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OPEN-FILE NO. 96-4

Title: *Preliminary Report: Bedrock Geology of the Naples and Raymond Quadrangles*

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Date: *1996*

Financial Support: Funded in part by: Cooperative Agreement No. 1434-94-A-1234 with the U.S. Geological Survey, National Geologic Mapping Program.

Contents: 9 p. report and 2 maps

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Open-File 96-4

Preliminary Report: Bedrock Geology of the Naples and Raymond Quadrangles

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INTRODUCTION

The bedrock of the Naples and Raymond quadrangles consists primarily of igneous rocks, mainly granite assigned to the Sebago pluton of Carboniferous age (Osberg and others, 1985). This investigation recognizes three abundant varieties of granite within the Naples and Raymond quadrangles: muscovite-garnet granite and migmatite, two-mica granite, and biotite granite. All three granites have various textural aspects, including pegmatite. Biotite granite of the Naples quadrangle is older than two-mica granite. Biotite granite is of minor occurrence in the Raymond quadrangle where age relations are uncertain. However, in the Gray quadrangle to the east, biotite granite is younger than two-mica granite. Both biotite and two-mica granite intrude muscovite-garnet granite and migmatite. Syenites and trachytes assigned to the Rattlesnake Mountain igneous complex of Jurassic age and basaltic dikes of Mesozoic age intrude these granites (Creasy, 1989). Large and extensive occurrences of metamorphic rocks are not present within the Naples or Raymond quadrangles. Metamorphic rocks do occur as small screens or pendants intruded by granite; as inclusions within granite; and as a component of migmatites. A variety of metamorphic lithologies are represented: biotite granofels, pelitic schist, feldspathic biotite schist, quartzite, and calc-silicate gneiss.

LITHOLOGY

Brief lithologic descriptions are given for the various map units indicated on the accompanying geologic maps of the Naples and Raymond quadrangles. These lithologic units and the brief descriptions that follow are based upon hand specimen characteristics. Descriptions are presented in order from oldest to youngest where possible, except for metamorphic rocks where lithologic types are listed by relative abundance.

Metamorphic Rocks

A wide range of metamorphic lithologies occur within the Naples and Raymond quadrangles, but exposures are generally limited to discontinuous outcroppings < 200 sq ft and planar fabric elements within foliated granites and migmatites. Thus, individual occurrences cannot be adaquately represented at the scale of the accompanying geologic maps. A few areas of metamorphic rocks are schematically represented in the Naples quadrangle where metamorphic rocks are more abundant. Compositional layering (apparent bedding) is a common feature of these rocks that was systematically recorded in the field. The metamorphic rocks are described in order of decreasing relative abundance.

Biotite Granofels is a medium-grained granoblastic metamorphic rock consisting of quartz, biotite, and feldspar. The ratio of quartz + feldspar : biotite varies considerably within layered sections or between outcrops.

Feldspathic Biotite Schist is similar in mineralogy to the biotite granofels, but the biotite has a preferred orientation that with few exceptions parallels apparent bedding and contacts with the surrounding granites.

Pelitic Schist occurs as thick (50 ft) sections and outcrops up to 500 sq ft on the hill north of the village of Crescent Lake in the northern part of the Raymond quadrangle and interlayered with biotite granofels in the eastern portion of the quadrangle. Muscovite, biotite, and quartz occur in subequal proportion and together constitute the majority of the rock. Small amounts of garnet are present in certain horizons and fibrolitic sillimanite is tentatively identified in some samples.

Calc-Silicate occurs as a few small outcrops (< 50 sq ft) of diopsidic quartzite compositionally layered (2-5 cm) due to varying abundances of quartz, diopside, and other diagnostic minerals such as epidote, actinolite, and grossularite.

Pinstripe Quartzite contains 1-2 mm thick pelitic laminae interlayered with 5-20 mm quartzite layers, recognized on weathered surfaces by the characteristic weathering pattern.

Rusty Schist occurs as a fine-grained muscovite quartz schist containing abundant pyrite and graphite. It is present at one location on the Egypt Road.

Muscovite-Garnet Granite and Migmatite

This unit is characterized by several rock types having strong mineralogic similarities and a range of textural expressions or aspects. These textural aspects result from variation in grain size and in the presence of a metamorphic component (migmatite). These aspects are commonly associated at outcrop scale. Contacts between migmatite and pegmatitic granite are commonly gradational. Because the map scale does not permit subdivision of this unit other than schematically and because all are interpreted to be representations of the same metamorphic/magmatic processes, these rocks are shown as a single map unit.

Heterotextural Muscovite-Garnet Granite ranges in texture from coarse granitic to pegmatitic; either aspect may occur individually, but frequently both are complexly distributed in gradational contact within single outcrops. Muscovite is abundant, often forming large spangles visible even on weathered surfaces. Garnet is not uniformly distributed throughout the rock, but is almost invariably present within all outcrops. Tourmaline and less frequently biotite are present in pegmatitic aspects. Leucocratic muscovite-garnet aplite is typically included within the coarse-grained granite or pegmatite; this association also is seen in the adjacent Gray quadrangle to the east. This textural variation reflects the heterogeneous distribution of volatiles within the parental anatectic partial melts.

Migmatite consists of muscovite-garnet granite (see above) with the inclusion of biotite granofels and/or pelitic schist as parallel fabric elements. The ratio of granite : metasedimentary rock varies from 2:1 to 10:1. The metasedimentary component seldom exceeds 5 cm in thickness and more frequently is 1-2 cm; spacing of these planar features ranges from 5-30 cm. With progressive 'dilution' of the metasedimentary component, the migmatite passes into the granite. This aspect is most common in the central and northern exposures of this unit within the Raymond quadrangle and in northern exposures within the Naples quadrangle.

Gray Two-Mica Granite

This unit, present in the Naples quadrangle, is a fine-grained homogeneous gray biotite-muscovite granite and is demonstrably older than two-mica granite and biotite granite. It is interpreted as a probable marginal facies of two-mica granite (as seen on Madison Mountain).

