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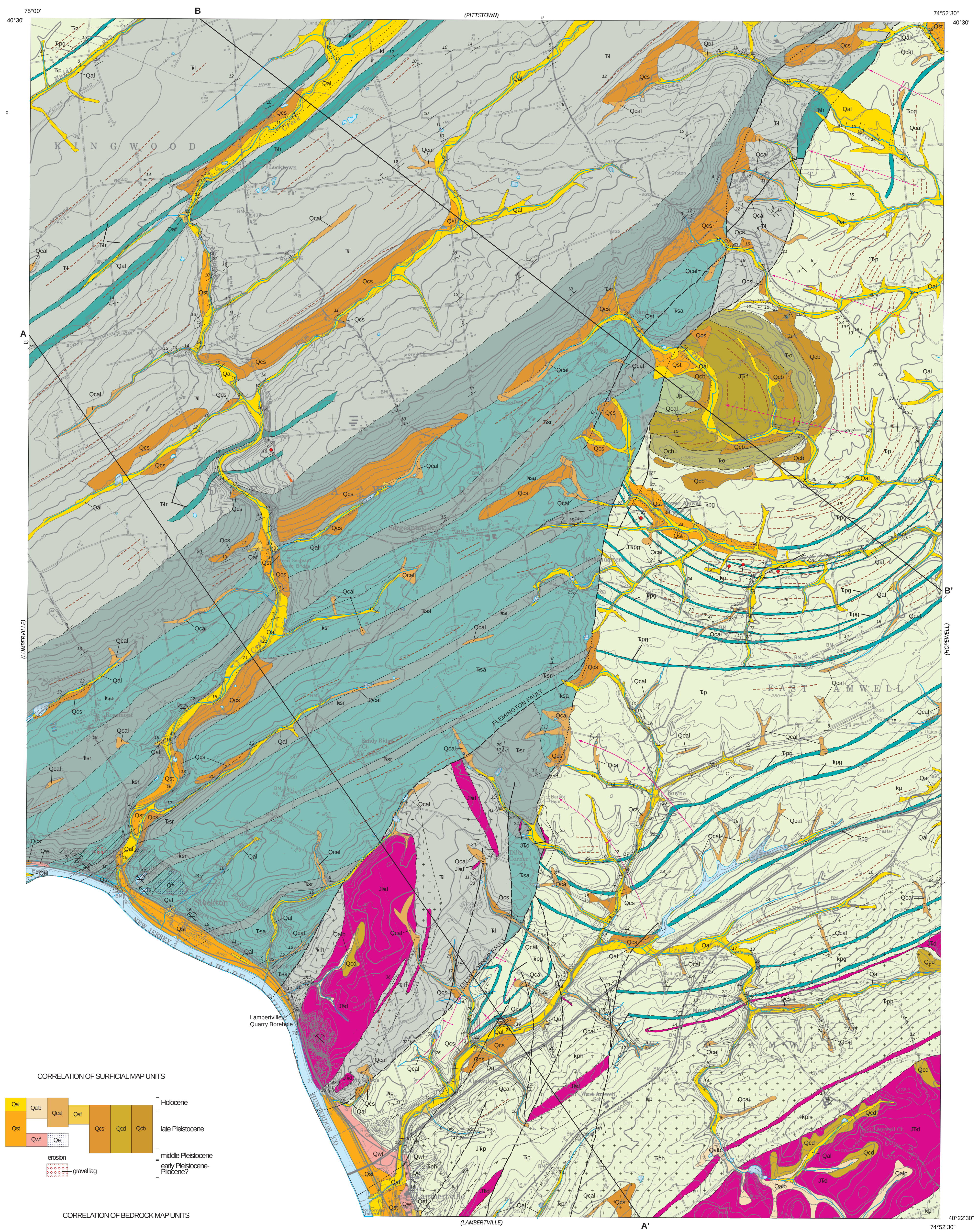
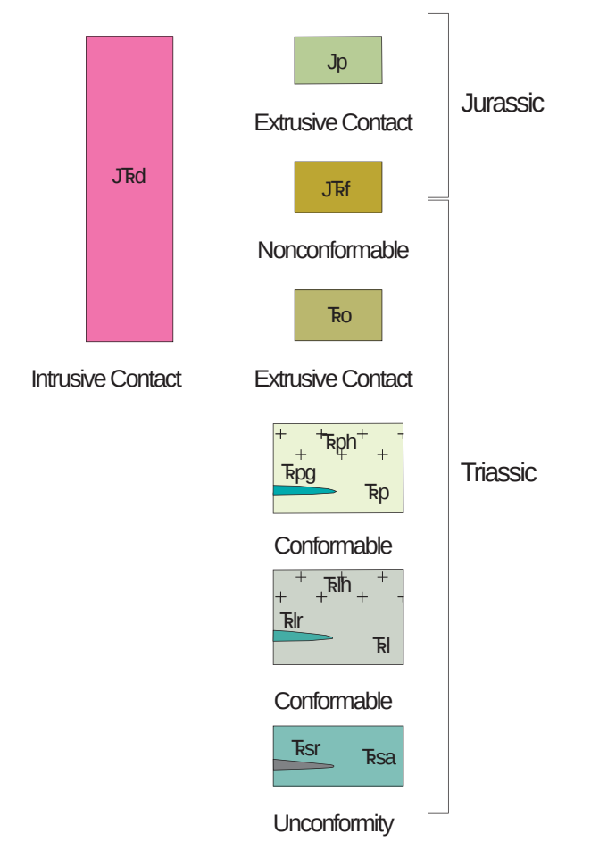
GEOLOGIC MAP OF THE STOCKTON QUADRANGLE
HUNTERDON COUNTY, NEW JERSEY
GEOLOGIC MAP SERIES GMS 15-1

