoproterozoic and Paleozoic rocks are also deformed by small faults striking northeast or northwest that range from a few inches to tens of feet wide and are rarely more

Joints are a ubiquitous feature in the Mesoproterozoic and Paleozoic rocks but are best developed in massive rocks such as Paleozoic limestone, dolomite, and sandstone, and in Mesoproterozoic granite and some gneiss. Joints developed in Mesoproterozoic rocks are characteristically planar, moderately well formed, moderately to widely spaced, and moderately to steeply dipping. Their surfaces are typically unmineralized, except near faults, and are smooth and less commonly slightly irregular. Joints are varied in their spacing from a foot to tens of feet apart. Those formed close to faults are spaced 2 feet or less apart.

The dominant joints in the Green Pond Mountain Region strike N.49°W. on average and dip mainly northeast at an average of 76°. Joints in rocks of the Kittatinny Valley sequence strike N.66°W. on average (fig. 3) and dip southwest at an average of 76°. A minor set strikes N.35°E. and dips nearly equally southeast or northwest at an average of 53°. The dominant joints in the Mesoproterozoic rocks are nearly perpendicular to the strike of crystallization foliation, a consistent feature in Mesoproterozoic rocks throughout the

granite, gneiss, and, very locally, marble. Detailed descriptions of most of the mines are

given in Bayley (1910) and Baker and Buddington (1970). Marble-hosted zinc-iron-manga-

nese ore was mined at the world-famous Franklin mine (Frondel and Baum 1974) and Ster-

ling Hill mine (Metsger and others, 1958, Metsger, 2001, Johnson, 2001) in the northwest

part of the map area. Both zinc deposits have been the subject of geologic inquiry for more

DESCRIPTION OF MAP UNITS

Green Pond Mountain Region

Dbv Bellvale Sandstone (Middle Devonian) (Bellvale Flags of Darton, 1894; Willard, 1937) -

Cornwall Shale (Middle Devonian) (Hartnagel, 1907) - Black to dark-gray, very thin to

Dkec Kanouse Sandstone, Esopus Formation, and Connelly Conglomerate, undivided

contact with Esopus Formation gradational. Unit is about 46 ft. thick.

in the map area.

shale and siltstone is about equal. Unit is 1,750 to 2,000 ft. thick.

Upper beds are grayish-red to grayish-purple sandstone containing quartz pebbles as

large as 1 in. in diameter. Lower beds are light-olive-gray to yellowish-gray- and green-

ish-black-weathering, medium-gray to medium-bluish-gray, very thin to very thick-bed-

ded siltstone and sandstone, crossbedded, graded, and interbedded with black to dark-

gray shale. More sandstone occurs in upper beds and is finer downward. Lower contact

conformable with the Cornwall Shale and placed where beds are thicker and volume of

thick-bedded, fossiliferous shale, interbedded with medium-gray and light-olive-gray to

yellowish-gray, laminated to very thin bedded siltstone that is more abundant in upper

(Lower Devonian) Kanouse Sandstone (Kümmel, 1908) – Medium-gray, light-brown,

and grayish-red, fine to coarse-grained, thin to thick-bedded sandstone and pebble con-

glomerate. Basal conglomerate is interbedded with siltstone and contains well-sorted,

Esopus Formation (Vanuxem, 1842; Boucot, 1959) - Light to dark-gray, laminated to

Connelly Conglomerate (Chadwick, 1908) – Grayish-orange-weathering, very light-gray to

Berkshire Valley and Poxono Island Formations, undivided (Upper Silurian) Berkshire