Two-Mica Granite

This unit consists of white to pale pink, medium-grained muscovite-biotite granite. The muscovite is typically coarser grained (5 mm) and the biotite finer grained (2-3 mm) with these minerals occurring in subequal amounts. Variants tend to have a higher proportion of muscovite relative to biotite. This unit is relatively free of inclusions of any type and is broadly homogeneous in texture even on the km-scale. Pegmatitic aspects of this unit are present in the two quadrangles, but usually as clearly cross-cutting dikes within granite or as rather uniform outcrops— distinctly different from the textural variability of the muscovite-garnet granite. On Raymond Hill and the northeastern part of Tarkiln Hill (Raymond quadrangle), the two-mica granite contains stringers of pelitic schist imparting a migmatitic aspect adjacent to the contact with the muscovite-garnet granite. This is shown as a distinct mappable area on the accompanying map.

Biotite Granite

Biotite granite occurs primarily in the eastern portion of the Naples quadrangle. The granite is medium-grained, locally subporphyritic, and contains accessory muscovite in some occurrences. Muscovite and garnet are present infrequently in trace amounts. The biotite granite is frequently associated with or grades into pegmatic stringers, segregations, and dikes associated with metasedimentary xenoliths and septa. A locally developed fine-grained aspect is interpreted as a probable marginal facies. Scattered occurrences of biotite granite are noted in the Raymond quadrangle, but show no coherent extensive distribution as seen in the Naples (or Gray) quadrangles. Relationships observed in both quadrangles are consistent with biotite granite being younger than the muscovite-garnet granite. In the Naples quadrangle, the biotite granite is younger than two-mica granite; however, the reverse relationship is noted in the Raymond (and Gray) quadrangle.

Syenites of Rattlesnake Mountain

The syenites occurring around Rattlesnake Mountain are described by Creasy (1989). Coarse-grained hornblende biotite alkali feldspar syenite is the most extensive unit. Nepheline-bearing variants are also present but of minor extent.

Dikes

Trachyte dikes (Creasy, 1989; Griffith, 1982) associated with the Rattlesnake Mountain igneous complex consist of feldspar- and nepheline-phyric types although field distinction is difficult. Feldspar-phyric trachytes weather chocolate brown, but are dark gray where fresh. Nepheline-bearing trachyte weathers a paler brown and has a distinctive bluish-gray color where fresh. These dikes frequently exceed 3 m in width and where present on steep slopes or in cliff exposures preferential erosion produces characteristic deep clefts and defiles.

Basaltic dikes weather reddish brown and are black where fresh. The basaltic dikes seldom exceed 1.5m in width.

Lamprophyre dikes are present in the vicinity of Rattlesnake Mountain. While there are several compositionally distinct mafic dikes, fine grain size makes field distinction of these difficult.

DISTRIBUTION OF MAP UNITS

Igneous rocks crop out over 95% of the Naples and Raymond quadrangle and granitoids alone account for about 90%. The dominant rock of both quadrangles is two-mica granite (including pegmatitic aspects). The eastern 1/3 of the Raymond quadrangle is dominated by garnet-muscovite granite (of various textural aspects) and migmatite which is clearly older than two-mica granite. Garnet-muscovite granite and migmatite is present to the east in the Gray quadrangle, to the north in the Mechanic Falls quadrangle, and to the west in the Naples quadrangle. Biotite granite is exposed over a broad area in the eastern third of the Naples quadrangle. Biotite granite is also present at scattered locations in the Raymond quadrangle, usually associated with the two-mica granite, but forms no large coherent areal distribution. Biotite granite intrudes two-mica granite at some locations in the Raymond quadrangle, but at others, sharp contacts are lacking. In the Naples quadrangle, biotite granite is older than two-mica granite. These conflicting observations suggest that several age-distinct biotite and/or two-mica granites are present. Metasedimentary rocks occur as isolated discontinuous outcrops that with few exceptions are elongate (5-50 m) parallel to and thin (< 5 m) perpendicular to strike of foliation or compositional banding ('apparent' bedding). Metasedimentary rocks are preferentially associated with the muscovite-garnet granite (Raymond) and biotite granite (Naples).

Syenites form the Rattlesnake pluton in the northwest part of the Raymond quadrangle (Creasy, 1989). The syenites are the youngest plutonic rocks intruding biotite and two-mica granites and are radiometrically dated as about 200 Ma. Trachyte dikes form a swarm of major magnitude trending about NE into the north-central part of the Raymond quadrangle: about 75-100 dikes ranging in width from .5-8 m are present on Pismire and Tenny Mountains. In the remaining parts of the Raymond quadrangle, basaltic and trachytic dikes are rare and sparsely scattered. The Rattlesnake dike swarm trends SW into the Naples quadrangle: nearly 100 trachyte dikes are exposed on Rolfe Hill; north of Maple Cove (Sebago Lake); and at South Naples, a distance of 12 km from Rattlesnake Mountain.

STRUCTURAL DATA

Planar structural features include: foliation and compositional layering of metamorphic rocks (n=85); joints (781), fractures (11), and quartz-filled fractures (47) within all rock types; and dikes of basalt (130), trachyte (180), and pegmatite (69). Synoptic plots of foliation data for the Raymond quadrangle (Figure 1a) emphasize the prevalence of WNW strikes and moderate northeasterly dips. Data for the Naples quadrangle (Figure 1b) is limited and no consistent orientation emerges. Joints, fractures, and quartz veins measured in both quadrangles are dominately NE-striking and steeply dipping (Figure 2a,b; 3a,b). Grouping of these brittle fracture data by lithologic 'host' (granite or pegmatite) reveal a slight difference in orientation (Figure 3c,d). The orientations of trachyte and basaltic dikes are very tightly clustered (Figure 4a-d and 5a-d) and coincident with the joint orientations, especially the northeast trend, a relationship noted by Griffith (1983) and Creasy (1989). Orientation of pegmatite dikes (Figures 6a-d) are widely scattered in both quadrangles. In the Naples quadrangle where data are more abundant, a northwest trend is present.