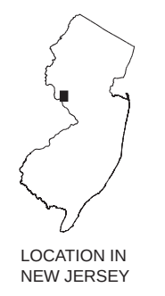


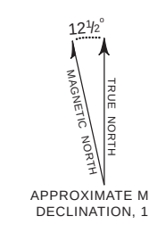
CORRELATION OF SURFICIAL MAP UNITS

CORRELATION OF BEDROCK MAP UNITS

NEWARK BASIN







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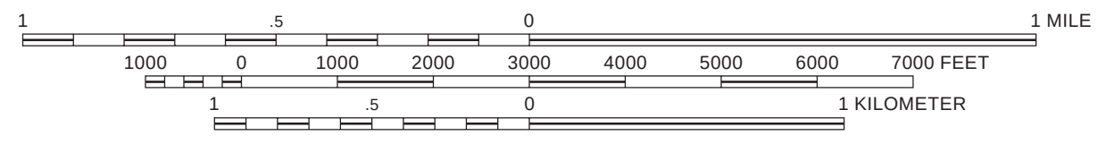

Geologic Map of the Stockton Quadrangle
Hunterdon County, New Jersey

by
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2015

Bedrock geology mapped by G.C. Herman in 1999
D.H. Monteverde and S. Spayd in 2000-2001
Surficial geology mapped by S.D.Stanford in 1989
Digital cartography by D.H. Monteverde
Reviewed by Michael Hozik and MaryAnn Malinconico

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INTRODUCTION

The Stockton 7.5-minute quadrangle lies within the Piedmont Physiographic Province, Hunterdon County, west central New Jersey. The area maintains its rural character despite increasing pressures from suburban development. U.S. Route 202 provides easy passage through the quadrangle from Lambertville in the south to Flemington, Somerville, and other northeast destinations.

This report provides detailed information on the stratigraphy, structure and description of geologic units in the map area. An aerial view of the bedrock and surficial geology is provided in the accompanying map. Cross sections A-A' and B-B' show a vertical profile of the bedrock geologic units and their structure. Rose diagrams in figures 1 and 2 provide a directional analysis of bedding and fracture orientations in the map area.

The bedrock geology controls the varied topography in the area. The Hunterdon Plateau occupies the northwestern section of the quadrangle where topographic elevations range from about 400 to 500 feet. The surface water drainage patterns on the plateau reflect the northeast-southwestern strike of bedrock. Wickecheoke Creek transects the plateau along a southwardly trend and drains into the Delaware River north of Stockton. Abundant rock ledges commonly crop out along its banks. The topography is more varied in the southeast where topographic elevations range from about 100 to 400 feet. Topographic elevations exceeding 300 feet are commonly associated with outcropping diabase (trap rock), basalt, and associated hornfelsic rocks. Sedimentary rocks generally underlie lower elevations (90 to 220 feet). Varying drainage patterns in the southeast reflect the folded and faulted bedrock trends of this area.