Poxono Island Formation (White, 1882: Barnett, 1970) - Very thin to medium-bedded se-

quence of medium-gray, greenish-gray, or yellowish-gray, mud-cracked dolomite; light-

green, pitted, medium-grained calcareous sandstone, siltstone, and edgewise conglom-

erate containing gray dolomite; and quartz-pebble conglomerate containing angular to

subangular pebbles as much as 0.8 in. long. Interbedded grayish-green shale at lower

contact is transitional into underlying Longwood Shale. Unit ranges in thickness from

to very thick-bedded shale interbedded with cross-bedded, very dark-red, very thin-

to thin-bedded sandstone and siltstone. Lower contact conformable with Green Pond

grained quartz-pebble conglomerate, quartzitic arkose and orthoquartzite, and thin to

thick-bedded reddish-brown siltstone. Grades downward into less abundant gray, very

dark red, or grayish-purple, medium to coarse-grained, thin- to very thick-bedded peb-

ble to cobble-conglomerate containing clasts of red shale, siltstone, sandstone, and

chert; yellowish-gray sandstone and chert; dark-gray shale and chert; and white-gray

and pink milky quartz. Quartz cobbles are as much as 4 in. long. Unconformably over-

lies, or is in fault contact with, Mesoproterozoic rocks. Unit is about 1.000 ft. thick.

Valley and Ridge

Beemerville Intrusive Suite

Kittatinny Valley Sequence

Allentown Dolomite (Upper Cambrian) (Wherry, 1909) – Upper sequence is light-gray-to

medium-gray-weathering, medium-light- to medium-dark-gray, fine to medium-grained,

locally coarse-grained, medium to very thick-bedded dolomite; local shaly dolomite near

the bottom. Floating quartz sand and two series of medium-light- to very light-gray,

medium-grained, thin-bedded quartzite and discontinuous dark-gray chert lenses occur

directly below upper contact. Lower sequence is medium- to very-light-gray-weathering,

light- to medium dark-gray, fine to medium-grained, thin to medium-bedded dolomite

and shaly dolomite. Weathered exposures characterized by alternating light and dark-

ate, mud cracks, and paleosol zones occur throughout but are more abundant in lower

sequence. Lower contact gradational into Leithsville Formation. Unit contains a trilobite

fauna of Dresbachian (early Late Cambrian) age (Weller, 1903; Howell, 1945). Unit is

gray beds. Ripple marks, ooids, algal stromatolites, cross-beds, edgewise conglomer-

Lamprophyre dikes (Lower Silurian to Upper Ordovician) - Light-medium- to medi-

um-dark-gray, fine-grained to aphanitic dike of mainly alkalic composition. Contacts are

chilled and sharp against enclosing Mesoproterozoic country rock. Dike is exposed in

the Buckwheat open cut at the Franklin zinc mine, north of Franklin Pond. It is as much

Green Pond Conglomerate (Middle to Lower Silurian) (Rogers, 1836) - Medium to coarse-

with Poxino Island Formation. Unit ranges in thickness from 90 to 125 ft.

SI Longwood Shale (Upper to Middle Silurian) (Darton, 1894) – Dark reddish-brown, thin

Conglomerate. Unit is about 330 ft. thick.

as 25 ft. wide and of uncertain length.

about 1,800 ft. thick regionally.

yellowish-gray, thin-bedded quartz-pebble conglomerate. Quartz pebbles are subround-

ed to well rounded, well sorted, and as much as 0.8 in. long. Unit is about 36 ft. thick.

Valley Formation (Barnett, 1970) - Yellowish-gray-weathering, medium-gray to pink-

ish-gray, very thin to thin-bedded fossiliferous limestone interbedded with gray to green-

ish-gray calcareous siltstone and silty dolomite, medium-gray to light-gray dolomite

conglomerate, and grayish-black thinly laminated shale. Lower contact conformable

thin-bedded siltstone interbedded with dark-gray to black mudstone, dusky-blue sand-

stone and siltstone, and yellowish-gray, fossiliferous siltstone and sandstone. Lower

contact probably conformable with Connelly Conglomerate. Unit is about 180 ft. thick

subangular to subrounded, gray and white quartz pebbles less than 0.4 in. long. Lower

part. Lower contact with Kanouse Sandstone probably conformable. Unit is about 950