DISCUSSION

The most significant feature of the Raymond quadrangle is the boundary between the two-mica granite and the muscovite-garnet granite and migmatite. The strike of foliation and of compositional layering of metasediments included with or related to the muscovite-garnet granite is generally parallel to this boundary and dips at low or moderate angles to the north or east, away from this boundary. Given this geometric relation and that two-mica granite is younger, the muscovite-garnet granite and migmatite unit represents anatectic granites and migmatites of high metamorphic grade that covered and flanked the intrusive two-mica granite. The regionally homogeneous texture of the two-mica granite, the general lack of metamorphic xenoliths, and areal distribution support emplacement of the two-mica granite as a laterally extensive melt to form a pluton. In contrast, the abundance of associated metamorphic material, the presence of migmatite, the consistency of foliation of planar metamorphic fabric elements, and the heterotextural nature of the granites argue against intrusive emplacement of the muscovite-garnet granite and migmatite. Rather an origin as an extensive partial melting zone associated with regional high-grade metamorphism in southwestern Maine is likely. The regional pattern of foliation within the migmatite and metasedimentary rocks may reflect structural culminations and depressions developed during regional deformation and metamorphism that guided emplacement of the two-mica granite or may reflect deformation by emplacement of the two-mica granite. The distribution of two-mica and muscovite-garnet granites is consistent with a northeast-dipping boundary, the two-mica pluton intruding migmatized metasedimentary rocks and anatectic granites.

Muscovite-garnet granite and migmatite occurs in an analagous, if less extensive, fashion in the Naples quadrangle. The outcrops of this unit on Leach Hill, Gardiner Mountain, and unnamed hills north of Trickey Pond suggest that this unit is 'structurally' (and generally, topographically) above the two-mica granite. For example, on Gardiner Mountain the heights are muscovite-garnet granite, but flanking exposures of two-mica granite are fine-grained near contacts and coarsen distally and topographically downward away from the contact. On the southern end of Gardiner Mountain, biotite granite intrudes muscovite-garnet granite and migmatite and contains inclusions of calc-silicate. Elsewhere, biotite granite has a similar association with blocks of metasedimentary rocks—intrusive and inclusive—rather than lit-par-lit migmatitic appearance of the muscovite-garnet granite and migmatite. For example, in the eastern third of the Naples quadrangle (Quaker Hill, Mitchell Hill, and Rolfe Hill) exposures of biotite granite contain blocks of metasedimentary rocks. The biotite granite here is older than the two-mica granite present to the west. The distribution of metasedimentary inclusions, apparent association with the biotite granite, and age relations suggest that these exposures may represent roof or wall to the intrusion of two-mica granite. As noted above, a single two-mica granite is suggested by the map pattern with the geometry of the contact detemined by the shape of the original intrusive surface and the present erosion surface. It is also possible that several intrusions of two-mica granite are present.

The striking NE orientation of Mesozoic basalt and trachyte dikes, coincident with the dominant joint orientation, is controlled by the regional extensional stresses during rifting of eastern North America in late Triassic-early Jurassic time.

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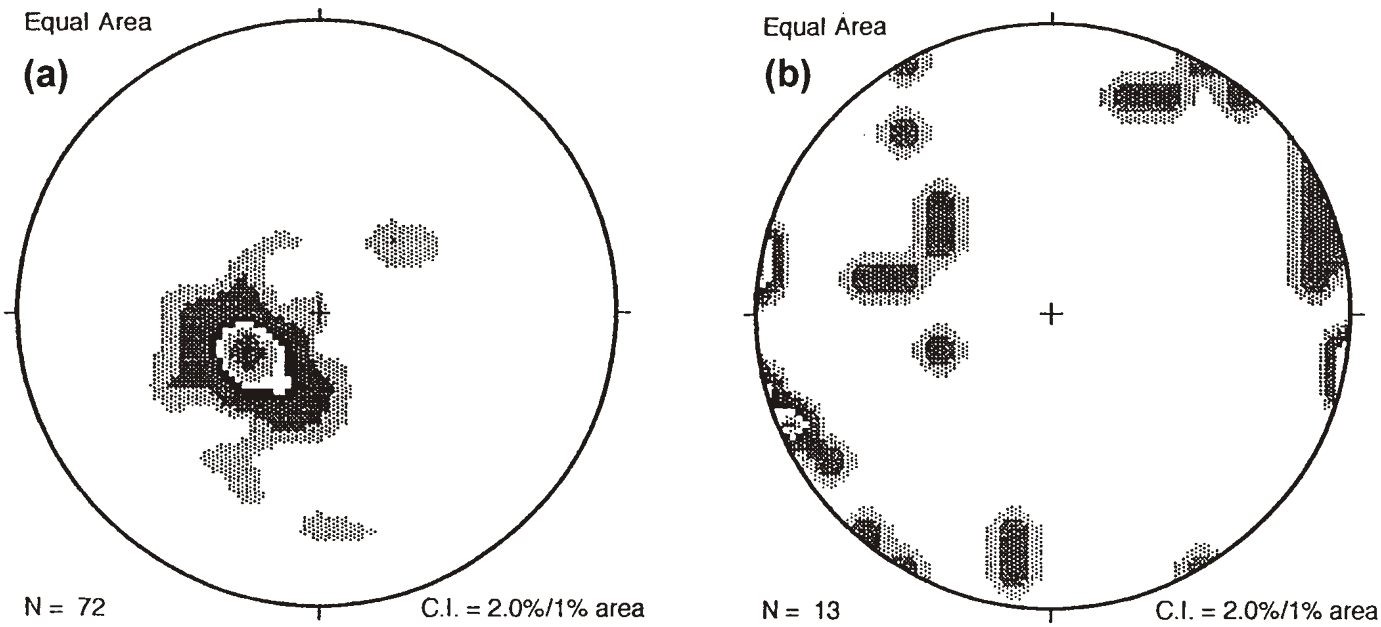


Figure 1. Poles to foliation in metamorphic rocks and granites: (a) Naples quadrangle; (b) Raymond quadrangle.