The bedrock in the Newark Basin of Mesozoic age was deposited as sediment and igneous material in a rift basin formed during the breakup of a supercontinent called Pangea. The basin fill has been tilted, faulted, and locally folded (see summaries in Schlische, 1992; and Olsen and others, 1996). Most tectonic deformation is probably Late Triassic to Middle Jurassic in age (Lucas and others, 1988; de Boer and Clifford, 1988). Southeast-dipping normal faults along the basin's northwestern margin primarily affected the basin morphology, sediment deposition patterns, and the orientation of secondary structures within the basin. Episodic, periodic motion on these faults also affected the deposition of sediment to the basin from the Highlands to the west, and resulted in a general sediment dispersal pattern parallel to the basin's long axis (northeast-southwest). Synrift sedimentation continued into the Early Jurassic (Malinconico, 2010). While some of the intra-basinal faulting, transverse folding (Schlische, 1992, 1993), and northwest tilting of the basin occurred during active deposition, most post-dates syn-rift sedimentation (Withhack and others, 2013). Post-rift contractional deformation, basin inversion, and associated erosion have been recgnized in the Newark and other Mesozoic basins (de Boer and Clifford, 1988; Withjack and others, 1995; R. Schlische, 1996, oral communication). Inversion and erosion of Newark basin rocks was followed by flexural loading of the passive margin by Cretaceous sediments of the Coastal Plain sequence.

STRATIGRAPHY

Surficial deposits in the Stockton quadrangle include fluvial, colluvial, and windblown sediment. The oldest surficial material in the map area is a lag of quartzite cobbles on a bedrock bench about 100 feet above the Delaware River near Prallsville. These cobbles are erosional remnants of fluvial gravel laid down by the Delaware 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. After deposition of these gravels, the Delaware River and its tributaries deepened their valleys 50 to 100 feet into bedrock, in the early and middle Pleistocene (2.5 Ma to 125 ka). During the late Wisconsinan glaciation, which reached its maximum extent at about 25 ka, glaciofluvial gravel was laid down in the Delaware Valley (unit Qwf). This gravel was deposited about 30 to 20 ka as the glacier advanced into, and then retreated from, the Delaware Valley, reaching as far south as the Belvidere, N.J., area. At the same time, sediment aggraded in tributary valleys (units Qst, Qaf), colluvium collected on footslopes (units Qcs, Qcb, Qcd), and silt and fine sand were blown off of terraces in the Delaware Valley (unit Qe). About 20 to 15 ka, the Delaware, no longer transporting glacial gravel, incised into the glaciofluvial deposit and cut a lower terrace on which it laid down sand and silt (unit Qst in the Delaware Valley). By 10 ka, continued downcutting had formed the present floodplain and channel of the Delaware River and tributary streams. Channel and overbank deposits have aggraded in these floodplains within the past 10 ka (unit Qal). In headwater areas during this period, and earlier, colluvium and weathered rock material have been incised, washed, and winnowed by runoff and groundwater seepage (units Qcal, Qalb).

Bedrock units range in age from the Early Jurassic to Late Triassic (Olsen, 1980a) and consist of a sequence of alluvial and lacustrine sedimentary rocks that are locally intruded and overlain by igneous rocks. Sedimentary rocks cover the majority of the mapped area. The basal Stockton Formation is dominantly an alluvial sequence of red, light-brown, gray, and buff sandstone, arkosic sandstone, and conglomerate. Sandstone, siltstone and mudstone are more common in the upper half of the Stockton (McLaughlin, 1945, 1959). The overlying Lockatong and Passaic Formations are dominantly red, gray, and black shale, siltstone, and argillite that 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 the 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 with the 20,000-yr climatic precession cycle and consists of about 20 feet of lacustrine sediment deposited in shallowing lacustrine to mudflat environments.