Highlands (Volkert, 1996). Therefore, the strike of joints is somewhat varied because of folding. The dominant joints strike N.59°W. (fig. 4) and dip moderately to steeply southwest thite, quartz, oligoclase, and clinopyroxene. Locally contains titanite, magnetite, apatite, ECONOMIC RESOURCES Mesoproterozoic rocks in the quadrangle host economic deposits of iron ore (magnetite), zinc ore (franklinite, zincite, and willemite), and graphite that were mined predominantly during the 19th century. Magnetite was extracted from mines hosted by Mesoproterozoic

than a century, and a complete bibliography of references pertaining to these deposits is given in Dunn (1995). Graphite was mined during the 19th century from rusty-weathering biotite-quartz-feldspar gneiss at a single location west of Oak Ridge Reservoir. Mesoproterozoic marble in the northwest part of the map was quarried for crushed

stone at several locations, and is currently quarried at a single location north of the Sterling Yk Potassic feldspar gneiss (Mesoproterozoic) – Light-gray or pinkish-buff-weathering, pink-The Neoproterozoic Chestnut Hill Formation hosts a deposit of hematite that was mined during the 19th century on the east side of the Wallkill River Valley. The deposit was small, line, and sillimanite occur locally. and no record of mining is known, so this may not have been a producing mine. Microcline gneiss (Mesoproterozoic) – Pale pinkish-white-weathering, tan or pinkish-white,

Hornblende-quartz-feldspar gneiss (Mesoproterozoic) – Light-gray or pinkish-buff-weath-

garnet, and magnetite. trace amounts of epidote, biotite, titanite, and magnetite.

Pyroxene gneiss (Mesoproterozoic) – White or tan-weathering, greenish-gray, medium-grained, layered and foliated gneiss composed of oligoclase, clinopyroxene, and titanite. Contains varied amounts of quartz, magnetite, scapolite, or calcite. Commonly interlayered with amphibolite or marble. Elsewhere, unit contains clots and layers of dark green, medium to coarse-grained rock mapped as diopsidite composed almost entirely of diopside to hedenbergite.

titanite. Locally grades into pyroxene gneiss with decrease in epidote and microcline. Yff/Yfw Franklin Marble (Mesoproterozoic) – White, pink, or light-gray-weathering, white, light gray,

Magmatic Arc Rocks

hene-quartz-plagioclase gneiss. **Biotite-quartz-oligoclase gneiss** (Mesoproterozoic) – Light-gray-weathering, gray or greenish-gray, medium to coarse-grained, layered and foliated gneiss composed of oligoclase or andesine, quartz, biotite, and trace amounts of garnet. Some outcrops contain hornblende. Unit locally contains thin, conformable layers of amphibolite.

or andesine, quartz, hornblende, magnetite, and local clinopyroxene. ine or oligoclase, quartz, clinopyroxene, hornblende, and hypersthene. Commonly contains thin, conformable layers of amphibolite and quartz-plagioclase gneiss containing hornblende and clinopyroxene.

Yma Microantiperthite alaskite (Mesoproterozoic) – Tan or buff-weathering, light-greenishgray, medium to coarse-grained, massive, indistinctly foliated rock composed of micro-

south of Edison Pond. Yu Mesoproterozoic rocks, undifferentiated – Shown in cross section only.

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Granite pegmatite (Mesoproterozoic) – Pinkish-gray or buff-weathering, pinkish-white or rangle Map GQ-1700, scale 1:24,000. light-pinkish-gray, coarse- to very-coarse-grained, massive, unfoliated granite. Composed of microcline microperthite, quartz, oligoclase, and local hornblende. Intrudes most other Mesoproterozoic rocks in the map area as tabular to irregular bodies of varied thickness that are discordant to crystallization foliation.