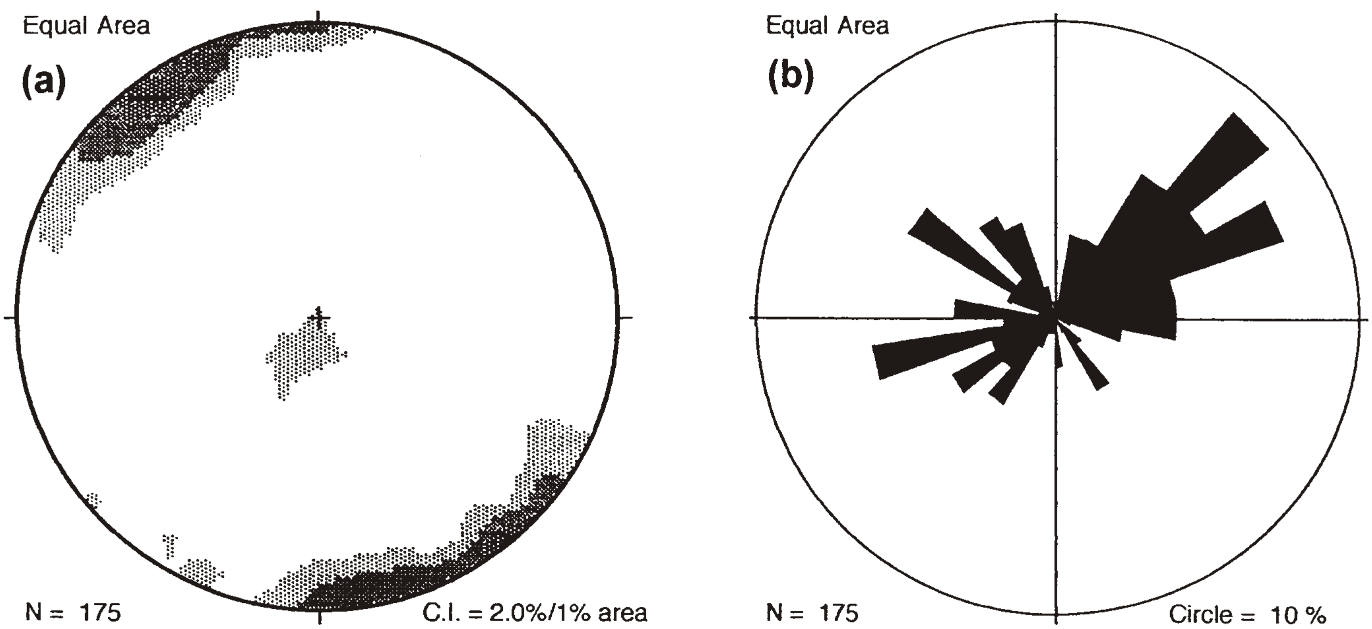


Figure 2. Joints, fractures, and quartz veins, Raymond quadrangle: (a) contoured pole plot; (b) rose diagram.

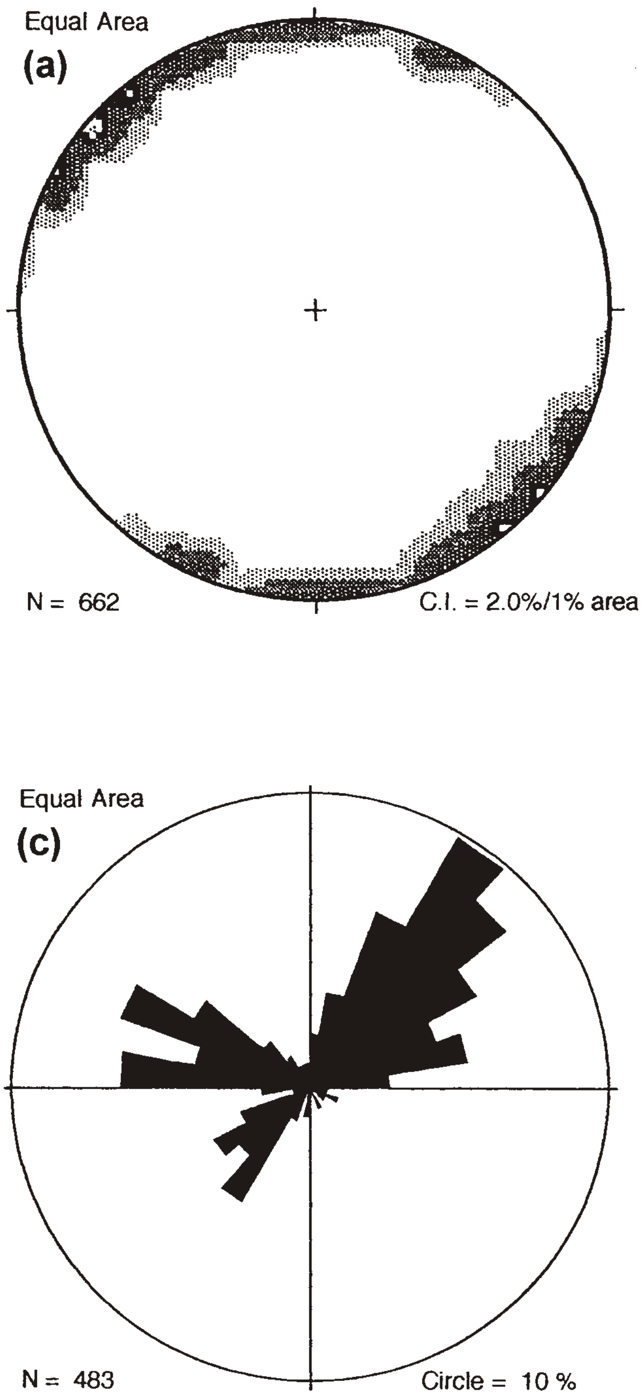


Figure 3. Joints, fractures, and quartz veins, Naples quadrangle: (a) contoured pole plot for all data; (b) rose diagram for all data; (c) rose diagram of only granite-hosted data; (d) rose diagram of only pegmatite-hosted data.

