DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER RESOURCES MANAGEMENT
NEW JERSEY GEOLOGICAL AND WATER SURVEY

Prepared in cooperation with the
U.S. GEOLOGICAL SURVEY
NATIONAL GEOLOGIC MAPPING PROGRAM

INTRODUCTION

The Lumberville 7.5-minute topographic quadrangle lies within the Piedmont physiographic province, Hunterdon County, west central New Jersey and Bucks County, Pennsylvania. The region has not succumbed to the "growing" pressures from suburban development and continues to maintain a rural character. The Delaware River bisects the quadrangle in a north-south direction before swinging in a more easterly direction down stream.

The bedrock geology controls the variable topography in the quadrangle. The Hunterdon Plateau occupies the northern section of the quadrangle with topographic elevations ranging from about 400 to 500 feet. The surface water drainage patterns on the plateau dominantly align in a northeast-southwest direction which parallels the bedrock strike. Lockatong Creek transects the plateau with a southwardly trend and drains into the Delaware River. Abundant rock ledges frequently crop out along its banks. The quadrangle has more muted topography in the south with topographic elevations ranging from about 100 to 200 feet.

The bedrock within the Mesozoic-aged Newark basin was formed by the deposition of sediments and subsequent intrusion of magma within a half-graben rift basin formed during the breakup of the Pangea supercontinent. The Newark basin is filled with Triassic-Jurassic sedimentary and igneous rocks that have been tilted, faulted, and locally folded (Schlische, 1992; and Olsen and others, 1996). Most tectonic deformation is probably Late Triassic to Middle Jurassic age (Lucas and others, 1988; de Boer and Clifford, 1988). Southeast-dipping normal faults along the basin's northwestern margin primarily influenced the basin morphology, sediment deposition patterns, and the orientation of secondary structures within the basin. Episodic, periodic motion on these faults also influenced the position where sediment was input to the basin from the Highlands to the northwest, and resulted in having a general sediment dispersal pattern parallel to the basin's long axis (northeast-southwest). Intrabasinal faulting also occurred during active deposition (Schlische, 1992, 1993). Differential fault slip along individual segments of the border and intrabasinal fault systems resulted in having a series of depressions (synforms) and ridges (antiforms) oriented normal to the fault trends along their length (Schlische, 1995). Sediment thickening into the fold troughs indicates the syndepositional nature of these regional fold structures. Tectonic deformation and synchronous sedimentation continued into the Middle Jurassic at which time extensional faulting and associated tilting and folding ceased. At this stage, the basin likely experienced a period of post-rift contractional deformation and localized basin inversion, which have been recognized in other Mesozoic rift basins (de Boer and Clifford, 1988; Withjack and others, 1995; R. Schlische, 1996, oral commun.). Subsequent erosion of Mesozoic rocks was followed by flexural loading of the passive margin by Cretaceous-age sediments of the Coastal Plain sequence.

Stratigraphy

Surficial deposits in the Lumberville quadrangle include fluvial, colluvial, and windblown sediment. The oldest surficial deposit in the quadrangle is deeply weathered fluvial gravel (unit Qps) on a bedrock bench about 130 feet above the Delaware River near Raven Rock. An erosional lag of quartzite cobbles on a similar bench half-a-mile to the east (open-dot pattern on map) is of similar age and origin. This deposit is an erosional remnant of fluvial gravel laid down by the Delaware River that may be equivalent to the Pensauken Formation, a Pliocene fluvial deposit in central New Jersey that formerly extended up the Delaware Valley from the Trenton area. Alternatively, it may be an erosional remnant of pre-Illinoian glaciofluvial gravel laid down during a glaciation in the early Pleistocene that advanced to the vicinity of Riegelsville, about 15 miles upvalley from Raven Rock. Both the Pensauken Formation and the pre-Illinoian glacial deposits are deeply weathered and are similarly preserved on bedrock straths between 100 and 150 feet above the present Delaware River. After deposition of these gravels, the Delaware River and its tributaries deepened their valleys by 50 to 100 feet into bedrock, in the early and middle Pleistocene (2.5 million years ago [2.5 Ma] to 125,000 years ago [125 ka]).

A glaciation in the middle Pleistocene, probably during the Illinoian Stage at around 150 ka, advanced to the vicinity of Phillipsburg, about 25 miles upvalley from Raven Rock. Glaciofluvial gravel laid down during this glaciation (unit Qif) forms a terrace that is as much as 100 feet above the Delaware River east of Raven Rock, where the valley widens and terraces are protected from erosion. Elsewhere in the Delaware Valley, erosion following this glaciation removed the Illinoian gravel. During the late Wisconsinan glaciation, which reached its maximum extent at about 25 ka, glaciofluvial gravel was again laid down in the Delaware Valley (unit Qwf). This gravel was deposited between about 30 and 20 ka as the glacier advanced into, and then retreated from, the Delaware Valley, reaching as far south as the Belvidere area, about 35 miles upvalley from Raven Rock. Erosional remnants of this gravel form terraces up to 60 feet above the river east of Raven Rock, on both sides of the river near Marshall Island, and at Point Pleasant and Lumberville, Pennsylvania. Elsewhere in the Delaware Valley, the gravel underlies sand of the postglacial terrace deposit (unit Qst), and, in places, for example along the east bank of the river north of Shyhawks Island, colluvium (unit Qcs). Silt and fine sand blown from the glacial terrace on the east side of the river near Marshall Island form a thin sheet of windblown sediment on the adjacent hillslope (unit Qe).

After the late Wisconsinan glaciation the Delaware River again eroded the glaciofluvial gravel and deposited sand and silt on the eroded gravel to form a postglacial terrace (unit Qst) which is between 15 and 20 feet above the modern floodplain. The postglacial terrace began to accumulate around 12 ka, when erosion of the glacial gravel was completed. Minor deposition on the terrace during large floods continues today.

In tributary valleys during the late Wisconsinan glacial period, and during earlier periods of cold climate, permafrost and reduced tree cover led to increased erosion on hillslopes. This sediment aggraded in alluvial plains (now terraces) and fans in valley bottoms (units Qst, Qaf), and in colluvial deposits on footslopes (unit Qcs). By 14 ka, permafrost had melted and tree cover was reestablished. Streams eroded into the valley-fill sediments to form modern floodplains. Channel and overbank deposits have aggraded in these floodplains within the past 14 ka (unit Qal). In headwater areas during this same time, colluvium and weathered rock material have been incised, washed, and winnowed by runoff and groundwater seepage (unit Qcal).