> Vernon Supersuite (Volkert and Drake, 1998) Byram Intrusive Suite (Drake and others, 1991)

Hornblende granite (Mesoproterozoic) – Pinkish-gray or buff-weathering, pinkish-white or light-pinkish-gray, medium- to coarse-grained, massive, foliated granite composed principally of microcline microperthite, quartz, oligoclase, hornblende, and local zircon, apatite, and magnetite. Unit grades into alaskite with decrease in concentration of hornblende and into monzonite with decrease in quartz. Includes bodies of pegmatite and amphibolite too small to show on the map. **Hornblende monzonite** (Mesoproterozoic) – Pinkish-gray or buff-weathering, pinkish-gray or greenish-gray, medium to coarse-grained, massive, foliated monzonite, and less

abundant syenite or quartz monzonite, composed of microcline microperthite, oligoclase, hornblende, and quartz. Contains sparse amounts of pyroxene where in contact with rocks of the Lake Hopatcong Intrusive Suite. Lake Hopatcong Intrusive Suite (Drake and Volkert, 1991) Ypg Pyroxene granite (Mesoproterozoic) – Buff or white-weathering, greenish-gray, medium to coarse-grained, massive, foliated granite composed of mesoperthite to microantiper-

and trace amounts of zircon and pyrite. Unit grades into alaskite with decrease in concentration of clinopyroxene and into monzonite with decrease in quartz. Ypa Pyroxene alaskite (Mesoproterozoic) - Buff or white-weathering, greenish-buff or lightpinkish-gray, medium to coarse-grained, massive, moderately foliated granite composed of mesoperthite to microantiperthite, quartz, oligoclase, and sparse amounts of

clinopyroxene. Commonly contains titanite, magnetite, apatite, and trace amounts of

Leithsville Formation (Middle to Lower Cambrian) (Wherry, 1909) - Upper sequence,

rarely exposed, is mottled, medium-light- to medium-dark-gray-weathering, medium-

to medium-dark-gray, fine to medium-grained, medium to thick-bedded, locally pitted

and friable dolomite. Middle sequence is grayish-orange or light- to dark-gray, gray-

ish-red, light-greenish-gray- or dark-greenish-gray-weathering, fine-grained, thin to

medium-bedded dolomite, argillaceous dolomite, dolomitic shale, quartz sandstone,

medium-gray, fine to medium-grained, thin- to medium-bedded dolomite. Quartz-sand lenses occur near lower gradational contact with Hardyston Quartzite. Archaeocyathids

of Early Cambrian age are present in formation at Franklin, New Jersey, suggesting

an intraformational disconformity between Middle and Early Cambrian time (Palmer

Ch Hardyston Quartzite (Lower Cambrian) (Wolff and Brooks, 1898) – Medium to light-gray,

New Jersey Highlands

zoic rocks. Dikes are as much as 40 feet wide and 0.5 mile or more long.

dikes are common. Thickness regionally is as much as 40 ft.

Chestnut Hill Formation (Neoproterozoic) (Drake, 1984; Gates and Volkert, 2004) – In-

Diabase dikes (Neoproterozoic) (Volkert and Puffer, 1995) - Light-gray or brown-

1968). Thickness is approximately 800 ft. regionally.

as much as 30 ft.

and Rozanov, 1967). Unit also contains Hyolithellus micans (Offield, 1967; Markewicz,

fine to coarse-grained, medium to thick-bedded pebble conglomerate, quartzite, arkosic

sandstone and dolomitic sandstone. Conglomerate contains subangular to subrounded

proterozoic rocks. Contains Scolithus linearis (?) and fragments of the trilobite Olenellus

thompsoni of Early Cambrian age (Nason, 1891; Weller, 1903). Thickness regionally is

ish-gray-weathering, dark-greenish-gray, aphanitic to fine-grained dikes. Composed

principally of plagioclase (labradorite to andesine), augite, and iron-titanium oxides. Py-

rite blebs are common. Contacts are chilled and sharp against enclosing Mesoprotero-

terbedded sequence of gray, brownish-gray, greenish-gray, tan, or light green, medi-

glomerate, and thin ironstone beds. Conglomerate contains subangular to subrounded

clasts of quartz and feldspar. Interbedded coarser-grained lithologies locally are as

much as 6 ft. thick, but are not laterally continuous and likely are channel deposits.