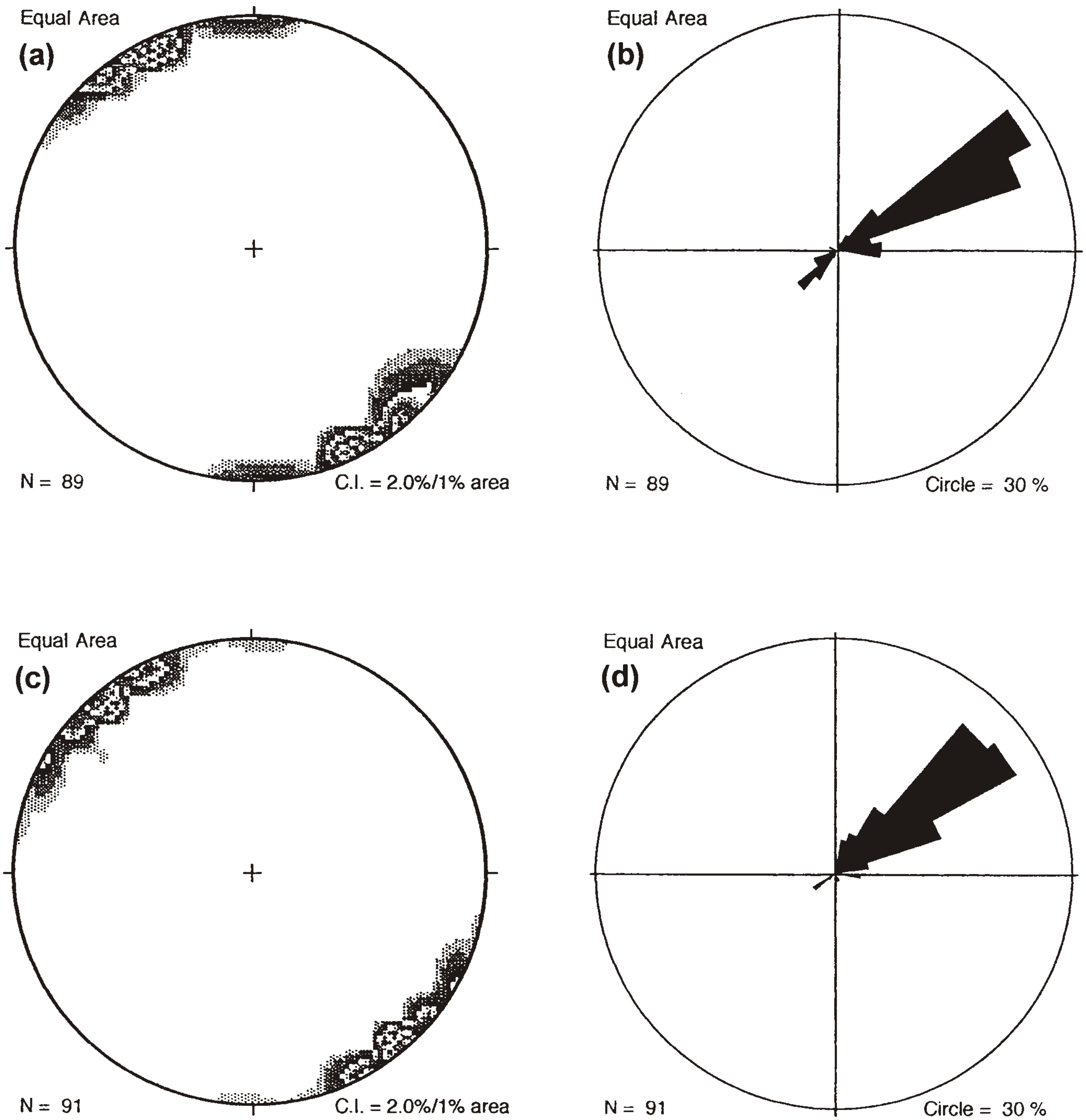


Figure 4. Orientation of trachyte dikes. Naples quadrangle: (a) contoured pole plot; (b) rose diagram. Raymond quadrangle: (c) contoured pole plot; (d) rose diagram.