A succession of three basaltic units, each containing multiple flow events in the basin begins at the top of the Passaic Formation. Thin sequences of lacustrine sediment separate each basalt unit. Two of these basalt sequences occur in the Stockton Quadrangle near Sand Brook. They consist of two separate units that correlate geochemically to the 1st (Orange Mountain) and 2nd (Preakness) Basalts of the Watchung Mountain region to the northeast (Puffer, 1984; Houghton and others, 1992). Red-brown siltstone and shale sequences, mapped as the Feltville Formation, occur between the two basalt sequences. Ratcliffe and Burton (1988) interpreted the Preakness Basalt at Sand Brook as a granophyre plug, based on local Stockton Formation hornfels on the footwall of the Flemington fault and a “very coarse-grained diabase stock”. These lithologies were not encountered during the current mapping. A foundation cut for a new home instead exposed fine-grained basalt with hints of columnar features.In addition, no exposures of hornfelsic Stockton were found near the fault contact with the basalt. The coarse-grained diabase described by Ratcliffe and Burton (1988) may correlate with gabbroid layers elsewhere in the Preakness (Puffer and Volkert, 2001). Therefore this map correlates this feature with the Preakness Basalt rather than a granophyre plug. The Sand Brook basalts show subtle topographic ridges but are poorly exposed. Characteristic orange soil, easily distinguished from surrounding red soils developed over basin sediment, facilitated mapping the extent of the basalts. Diabase sills and dikes also intrude Triassic sediment in the Stockton quadrangle. These intrusive bodies originate from the same magmatic source (Husch, 1988) as the Orange Mountain Basalt based on geochemical and paleomagnetic data (Hozik and Colombo, 1984; Houghton and others, 1992). Thermally metamophosed sediment of the Lockatong and Passaic formations surround the diabase intrusions.

STRUCTURE

The Flemington and Dilts Corner intrabasinal faults dip south (Kummel, 1897, 1898) displaying normal offset essentially split the area in two. Several splays branch off both faults in their footwall blocks. Small faults bisect the hanging wall blocks. The Flemington Fault extends through the quad, trending N30ºE in the north to Sand Brook where it veers to N20ºE. South of Headquarters the fault changes to N40ºE as far as the Delaware River. The Dilts Corner Fault branches off the Flemington Fault south of Headquarters and continues a N20ºE trend before it extends to parallel the Flemington and crosses into Pennsylvania where the two faults merge and join the Chalfont Fault dipping 45º south (Ratcliffe and Burton, 1988).

Extensional fault-related folds are on the Flemington Fault hanging-wall block. They result from differential motion along a single fault that combines with more regional faults such as the Flemington (Schlische, 1995). The largest displacement occured at the center of the fault trace and decreasing offset to either side. A transverse basin develops from the differential offset. Anticlinal structures formed where displacement was minimal or where fault segments intersected. Synclines are generally broader than the corresponding anticlines.

Circular histograms (Allmendinger and others. 2013, Cordozo and Allmendinger 2013) enabled analysis of bedding and fracture orientations of sedimentary rocks throughout the mapped area. Additional analysis included Lockatong and diabase data collected in the Lamberville Quarry borehole, located between the towns of Stockton and Lambertville (figs. 1 and 2). Lambertville Quarry borehole is located along Route 29 and close to the Lockatong-diabase contact. An optical borehole televiewer recorded data in the borehole below casing at 40 ft down to its total depth at 342 ft. The borehole intersected Lockatong from the top of the borehole to a depth of 230.5 ft. Diabase occurs next and continues to the bolehole bottom. The strike of bedding in the Stockton Formation in the footwall block of the Flemington or Dilts Corner Faults, ranges from N30ºE to N70ºE and a maximum of N60ºE to N70ºE. Dip is dominately northwestward except close to faults (fig. 1). Lockatong bedding in the same structural blocks as the Stockton dips N50ºE to N60ºE. Between the Flemington and Dilts Corner Faults the Lockatong bedding strikes almost north at a right angle to its strike elsewhere. The Passaic Formation occurs almost exclusively within the Flemington hanging wall block. It diplays the widest range in bedding orientation here because of the hanging wall folds created by the differential slip components on the fault segments that merged into the Flemington Fault (Schlische, 1995).

Joints lacking evidence of shear dominate the fractures in the sedimentary units and display fairly consistent trends. Prevailing strike of all three formations trends N20ºE to N30ºE. The Lockatong exhibits a more varied fracture trend from N20ºE to N40ºE and a secondary trend from N40ºE to due East. A N20ºE to N30ºE strike of fractures is strong in the Passaic but the dominant trend is from N10ºE to N50ºE. Fractures predominantly dip southeast in all three formations. Lockatong Quarry borehole results show that the dominant strike trends parallel to the north-trending bedding strike in the area between the Flemington and Dilts Corner Faults. Diabase fractures fan around due North plus a secondary distribution between N20ºE to N70ºE.