Bedrock units range in age from the Early Jurassic to Late Triassic (Olsen, 1980a, 1980b) and consist of a sequence of alluvial to lacustrine sedimentary rocks that are locally intruded by igneous rocks. Sedimentary rocks cover the majority of the mapped area. The basal Stockton Formation, located just to the south in the Stockton quadrangle is dominantly an alluvial sequence of red, light-brown, gray, and buff sandstone, arkosic sandstone, and conglomerate. Red sandstone, siltstone and mudstone are more common in the upper half of the Stockton (McLaughlin, 1945, 1959). These two rock assemblages form a sequential pattern, basal arkose-dominated overlain by red sandstone-shale dominated, that is repeated through the Stockton. Two such sequences, forming the upper Raven Rock and Cuttalossa members of the Stockton (McLaughlin, 1945; Johnson and McLaughlin, 1957; Olsen and others, 1996) crop out in the mapped area. Member contacts are covered and inferred.

The overlying Lockatong Formation, dominated by black shale and argillite and the Passaic Formation, dominantly red, and less commonly gray, and black shale, and siltstone were deposited in lacustrine environments. The red and gray to black bedrock units display a cyclical pattern at four different scales related to both thickness and duration of sedimentary environment (Olsen and others; 1996). Olsen and Kent (1995) and Olsen and others (1996) show that these cycles reflect climatic variations influenced by celestial mechanics (Milankovitch orbital cyclicity). The basic (Van Houten) cycle correlates to the 20,000-yr climatic precession cycle and consists of about 20 feet of lacustrine sediments deposited in a shallowing-upward environment. Four to six Van Houten cycles combine to form a Short Modulating Cycle, approximately 95,000-125,000 year duration (Olsen and others, 1996). McLaughlin cycle forms the next higher level cycle and contains four Short Modulating Cycles. The 413,000-year eccentricity of the earth's orbit controls this depositional pattern. A McLaughlin cycle forms the basis of the different Passaic Formation members (Olsen and others, 1996). Olsen and others (1996) delineate a final thickest cycle, Long Modulating Cycle, as composed of four McLaughlin cycles and representing the 1.6-2.0 million-year eccentricity cycle.

A single diabase body, called the Byram Diabase (Van Houten, 1969; Olsen and others, 1996) and Point Pleasant diabase (Husch, 1988) intrudes Triassic sediment in the Lumberville quadrangle. This intrusive body has the same magmatic source as the Orange Mountain Basalt based on geochemical and paleomagnetic data (Hozik and Colombo, 1984; Husch, 1988; Houghton and others, 1992). Limited thermally metamophosed sediments surround the diabase intrusions and have been discussed by Van Houten, (1969, 1971, 1980, 1987).

Structure

Newark Basin rocks show limited signs of structural deformation except near the diabase intrusion where several small faults are present (photo 1). The sediments uniformly strike northeast-southwest and dip northwest, forming a gentle homocline (figure 1). Surface data from Stockton and Lockatong Formations have almost identical bedding trends with the Passaic Formation showing a wider range of orientations. Downhole bedding trends in the Passaic display a slightly more northern strike trend.

Fracture orientations show a wider variability across the three sedimentary formations (figure 2). Stockton fractures have the tightest range of orientations, with a dominant trend of 036/74SE. This tight density is possibly due to the smaller number of recorded fractures (22) as compared to the Lockatong (172) and Passaic (199). Lockatong fractures display a nearly identical dominant trend as the Stockton. Two other subsidiary trends of 027/79SE and 115/87NE are also present in the Lockatong. Passaic data have the larger variation. A somewhat dominant trend of 006/87SE is supplemented with weaker trends of 032/84SE, 045/86SE and 069/87SE. The intrusive diabase has the widest range of fracture orientations of all the units. Again, this range could be due to a small amount of data (35). These overall trends mimic the dominant Newark Basin orientation in the eastern section of the western fault block. The Flemington - Dilts Corner - Furlong faults crop out to the east and south of the mapped area and mark the eastern boundary of this block (Herman and others, 1992; Monteverde and others, 2015).

There is a wide variability between surface trends and those measured in two shallow boreholes, one in the diabase intrusive and the other in Lockatong hornfels zone (figures 2 and 3). Optical televiewer downhole data is shown in figure 3.

No strong deformational fabric exists over the mapped region with the exception of the region of the Byram Sill. Previous workers have mapped a single fault along the sill's northwestern boundary with the Lockatong (Kummel, unpublished data, ca 1890; Van Houten, 1969, 1980, 1987; Houghton, unpublished data, ca 1985). However, the northern Lockatong/diabase contact was not exposed during field research for this map. Two other fault trends were recorded within the diabase and the Lockatong hornfels. An older nearly east-west trend with a southern dip occurred separating the hornfels on the north from the diabase to the south. This fault can be seen on a road cut (photo 2) and wrapping around to paralleling the stream. Motion direction on this fault suggests normal sense of offset. A younger trend observed at several different locations within the diabase was orientated nearly north-south and dipped steeply east to vertical. Slickenlines were oriented nearly horizontal and displayed a left lateral offset. Most of these features are too small for accurate depiction on this scale map.

DESCRIPTION OF MAP UNITS

Qal **Alluvium** - Silt, pebble-to-cobble gravel, minor fine sand and clay. Moderately to well-sorted and stratified. Contains minor amounts of organic matter. Color of fine sediment is reddish brown, grayish brown, and brown, locally yellowish-brown. Gravel in tributary valleys is dominantly subangular to angular flagstones and chips of red and gray shale and mudstone with minor subrounded to rounded pebbles and cobbles of red and gray sandstone. Gravel in the main Delaware Valley includes cobbles and boulders of red and gray sandstone; gray, red, and brown quartzite and quartzite-conglomerate; gray and white gneiss; and dark gray chert. Silt, fine sand, and clay occur as overbank deposits on floodplains along low-gradient stream reaches. Overbank sediments are sparse or absent along steeper stream reaches. Gravel is deposited in stream channels and is the dominant floodplain material along steeper stream reaches. Flagstone gravel typically shows strong imbrication. As much as 10 feet thick. Many stream channels are floored by bedrock, particularly in steep reaches.