Graded beds, tabular cross beds, rip-up clasts, slump folds, load casts, and clastic

um-grained, thin-bedded lithic sandstone, guartzose sandstone, siltstone, pebble con-

white quartz pebbles as much as 1 in. long. Lower contact unconformable with Meso-

siltstone, and shale. Lower sequence is medium-light- to medium-gray-weathering,

Pyroxene monzonite (Mesoproterozoic) – Gray, buff, or tan-weathering, greenish-gray, medium to coarse-grained, massive, moderately foliated monzonite to syenite. Composed of mesoperthite, microantiperthite to microcline microperthite, oligoclase, clinopyroxene, titanite, magnetite, and sparse amounts of apatite and quartz.

Back-Arc Basin Supracrustal Rocks ish-white or light-pinkish-gray, medium-grained, moderately foliated gneiss composed of quartz, microcline microperthite, oligoclase, biotite, and magnetite. Garnet, tourma-

medium-grained, layered and foliated gneiss composed of quartz, microcline microperthite, oligoclase, and biotite. Commonly contains garnet, magnetite, and trace amounts of sillimanite and tourmaline. Unit is spatially associated with marble or amphibolite. Biotite-quartz-feldspar gneiss (Mesoproterozoic) – Gray-weathering, locally rusty, gray, tan, or greenish-gray, medium to coarse-grained, moderately layered and foliated gneiss containing microcline microperthite, oligoclase, quartz, and biotite. Locally contains garnet, sillimanite, and magnetite; graphite and pyrrhotite are confined to the variant that weathers rusty. Unit is spatially associated with amphibolite or pyroxene gneiss.

quartz, microcline microperthite, oligoclase, and hornblende. Locally contains biotite, Clinopyroxene-quartz-feldspar gneiss (Mesoproterozoic) – Pinkish-gray or pinkish-buffweathering, white, pale-pinkish-white, or light-gray, medium to coarse-grained, moderately foliated gneiss composed of quartz, microcline, oligoclase, clinopyroxene, and

ering, pinkish-white or pinkish-gray, medium-grained, foliated gneiss composed of

Ype Pyroxene-epidote gneiss (Mesoproterozoic) - Light-greenish-gray or greenish-pinkweathering, pale-pinkish-white or light-greenish-gray, medium-grained, layered and foli-

ated gneiss containing quartz, oligoclase, pyroxene, epidote, microcline, scapolite, and orange, or pink, medium to coarse-grained, calcitic to locally dolomitic marble composed mainly of calcite, graphite, and phlogopite. Contains varied amounts of amphibole, clinopyroxene and other minerals. Separated by Hague and others (1956) into a lower Franklin marble layer (Yff) and an upper Wildcat marble layer (Yfw) that are separated by gneiss. Locally contains relict karst features that include bedrock pinnacles, solution caves, and paleo-solution breccia. Franklin marble layer is host rock for zinc-iron-manganese deposits at the Franklin and Sterling Hill mines.

Losee Metamorphic Suite (Drake, 1984; Volkert and Drake, 1999) Quartz-oligoclase gneiss (Mesoproterozoic) - White-weathering, light-greenish-gray, medium to coarse-grained, layered to massive, foliated gneiss composed of oligoclase or andesine, quartz, and varied amounts of hornblende, biotite, clinopyroxene, and magnetite. Locally contains layers of amphibolite too thin to be shown on the map. Unit commonly has gradational contacts with biotite-quartz-oligoclase gneiss and hyperst-

Hornblende-quartz-oligoclase gneiss (Mesoproterozoic) – White or light-gray-weathering, greenish-gray, medium to coarse-grained, foliated gneiss composed of oligoclase Hypersthene-quartz-plagioclase gneiss (Mesoproterozoic) – Gray or tan-weathering, greenish-gray or greenish-brown, medium-grained, foliated gneiss composed of andes-