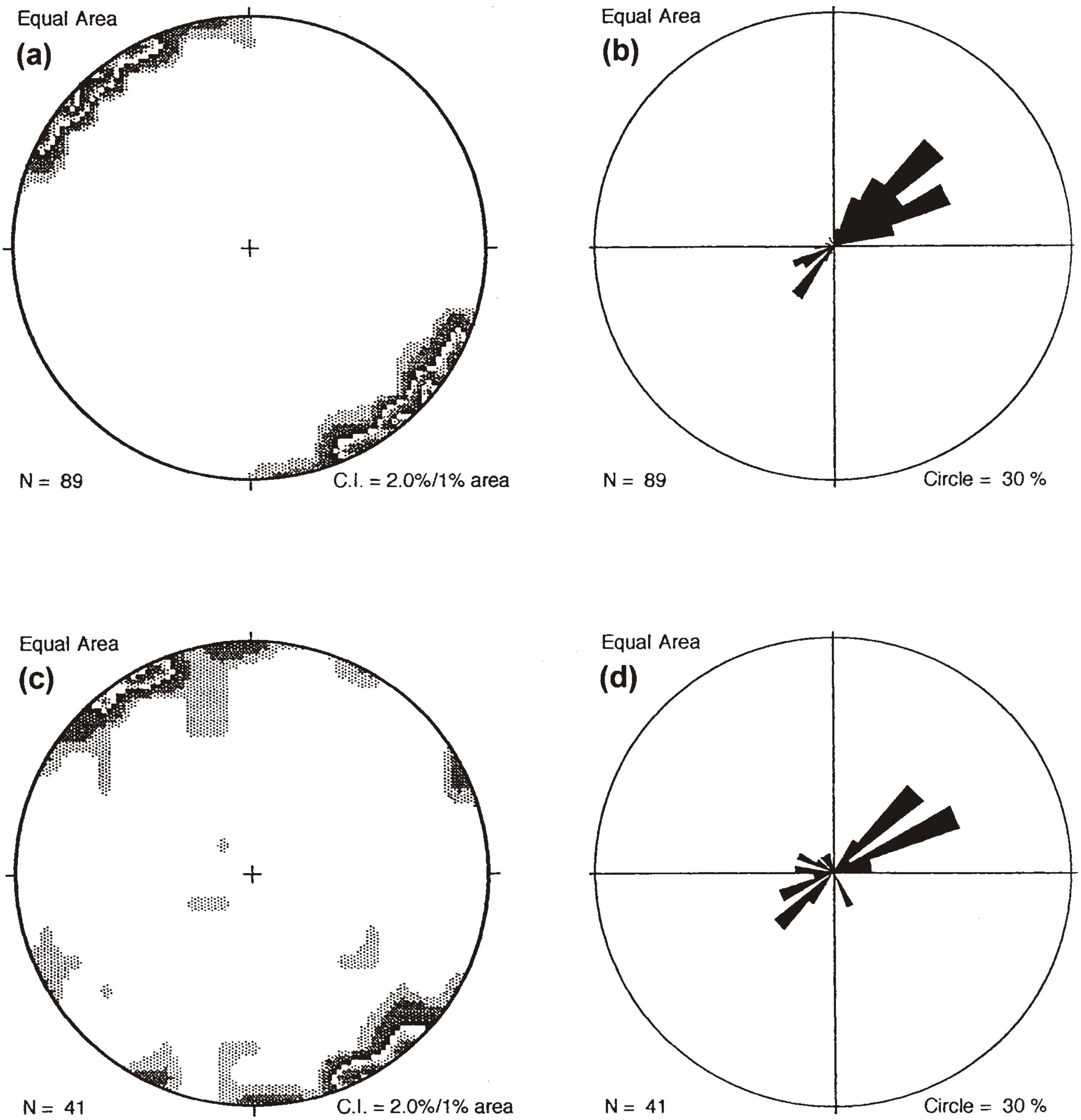


Figure 5. Orientation of basalt dikes. Naples quadrangle: (a) contoured pole plot; (b) rose diagram. Raymond quadrangle: (c) contoured pole plot; (d) rose diagram.

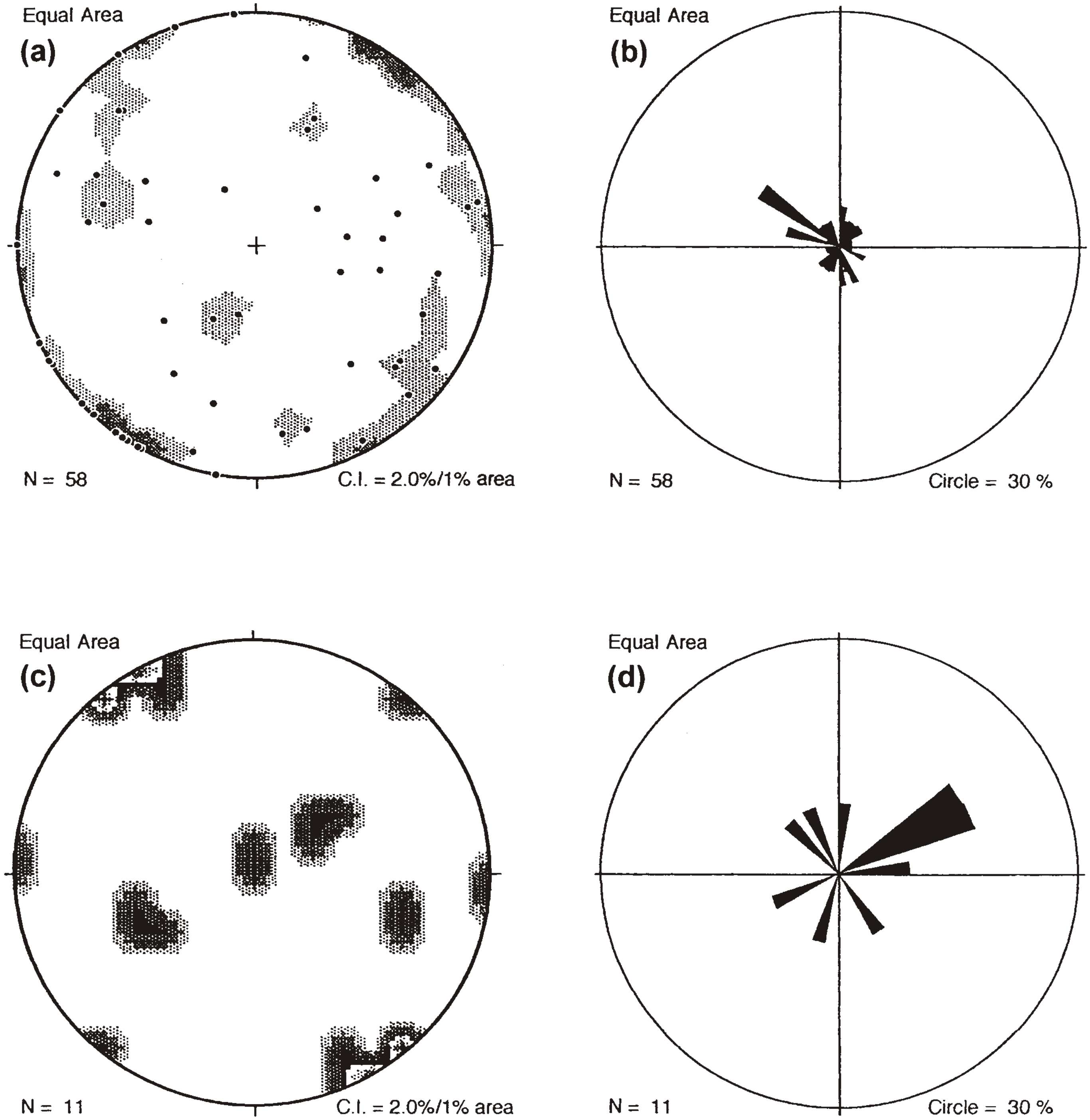
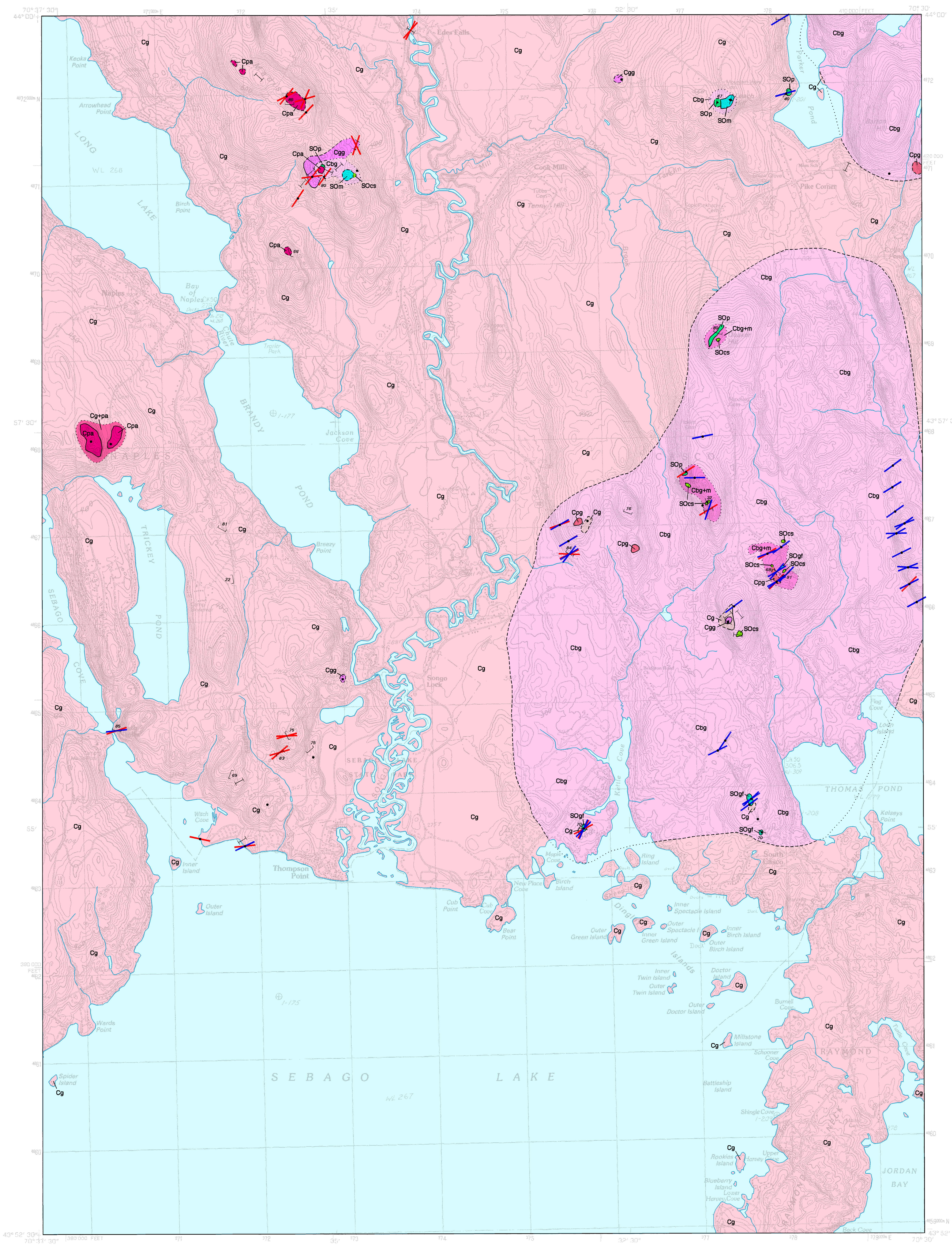