Qcal **Colluvium and Alluvium, Undivided** - Interbedded alluvium as in unit Qal and colluvium as in unit Qcs in narrow headwater valleys. As much as 10 feet thick

Qaf **Alluvial Fan Deposits** - Flagstone gravel as in unit Qal and minor reddish-brown to grayish-brown silt and fine sand. Moderately sorted and stratified. As much as 15 feet thick. Form fans at mouths of steep tributary streams.

Qst **Stream-Terrace Deposits** - Silt, fine sand, and pebble-to-cobble gravel, moderately sorted, weakly stratified. Deposits along Lockatong Creek are chiefly flagstone gravel composed of gray and red mudstone, with a matrix of reddish-brown to grayish-brown silt, and are generally less than 10 feet thick. They form terraces 5 to 10 feet above the modern floodplain and are likely of late Wisconsinan age. Deposits along the Delaware River are chiefly yellowish-brown silt and fine sand as much as 25 feet thick that form a terrace 15 to 20 feet above the modern floodplain. They rest on a strath cut into the glaciofluvial gravel (unit Qwf) and so are of postglacial age.

Qcs **Shale, Sandstone, and Mudstone Colluvium** - Silt, sandy silt, clayey silt, reddish-brown to yellowish-brown, with some to many subangular flagstones, chips, and pebbles of red and gray shale, mudstone, and minor sandstone. Poorly sorted, nonstratified to weakly stratified. Flagstones and chips have strong slope-parallel alignment of a-b planes. The unit is as much as 30 feet thick and forms footslope aprons along base of hillslopes. It is chiefly of late Wisconsinan age.

Qe **Eolian Deposits** - Silt and very fine-to-fine sand, reddish yellow. Well-sorted, nonstratified. As much as 3 feet thick. These are windblown deposits blown from the glaciofluvial plain in the Delaware River valley.

Qwf **Late Wisconsinan Glaciofluvial Deposit** - Pebble-to-cobble gravel and pebbly sand, moderately to well-sorted and stratified. Sand is yellowish brown, brown, light gray. Gravel includes chiefly red and gray mudstone and sandstone; gray, white, and purplish-red quartzite and conglomerate; and some gray and white gneiss and dark-gray chert. Gneiss clasts are unweathered or have a very thin weathered rind. It is as much as 40 feet thick and forms an eroded plain in the Delaware River valley with a top surface between 30-60 feet above the modern floodplain. Deposited by glacial meltwater descending the Delaware River valley during the late Wisconsinan glaciation.

Qif **Illinoian Glaciofluvial Deposit** - Pebble-to-cobble gravel, silty sand, sandy silt, moderately to poorly sorted and stratified. Matrix is reddish-brown to brown. Gravel includes chiefly red and gray mudstone and sandstone; gray, purplish-red, and white quartzite and conglomerate; and some gray and white gneiss and dark gray chert. Gneiss and sandstone clasts have thick weathered rinds or are decomposed. As much as 20 feet thick. Forms terrace remnants in the Delaware River valley with a top surface between up to 100 feet above the modern floodplain. Deposited by glacial meltwater descending the Delaware River valley during the Illinoian glaciation.

Qps **Pre-Illinoian Gravel** - Pebble-to-cobble gravel, minor boulder gravel, in a matrix of clayey silt to sandy silt. Poorly sorted, nonstratified to poorly stratified. Matrix is reddish-yellow to yellowish-brown. Gravel includes chiefly red and gray mudstone and sandstone; gray, purplish-red, and white quartzite and conglomerate; and some gray and white gneiss and dark gray chert. Gneiss and sandstone clasts have thick weathered rinds or are fully decomposed. Quartzite clasts at and near the surface are varnished and pitted. As much as 15 feet thick. Caps a bedrock bench near Raven Rock that is 130 feet above the modern floodplain of the Delaware River. Deposited either during or before the pre-Illinoian glaciation.

JƦd **Diabase** (Lower Jurassic and Upper Triassic) - Fine-grained to aphanitic dikes (?) and sills and medium-grained, discordant, sheet-like intrusion of dark-gray to dark greenish-gray, sub-ophitic diabase; massive-textured, hard, and sparsely fractured. Composed dominantly of plagioclase, clinopyroxene, opaque minerals and locally olivine. Contacts are typically fine-grained, display chilled, sharp margins and may be vesicular adjacent to enclosing sedimentary rock. Exposed in Bryam Diabase sheet that intrudes Lockatong Formation located on Route 29 edge of the mapped area.

Ʀp, Ʀpg **Passaic Formation** - (Upper Triassic) (Olsen, 1980a) - Interbedded sequence of reddish-brown to maroon and purple, fine-grained sandstone, siltstone, shaly siltstone, silty mudstone and mudstone, separated by interbedded olive-gray, dark-gray, or black siltstone, silty mudstone, shale and lesser silty argillite. Reddish-brown siltstone is medium- to fine-grained, thin- to medium-bedded, planar to cross-bedded, micaceous, locally containing mud cracks, ripple cross-lamination, root casts and load casts. Shaly siltstone, silty mudstone, and mudstone form rhythmically fining-upward sequences up to 15 feet thick. They are fine-grained, very-thin- to thin-bedded, planar to ripple cross-laminated, fissile, locally bioturbated, and locally contain evaporate minerals. Gray bed sequences (Ʀpg) are medium- to fine-grained, thin- to medium-bedded, planar to cross-bedded siltstone and silty mudstone. Gray to black mudstone, shale and argillite are laminated to thin-bedded, and commonly grade upwards into desiccated purple to reddish-brown siltstone to mudstone. Thickness of gray bed sequences ranges from less than 1 foot to several feet thick. Unit is approximately 11,000 feet thick but the upper contact is a nonconformity with the Orange Mountain Basalt that can be found on the Stockton quadrangle to the east of the map area (Monteverde and others, 2015).