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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 to brown, locally yellowish-brown. Gravel is dominantly flagstones and chips of red and gray shale and mudstone with minor pebbles and cobbles of basalt, diabase, sandstone, and hornfels. Silt, fine sand, and clay occur as overbank deposits on floodplains along low-gradient stream reaches. Overbank silts 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.

Qalb **Alluvium and boulder lag** - Silt, sand, minor clay and organic matter, dark brown, brown, yellowish-brown, reddish-yellow, moderately sorted, weakly stratified, overlying and alternating with surface concentrations (lags) of rounded to subrounded diabase (and, in places, hornfels) boulders and cobbles. As much as 10 feet thick (estimated). Formed by washing of weathered diabase and hornfels by surface water and groundwater seepage.

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 (estimated).

Qaf **Alluvial fan deposits** - Flagstone gravel as in unit Qal and minor reddish-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 in the Neshanic River basin are chiefly reddish-yellow to reddish-brown silt with minor fine sand and trace of red and gray shale, mudstone, and sandstone pebble gravel, 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. Deposits along Wickecheoke Creek are dominantly flagstone gravel and minor reddish-brown silt and fine sand. They are as much as 15 feet thick and form terraces 5 to 10 feet above the modern floodplain. They are likely of both late Wisconsinan and postglacial age.

Qe **Eolian deposits** - Silt and very fine-to-fine sand, reddish yellow. Well-sorted, nonstratified. As much as 5 feet thick. These are windblown deposits blown from the glaciofluvial plain in the Delaware River valley.

Qwf **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 and white quartzite and conglomerate, and some gray and white gneiss, dark gray chert, and dark gray diabase. As much as 40 feet thick. Forms an eroded plain in the Delaware River valley with a top surface about 35-40 feet above the modern floodplain. Deposited by glacial meltwater descending the Delaware River valley during the late Wisconsinan glaciation.

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. As much as 30 feet thick. Forms footslope aprons along base of hillslopes. Chiefly of late Wisconsinan age. In the lower reaches of Wickecheoke and Alexauken creeks, incision and erosion by the creeks has reduced some of the colluvial aprons to narrow benches along the valley side.

Qcd **Diabase colluvium** - Clayey silt to clayey sandy silt, yellowish-brown to reddish-yellow, with some to many subrounded boulders and cobbles of diabase. Poorly sorted, nonstratified to weakly stratified. As much as 15 feet thick (estimated). Forms footslope aprons along base of hillslopes. Includes some areas of boulder lag formed by footslope groundwater seepage, with little or no accumulation of colluvium. Chiefly of late Wisconsinan age.

Qcb **Basalt Colluvium** - Clayey silt to silt, reddish-yellow, brown, yellowish-brown, light gray, with some to many subangular to subrounded pebbles and cobbles of basalt. Poorly sorted, nonstratified. As much as 10 feet thick (estimated). Forms footslope aprons along base of hillslopes. Chiefly of late Wisconsinan age.

JT̶Rd **Diabase** (Lower Jurassic) - 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 map area in sills, southeast of Stockton and east of Lambertville, and in the Sourland Mountain diabase sheet on the southern edge of the mapped area. This sheet may be the southern extension of the Palisades sill. The thickness of the Rocky Hill diabase in the quadrangle, known mainly from drill-hole data, is approximately 1,325 feet.

Jp **Preakness Basalt** - (Lower Jurassic) (Olsen, 1980a) - Unit poorly exposed in the quadrangle. Elsewhere, dark-greenish-gray to black, fine-grained, dense, hard basalt composed mainly of intergrown calcic plagioclase and clinopyroxene. Contains small spherical tubular gas-escape vesicles, some filled by zeolite minerals or calcite, just above scoriaceous flow contacts. Unit consists of at least three major flows, the tops of which are marked by prominent vesiculated zones up to 8 ft. thick. Radiating, slender columns 2 to 24 in. wide, formed by shrinkage during cooling, are abundant near the base of the lowest flow. Maximum thickness of unit is about 1,040 ft.