Figure 6. Orientation of pegmatite dikes. Naples quadrangle: (a) contoured pole plot; (b) rose diagram. Raymond quadrangle: (c) contoured pole plot; (d) rose diagram.



EXPLANATION OF UNITS

Intrusive Rocks

Mesozoic

Mafic dike. Reddish-brown weathering, black basaltic dikes.

Trachyte dike. Feldspar-bearing dikes are dark gray, weather chocolate-brown. Nepheline-bearing dikes are bluish gray, weather pale brown. Associated with the Rattlesnake Mountain igneous complex in neighboring Raymond quadrangle to the east.

Carboniferous

Rocks of the Sebago pluton

Cbg — **Biotite granite.** Medium-grained biotite granite with or without accessory muscovite, locally subporphyritic. Frequently associated with or gradational into pegmatitic stringers, segregations, and dikes. Associated with metasedimentary xenoliths and septa. Fine-grained variant interpreted as marginal facies.

Cbg + m - zones with extensive metasedimentary rock xenoliths.

Cpg — **Pegmatite.** Biotite-muscovite granite pegmatite generally free of metasedimentary inclusions and occurring as irregularly shaped bodies.

Cg — **Two-mica granite.** Medium-grained equigranular, biotite-muscovite granite, white to pale pink, generally lacking metasedimentary inclusions. Locally pegmatitic. Demonstrably younger than biotite granite. Best developed in southwestern portion of quadrangle.

Cg + pa - zones of extensive aplite intrusion about small aplite bodies.

Cgg — **Gray two-mica granite.** Fine-grained homogeneous, gray biotite-muscovite granite. Interpreted as marginal facies of Sebago granite.

Cpa — **Aplite.** Garnet-muscovite granite aplite and associated garnet-muscovite granite pegmatite. Outcrops heterogeneous with gradational (cm-scale) contacts between aplite and pegmatite.

Stratified Rocks

Ordovician or Silurian (?)

SOm — **Migmatite.** Metasedimentary lithologies intimately injected lit-par-lit by coarse-grained granite and pegmatite.

Metasedimentary rocks occurring chiefly as xenoliths and septa within granititc rocks, in particular biotite granite and pegmatite.

SOgf — **Biotite-quartz feldspar granofels.**

SOp — **Schist and metawacke.**

SOcs — **Calc-silicate rocks** (including layered granofels and skarn assemblages).

EXPLANATION OF SYMBOLS

20 — Foliation - inclined, vertical.

20 — Joint - inclined, vertical.

• Outcrops without structural data.

Symbols representing inclined planar features are annotated with dip angles.

? ? — Contact. All contacts are solid where approximately placed, dashed where inferred, dotted where concealed, and queried where uncertain.