Ʀl, Ʀlh, Ʀlr **Lockatong Formation** (Upper Triassic) (Kummel, 1897) - Cyclically deposited sequences of mainly gray to greenish-gray, and in upper part of unit, locally reddish-brown siltstone to silty argillite (Ʀlr) and dark-gray to black shale and mudstone. Siltstone is medium to fine grained, thin-bedded, planar to cross-bedded with mud cracks, ripple cross-laminations and locally abundant pyrite. Shale and mudstone are very thin bedded to thin laminated, platy, locally containing desiccation features. Thermally altered to dark gray to black hornfels (Ʀlh) where intruded by diabase. Thickness of hornfels directly related to thickness of intruded diabase (Van Houten, 1969). Lower contact gradational into Stockton Formation and placed at base of lowest continuous black siltstone bed (Olsen, 1980). Maximum thickness of unit regionally is about 2,200 feet (Parker and Houghton, 1990).

Ʀsr, Ʀsa **Stockton Formation** (Upper Triassic) (Kummel, 1897) - Unit is interbedded sequence of gray, grayish-brown, or slightly reddish-brown, coarse- to fine-grained, thin- to thick-bedded, poorly sorted, planar to trough cross-bedded, and ripple cross laminated arkosic sandstone (Ʀsa), and reddish-brown clayey fine-grained, sandstone, siltstone and mudstone (Ʀsr). Coarser units commonly occur as lenses and are locally graded. Finer units are bioturbated sequences that fine upward. Arkosic sandstone units are deeply weathered and more common in the lower half; siltstone and mudstone are generally less weathered and more common in upper half. Lower contact, located outside of mapped area, is an erosional unconformity. Thickness is approximately 4,500 feet.

REFERENCES CITED AND USED IN CONSTRUCTION OF MAP

Allmendinger, R. W., Cardozo, N. C., and Fisher, D., 2013, Structural Geology Algorithms: Vectors & Tensors, Cambridge, England, Cambridge University Press, p. 289.

Cardozo, N., and Allmendinger, R. W., 2013, Spherical projections with OSXStereonet: Computers & Geosciences, v. 51, p. 193 - 205, doi: 10.1016/j.cageo.2012.07.021.

de Boer, J.Z., and Clifford, A.E., 1988, Mesozoic tectogenesis: Development and deformation of "Newark" rift zones in the Appalachains (with special emphasis on the Hartford basin, Connecticut), *in*, Manspeizer, W., ed., Triassic-Jurassic rifting: New York, NY, Elsevier, p. 275-306.

Hager-Richter Geoscience Inc., 2017, Borehole geophysical logging - data report boreholes B-6 & B-7 Route 29 Rockfall Mitigation, Kingwood, New Jersey, Consulting Report, 15 pages.

Herman, G.C., Houghton, H.F., Monteverde, D.H., and Volkert, R.A., 1992, Bedrock geologic map of the Pittstown and Flemington quadrangles, Hunterdon and Somerset Counties, New Jersey, New Jersey Geological Survey, Open-file Map, OFM 10, scale 1: 24,000.

Houghton, H.F., Herman, G.C., and Volkert, R.A., 1992, Igneous rocks of the Flemington fault zone, central Newark basin, New Jersey: Geochemistry, structure, and stratigraphy, *in*, Puffer J.H., and Ragland, P.C., eds., Eastern North American Mesozoic Magmatism: Geological Society of America Special Paper 268, p. 219-232.

Hozik, M. J., and Columbo, R., 1984, Paleomagnetism in the central Newark basin, *in*, Puffer, J. H., ed., Igneous rocks of the Newark basin: Petrology, mineralogy, ore deposits, and guide to field trip: Geological Association of New Jersey 1st Annual Field Conference, p. 137-163.

Husch, J., 1988, Significance of major- and trace-element variation trends in Mesozoic diabase, west central New Jersey and eastern Pennsylvania, *in,* Froelich, A. and Robinson, G., eds., Geology of the Early Mesozoic Basins of Eastern North America. United States Geological Survey Bulletin, no. 1776, p. 141-150.

Johnson, M.E., and McLaughlin, D. B., 1957, Triassic formations of the Delaware Valley, *in*, Dorf, E., ed., Guidebook for field trips: Geological Society of America, Annual Meeting, Atlantic City, New Jersey, Trip 2, p. 31-68.

Kummel, H.B., 1897, The Newark system, report of progress, New Jersey Geological Survey, Annual Report to the State Geologist for the year 1896, p. 25-88.

Kummel, H.B., 1898, The Newark System of New Jersey, New Jersey Geological Survey, Annual Report to the State Geologist for the year 1897, p. 25-159.

Lucas, M., Hull, J., and Manspeizer, W., 1988, A foreland-type fold and related structures in the Newark Rift Basin, *in,* Manspeizer, W., ed., Triassic-Jurassic rifting, continental breakup and the origin of the Atlantic Ocean and passive margins, part A, Elsevier Science Publishers, New York, p. 307-332.

McLaughlin, D. B., 1945, Type sections of the Stockton and Lockatong formations, Proceedings of the Pennsylvania Academy of Science, v. 19, p.102-113.

McLaughlin, D. B., 1946, The Triassic rocks of the Hunterdon Plateau, New Jersey, Proceedings of the Pennsylvania Academy of Science, v. 20, p. 89-98.

McLaughlin, D. B., 1959, Mesozoic rocks, *in*, Willard, B., et al., Geology and mineral resources of Bucks County, Pennsylvania, Pennsylvania Geological Survey, Bulletin C-9, p. 55-114.

Monteverde, D.H., Herman, G.C., Stanford, S.D., and Spayd, Steven, 2015, Geologic map of the Stockton Quadrangle, Hunterdon County, New Jersey, New Jersey Geological and Water Survey, Geologic Map Series, GMS 15-1, scale 1: 24,000.

Olsen, P.E., 1980a, The latest Triassic and Early Jurassic formations of the Newark basin (eastern North America, Newark Supergroup): Stratigraphy, structure, and correlation: New Jersey Academy of Science, Bulletin, v. 25, p. 25-51.

Olsen, P.E., 1980b, Fossil great lakes of the Newark Supergroup in New Jersey; *in*, Manspeizer, W., ed., Field studies of New Jersey geology and guide to field trips: 52nd annual meeting of the New York State Geological Association, p. 352-398.

Olsen P.E. and Kent D.V., 1995: Milankovitch climate forcing in the tropics of Pangea during the Late Triassic. Palaeogeography, Palaeoclimatology, Palaeoecology, v. 122, 1-26.