JT̶Rf **Feltville Formation** - (Upper Triassic-Lower Jurassic) (Olsen, 1980a) - Unit is rarely exposed in this quadrangle. Elsewhere, it is reddish-brown, or light-grayish-red, fine- to coarse-grained sandstone, siltstone, shaly siltstone, and silty mudstone, and light- to dark-gray or black, locally calcareous siltstone, silty mudstone, and carbonaceous limestone. Upper part of unit is predominantly thin- to medium-bedded, reddish-brown siltstone. Reddish-brown sandstone and siltstone are moderately well sorted, commonly cross-laminated, and interbedded with reddish-brown, planar-laminated silty mudstone and mudstone. Several inches of unit have been thermally metamorphosed along contact with Preakness Basalt (Jp). Thickness ranges from 450 to 483 ft.

T̶Ro **Orange Mountain Basalt** - (Upper Triassic) (Olsen, 1980a) - Dark-greenish-gray to black, fine-grained, dense, hard basalt composed mostly of calcic plagioclase and clinopyroxene. Locally contains small spherical to tubular gas-escape vesicles, some filled by zeolite minerals or calcite, typically above base of flow contact. Elsewhere, unit consists of three major flows. Lower part of upper flow is locally pillowed; upper part has pahoehoe flow structures. Middle flow is massive to columnar jointed. Lower flow is generally massive with widely spaced curvilinear joints and is pillowed near the top. Individual flow contacts characterized by vesiculated zones up to 8 ft thick. Thickness of unit is about 591 ft.

T̶Rp
T̶Rpg
T̶Rph

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 (T̶Rpg) 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. Several inches of unit have been thermally metamorphosed along contact with Orange Mountain Basalt (Jo). Thicker thermally metamorphosed sections (T̶Rph) exist on the southern flank of Sourland Mountain, on the southern part of the mapped area. Unit is approximately 11,000 feet thick in the map area.

T̶Rl
T̶Rlr
T̶Rlh

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 (T̶Rlr) 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 (T̶Rlh) where intruded by diabase. Thickness of hornfels directly related to thickness of intruded diabase. Lower contact gradational into Stockton Formation and placed at base of lowest continuous black siltstone bed (Olsen, 1980a). Maximum thickness of unit regionally is about 2,200 feet (Parker and Houghton, 1990).

T̶Rsa
T̶Rsr

Stockton Formation - (Upper Triassic) (Kummel, 1897) - Unit is interbedded sequence of gray, grayish-brown, or slightly reddish-brown, medium- to fine-grained, thin- to thick-bedded, poorly sorted, to clast imbricated conglomerate, planar to trough cross-bedded, and ripple cross laminated arkosic sandstone (T̶Rsa), and reddish-brown clayey fine-grained sandstone, siltstone and mudstone (T̶Rsr). Coarser units commonly occur as lenses and are locally graded. Finer units are bioturbated sequences that fine upward. Conglomerate and 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 is an erosional unconformity. Thickness is approximately 4,500 feet.

EXPLANATION OF MAP SYMBOLS

Surficial Map Symbols

Contact - Contacts of units Qal, Qst, and Qwf 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 fluvial deposits.

Strath - Erosional terrace cut into bedrock by fluvial action.

Strike ridge - Ridge or scarp parallel to strike of bedrock. Mapped from stereo airphotos.

Bedrock Map Symbols

Contact - Dashed where approximately located; queried where uncertain; dotted where concealed

Faults - Solid where location known to be accurate. Dashed where approximately located; queried where uncertain; dotted where concealed

Arrows show relative motion

Motion is unknown

Folds

Anticline - showing trace of axial surface, direction and dip of limbs.

Syncline - showing trace of axial surface, direction and dip of limbs.

Planar features

11 Strike and dip of inclined beds

Other features

Abandoned rock quarry

Active rock quarry

Downhole Optical Televiewer interpretation. Shows marker beds identified in borehole projected to landsurface using bed orientation identified in well. Orange and black boxes/lines represent red and black sediments encountered in data. Red dot shows borehole location. Data from Herman and Curran (2010a, 2010b)