Other rocks Amphibolite (Mesoproterozoic) - Grayish-black-weathering, black or grayish-black, medium-grained, foliated rock composed of hornblende, andesine, and magnetite. Some variants contain biotite and others contain clinopyroxene. Amphibolite associated with the Losee Suite is metavolcanic in origin, and that associated with supracrustal rocks may be metavolcanic or metasedimentary in origin. All types are shown undifferentiated

antiperthite, brown rust-stained quartz, and oligoclase. Locally contains biotite, hornblende, altered clinopyroxene, hypersthene, and magnetite. Confined to one small body Barnett, S.G., III, 1970, Upper Cayugan and Helderbergian stratigraphy of southeastern

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CORRELATION OF MAP UNITS

GREEN POND MOUNTAIN REGION

Unconformity

Unconformity

VALLEY AND RIDGE

Beemerville Intrusive Suite

Intrusive Contacts

KITTATINNY VALLEY SEQUENCE

Unconformity

NEW JERSEY HIGHLANDS

Intrusive Contacts

Unconformity

Intrusive Contacts

Vernon Supersuite

Byram Intrusive Suite Lake Hopatcong Intrusive Suite

Intrusive Contacts

Back Arc Supracrustal Rocks

Magmatic Arc Rocks

Losee Metamorphic Suite

Other Rocks

Normal fault - U, upthrown side; D, downthrown side

Reverse fault - U, upthrown side; D, downthrown side

Strike slip - Arrows indicate relative horizontal movement

____ Inclined thrust fault - teeth on upper plate

plunge. Folds in bedding and/or cleavage.

Strike and dip of crystallization foliation

Bearing and plunge of mineral lineation in Proterozoic rocks

Abandoned mine - Fe, magnetite; Zn, zinc; G, graphite

Strike and dip of mylonitic foliation

Bedrock float used to construct map

⟨∑ Abandoned rock quarry |

Contact - Dotted where concealed

of fault, where known.

~ Brittle deformation zone

Overturned antiform

Overturned synform

Strike and dip of beds

EXPLANATION OF MAP SYMBOLS

Fault - Dotted where concealed. Queried where uncertain. Arrow shows dip direction and attitude

Folds in Proterozoic rocks showing trace of axial surface, direction and dip of limbs, and direction

Folds in Paleozoic rocks showing trace of axial surface, direction and dip of limbs, and direction of

PLANAR FEATURES

LINEAR FEATURES

OTHER FEATURES

Form line showing foliation in Mesoroterozoic rocks. Shown in cross section only.

NEOPROTEROZOIC

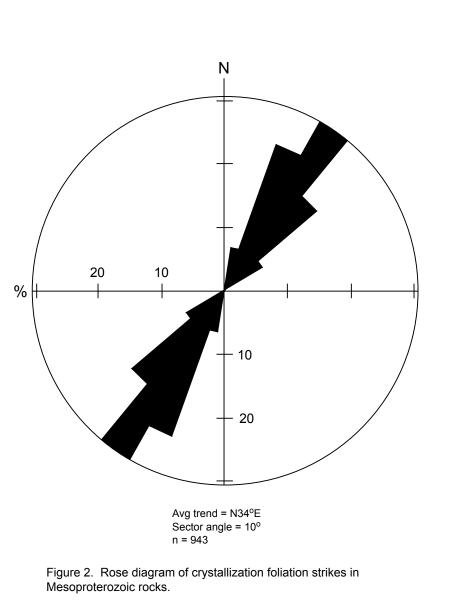
MESOPROTEROZOIC

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Avg trend = N46°E Sector angle = 10°

Figure 1. Rose diagram of bedding strikes in Lower Paleozoic rocks of the Kittatinny Valley sequence.