Olsen, P.E., Kent, D.V., Cornet, Bruce, Witte, W.K., and Schlische, R.W., 1996, High-resolution stratigraphy of the Newark rift basin (early Mesozoic, eastern North America): Geological Society of America, Bulletin, v. 108, p. 40-77.

Olsen, P.E., Schlische, R.W., and Gore, P.J., 1989, Tectonic, depositional, and paleoecological history of Early Mesozoic rift basins in eastern North America: Field trip guidebook T351, American Geophysical Union, 174 pages.

Parker, R.A., and Houghton, H.F., 1990, Bedrock geology of the Rocky Hill quadrangle, New Jersey, US Geological Survey, Open-File Report 90-219, scale 1:24,000.

Schlische, R.W., 1992, Structural and stratigraphic development of the Newark extensional basin, eastern North America: Evidence for the growth of the basin and its bounding structures; Geological Society of America, Bulletin, v.104, p.1246-1263.

Schlische, R.W., 1993, Anatomy and evolution of the Triassic-Jurassic continental rift system, eastern North America; Tectonics, v.12, p.1026-1042.

Schlische, R.W., 1995, Geometry and origin of fault-related folds in extensional settings, American Association of Petroleum Geologists Bulletin, v.79, p. 1661-1678.

Van Houten, F.B., 1969, Late Triassic Newark Group, north central New Jersey and adjacent Pennsylvania and New York, *in*, Subitzky, S., ed., Geology of selected area in New Jersey and eastern Pennsylvania and guidebook of excursions: Rutgers University Press, New Brunswick, New Jersey, p. 314-347.

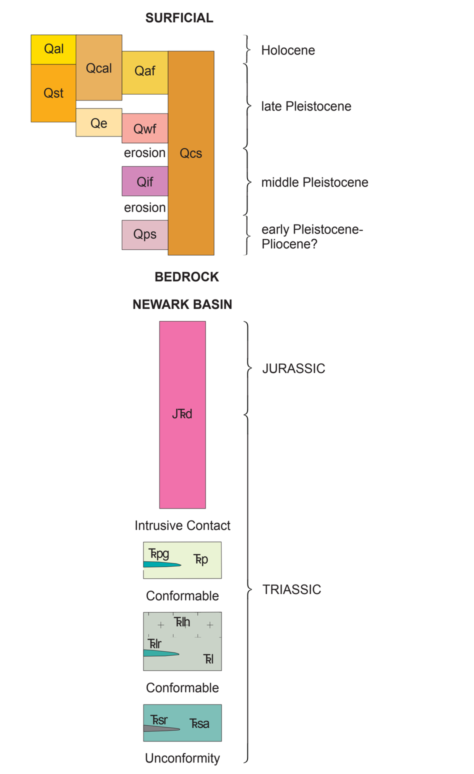
Van Houten, F.B., 1971, Contact metamorphic mineral assemblages, Late Triassic Newark Group, New Jersey: Contributions to Mineralogy and Petrology, v. 30, p. 1-14.

Van Houten, F.B., 1980, Late Triassic part of Newark Supergroup, Delaware River section, west-central New Jersey, *in*, Manspeizer, W., ed., Field studies of New Jersey geology and guide to field trips, 52nd Annual meeting of the New York State Geological Association, Newark, New Jersey, Rutgers, University, p. 246-276.

Van Houten, F.B., 1987, Late Triassic cyclic sedimentation; upper Lockatong and lower Passaic formations (Newark Supergroup), Delaware Valley, west-central New Jersey, *in*, Roy, D.C., ed., Northeastern section of the Geological Society of America, Centennial field guide, v. 5, p. 81-86.

Withjack, M. O., Olsen, P. E., and Schlische, R. W., 1995, Tectonic evolution of the Fundy basin, Canada: Evidence of extension and shortening during passive-margin development: Tectonics, v. 14, p. 390-405.

CORRELATION OF MAP UNITS



EXPLANATION OF MAP SYMBOLS

Surficial Map Symbols

Contact - Contacts of units Qal, Qst, Qwf, Qif, and Qps are well-defined by landforms and are drawn from 1:12,000 stereo airphotos. Contacts of other units are drawn at slope inflections and are feather-edged or gradational.

Gravel lag - Scattered cobbles of gray and white quartzite and quartzite-conglomerate left from erosion of unit Qps

Gravel lag - Scattered pebbles and cobbles of gray and white quartzite and quartzite-conglomerate, red and gray mudstone and sandstone, and weathered gray gneiss left from erosion of unit Qif.

Gravel lag - Scattered pebbles and cobbles of gray and white quartzite and quartzite-conglomerate, red and gray mudstone and sandstone, and gray gneiss left from erosion of unit Qwf.

Fluvial scarp - Line at top, ticks on slope. Marks former channels on terrace surfaces in Delaware Valley.

Bedrock Map Symbols

Contact - Solid where location known to be accurate. Dashed where approximately located; dotted where concealed.

Fault - Dashed where approximately located.

Planar features

Strike and dip of inclined beds

Other features

Abandoned rock quarry

Diabase float station

Hornfels float station

Driller's log - Used to project gray bed and other characteristic beds to surface.