○ Location of Lambertville Quarry borehole

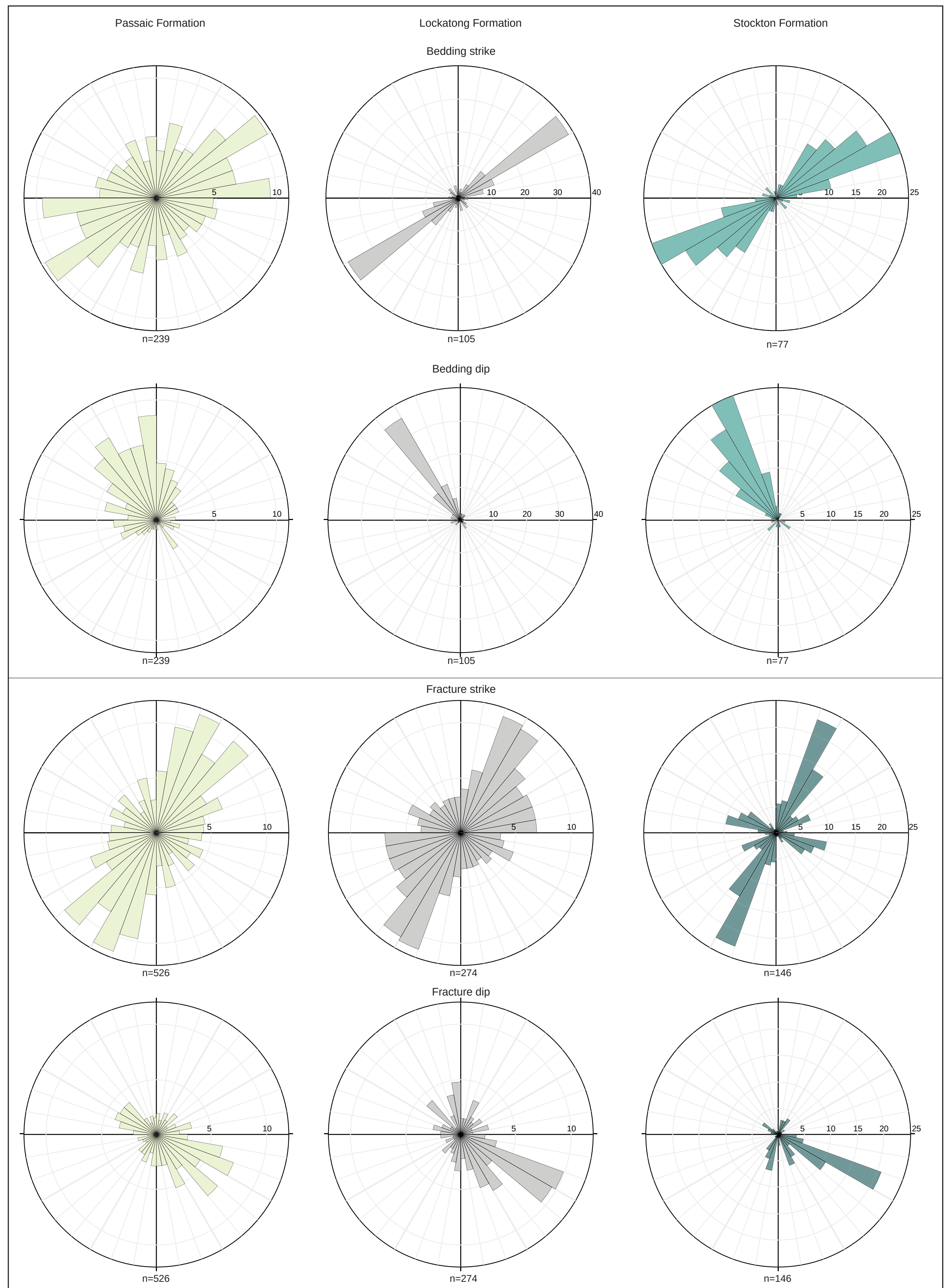

Figure 1. Rose diagrams depicting oriented surfaces measured on surface exposures of strike and dip directions of bedding and fractures within the Stockton, Lockatong and Passaic sedimentary beds. Plots are color coded to match unit colors used on map. “n” lists number of surfaces analyzed in each rose diagram. Plots created from Allmendinger and others (2013) and Caroza and Allmendinger (2013).