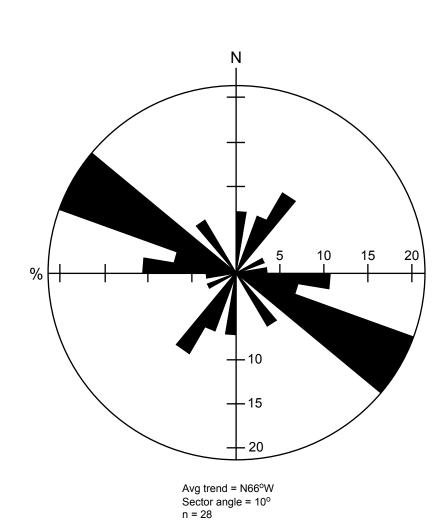
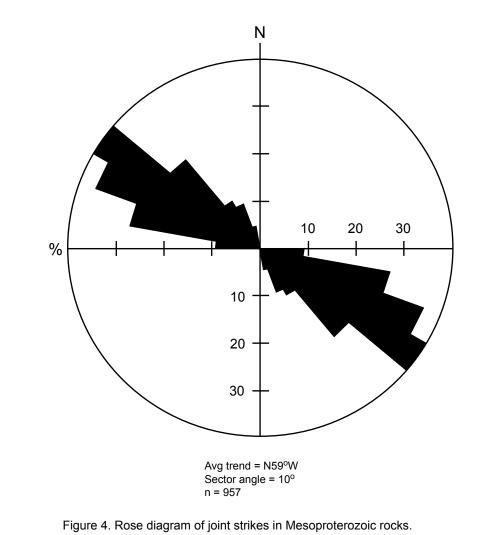
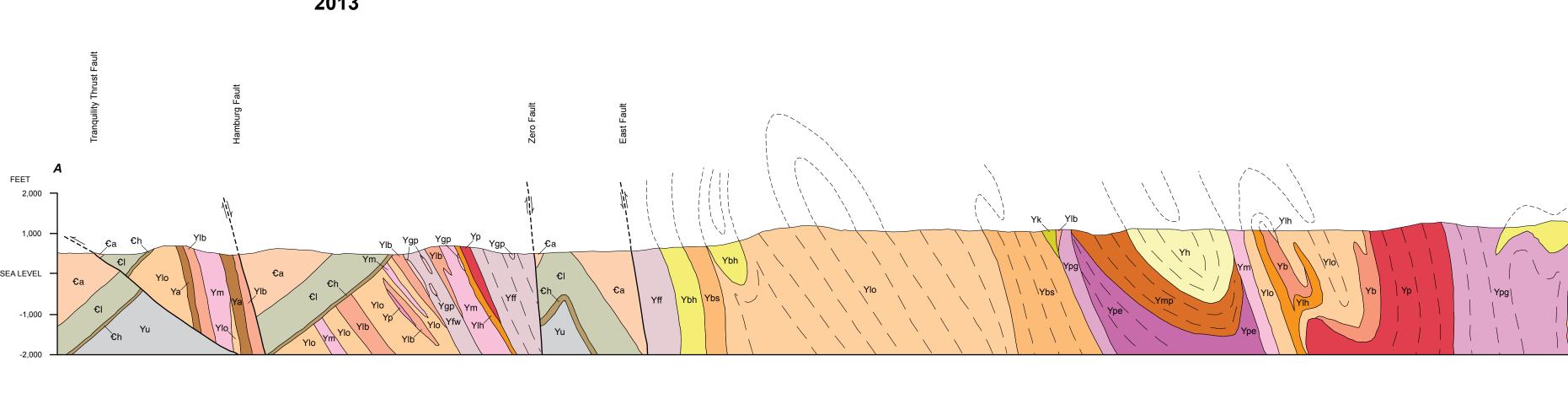


Figure 3. Rose diagram of joint strikes in Lower Paleozoic rocks of the Kittatinny Valley sequence.



Sussex and Morris Counties, New Jersey

Richard A. Volkert and Donald H. Monteverde



SEA LEVEL