Location of photo

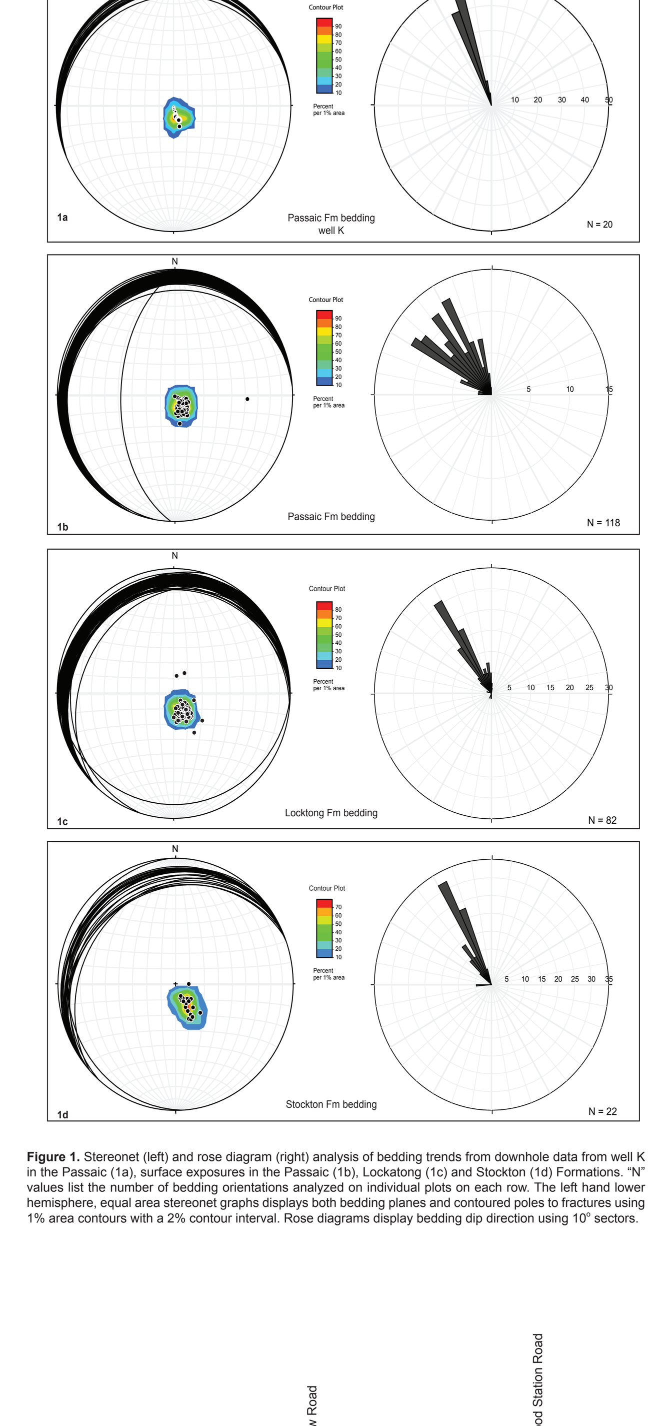
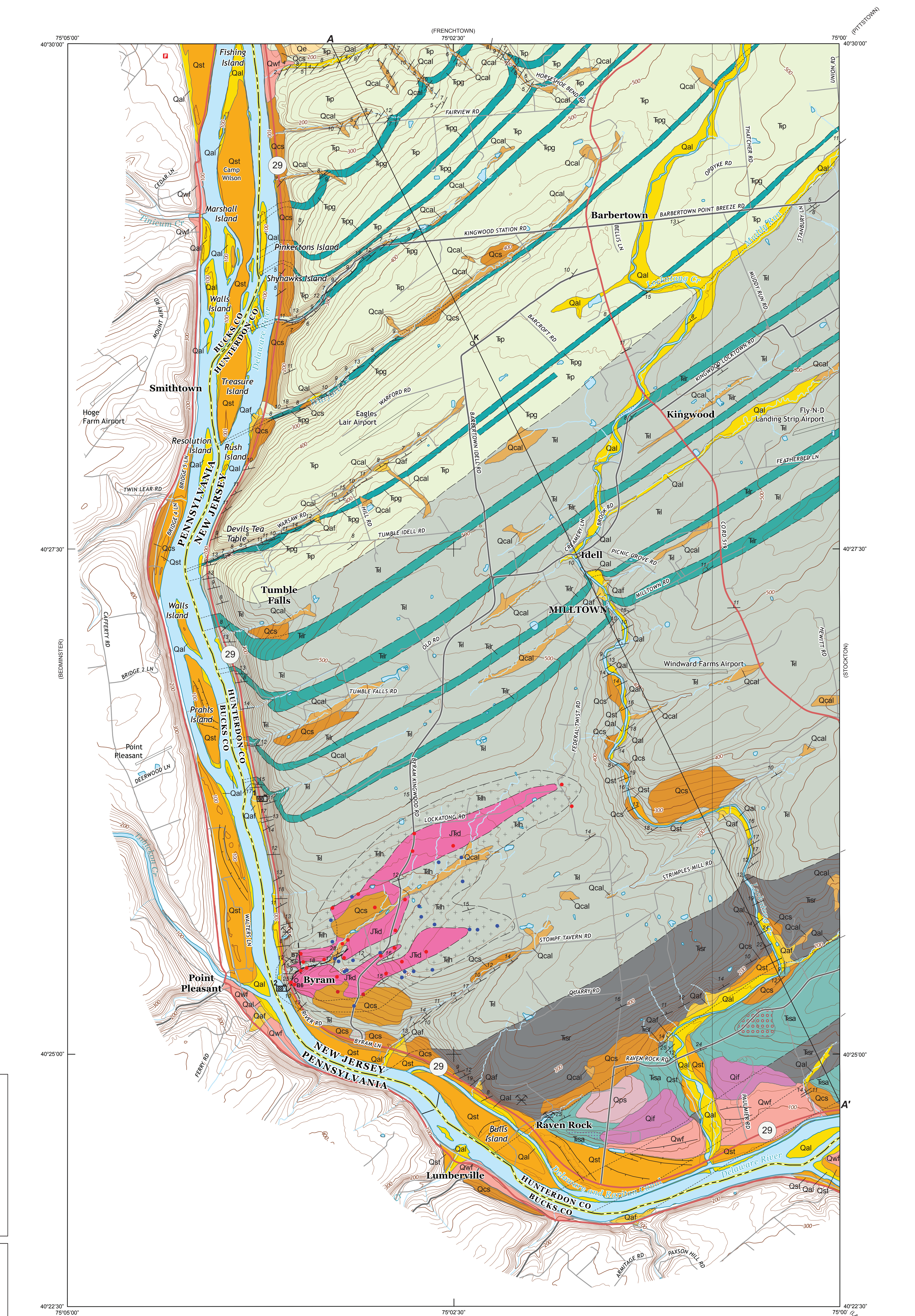


Figure 1. Stereonet (left) and rose diagram (right) analysis of bedding trends from downhole data from well K in the Passaic (1a), surface exposures in the Passaic (1b), Lockatong (1c) and Stockton (1d) Formations. "N" values list the number of bedding orientations analyzed on individual plots on each row. The left hand lower hemisphere, equal area stereonet graphs displays both bedding planes and contoured poles to fractures using 1% area contours with a 2% contour interval. Rose diagrams display bedding dip direction using 10° sectors.