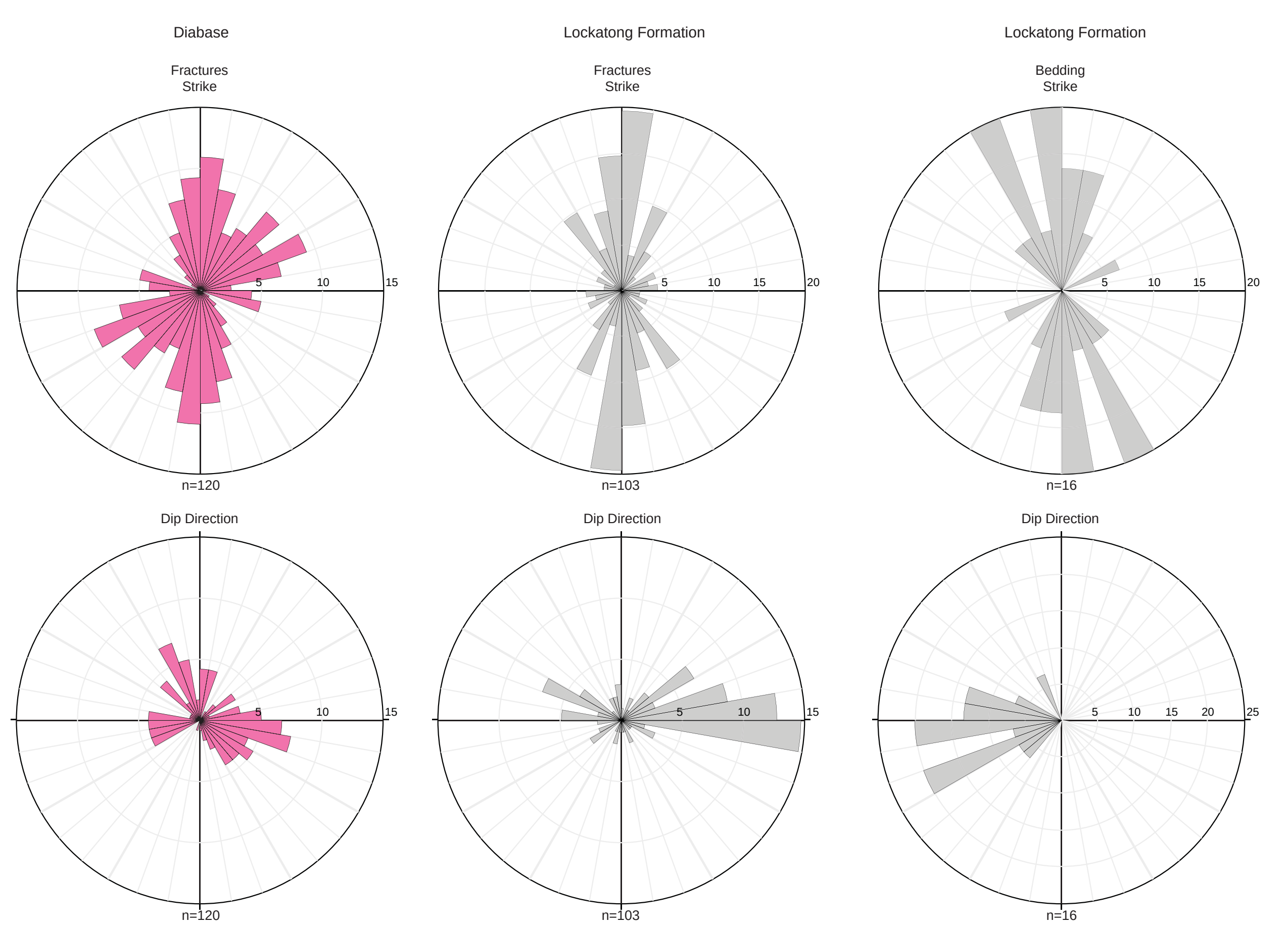

Figure 2. Results of measured oriented surfaces from an optical borehole televiewer data set collected in the Lambertville Quarry borehole using the Robertson Geologging Ltd downhole tool and software and methodology described in Herman (2010). Only diabase and Lockatong lithologies were encountered in the borehole. Rose diagrams depict strike and dip orientations of fractures occurring in diabase and the Lockatong and bedding strike and dip orientations encountered in the Lockatong. Plots are color coded to match unit colors used on map. “n” lists number of surfaces analyzed in each rose diagram. Plots created from Allmendinger and others (2013) and Caroza and Allmendinger (2013).