SCALE 1:24,000

CONTOUR INTERVAL 20 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

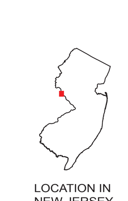
Bedrock geology mapped by D.H. Monteverde, G.C. Herman and R.W. Witte 2017
Surficial geology mapped by S.D. Stanford, 2014

[1] Retired, New Jersey Geological and Water Survey

Digital cartography by R.S. Pristas

Reviewed by Michael J. Hozik and Gary M. Fleeger

Research supported by the U. S. Geological Survey, National Cooperative Geologic Mapping Program, under U.S.G.S. award numbers G16AC00284 and G14AC00236. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government.

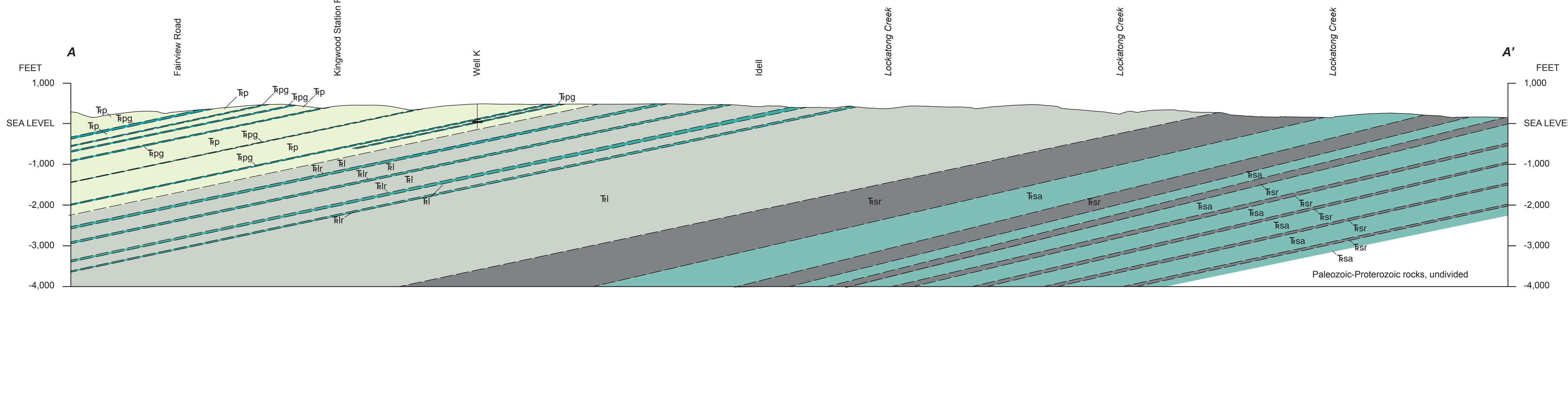


Geologic Map of the New Jersey Portion of the Lumberville Quadrangle, Hunterdon County, New Jersey

by

Donald H. Monteverde, Ron W. Witte[1], Scott D. Stanford and Gregory C. Herman[1]

2018



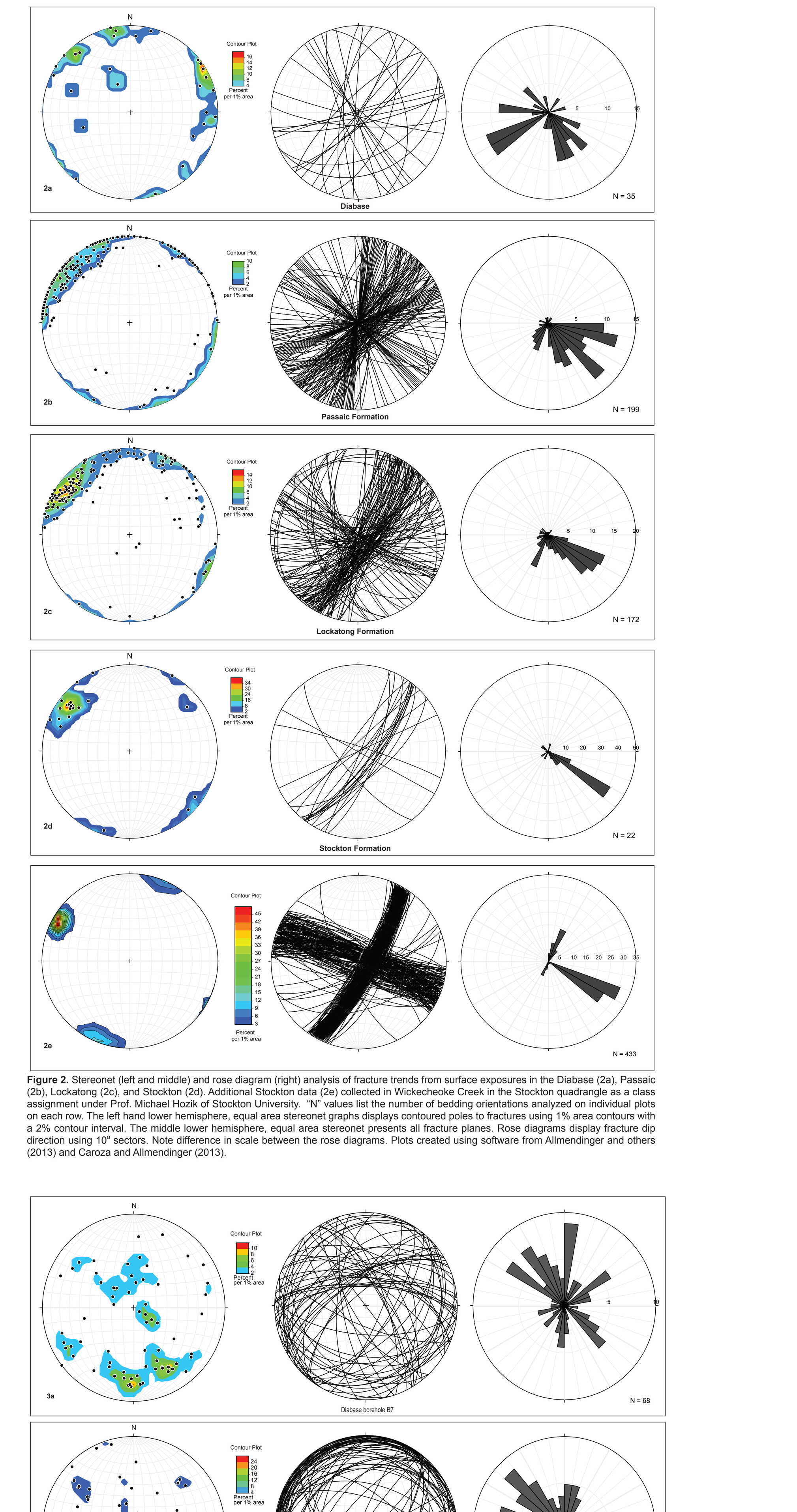


Figure 2. Stereonet (left and middle) and rose diagram (right) analysis of fracture trends from surface exposures in the Diabase (2a), Passaic (2b), Lockatong (2c), and Stockton (2d) collected in Lumberville quadrangle. Additional Stockton data (2e) collected in Wickecheoke Creek in the Stockton quadrangle as a class assignment under Prof. Michael Hozik of Stockton University. "N" values list the number of bedding orientations analyzed on individual plots on each row. The left hand lower hemisphere, equal area stereonet graphs contoured poles to fractures using 1% area contours with a 2% contour interval. The middle lower hemisphere, equal area stereonet presents all fracture planes. Rose diagrams display fracture dip direction using 10° sectors. Note difference in scale between the rose diagrams. Plots created using software from Allmendinger and others (2013) and Cardoza and Allmendinger (2013).

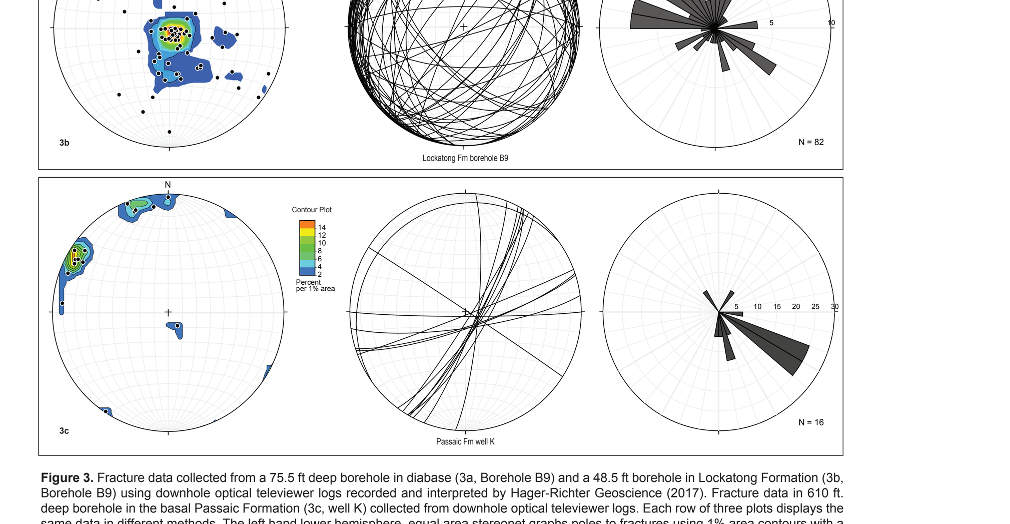


Figure 3. Fracture data collected from a 75.5 ft deep borehole in diabase (3a, Borehole B9) and a 48.5 ft borehole in Lockatong Formation (3b, Borehole B9) using downhole optical televiewer logs recorded and interpreted by Hager-Richter Geoscience (2017). Fracture data in 610 ft. deep borehole in the basal Passaic Formation (3c, well K) collected from downhole optical televiewer logs. Each row of three plots displays the same data in different methods. The left hand lower hemisphere, equal area stereonet graphs poles to fractures using 1% area contours with a 2% contour interval. The middle lower hemisphere, equal area stereonet presents all fracture planes and the rose diagrams on the right display fracture dip direction using 10° sectors. "N" value is the number of fracture orientations analyzed on individual plots on each row.

Photo 1: Exposure of the Lockatong Argillite displaying west dipping (to the left) beds with a spaced near vertical fracture pattern. One foot bar for scale.

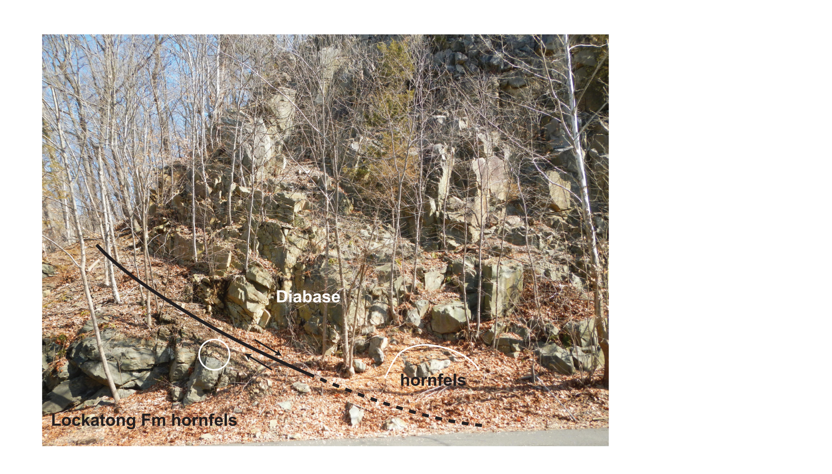


Photo 2: Photo looking east along Route 29 shows fault contact between the diabase to the right (south) and the Lockatong hornfels below and to the left (north). Indicators suggest normal motion on the fault. A small hornfels block lies above the fault but its contact relationship with the diabase cannot be discerned due to cover. Kummel (1898) described the overall contact between the diabase and the Lockatong here as unconformable with some note of shearing. His figure depicts the hornfels block above the fault shown above as a complete continuation of the hornfels body suggesting the contact has a stair step trace. Van Houten (1969) characterizes the overall contact as a fault with hornfels both below and above the fault. Van Houten (1987) depicts the small hornfels body above the fault shown above as a xenolith. Rock hammer in circle for scale.