Bedrock Geology of the
Naples Quadrangle, Maine

Bedrock geologic mapping by
John W. Creasy

Digital cartography by:
Bennett J. Wilson, Jr.

Robert G. Marvinney
State Geologist

Cartographic design and editing by:
Robert D. Tucker

Funding for the preparation of this map was provided in part by the U.S. Geological Survey National Geologic Mapping Program, Cooperative Agreement No. 1434-94-A-01234.

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Home page: http://www.maine.gov/doc/nrimc/nrimc.htm

Open-File No. 96-4
1996

First color printing: February, 2004

Quadrangle Location

SCALE 1 : 24,000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

TRUE NORTH

SOURCES OF INFORMATION

Bedrock mapping by John W. Creasy completed during the 1994 field season.

Topographic base from U.S. Geological Survey Naples quadrangle, scale 1:24,000 using standard U.S. Geological Survey topographic map symbols.

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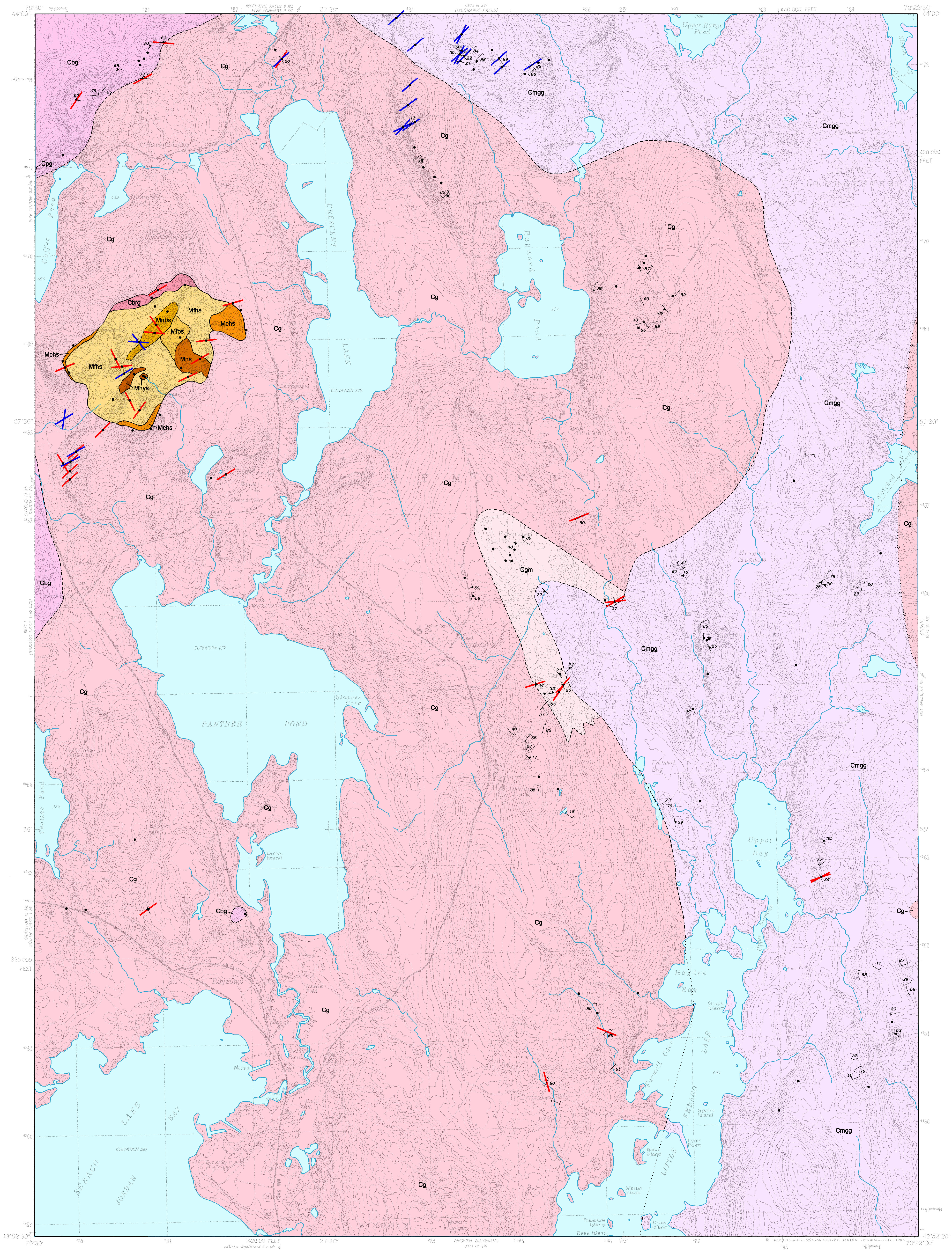

EXPLANATION OF UNITS

Intrusive Rocks

Mesozoic

Mafic dike. Reddish-brown weathering, black basaltic dikes.

Trachyte dike. Feldspar-bearing dikes are dark gray, weather chocolate-brown. Nepheline-bearing dikes are bluish gray, weather pale brown. Associated with the Rattlesnake Mountain igneous complex.

Rocks of the Rattlesnake Mountain igneous complex

Mns — **Nepheline syenite.** Medium-grained, 15-25% pink euhedral nepheline with clusters of irregular feldspar. Microperthite is dominant feldspar.

Mnbs — **Nepheline-bearing syenite.** Medium- to fine-grained, 2-10% nepheline. Microperthite is dominant feldspar. Also in abundant dikes (not mapped) intruding ferrohastingsite syenite.

Mfhs — **Ferrohastingsite syenite.** Coarse-grained, predominantly microperthite and ferrohastingsite with lesser orthoclase and oligoclase. Sparse nepheline; no quartz. Dominant lithology in the complex.

Mchs — **Mchs -** Chilled aspect of ferrohastingsite syenite in areas marginal to granite. Fine-grained.

Mfbs — **Biotite-ferrohastingsite syenite.** Medium-grained, greater abundance of biotite than ferrohastingsite syenite, greater proportion of orthoclase and oligoclase relative to microperthite.

Mhys — **Hybrid syenite.** A mixture of ferrohastingsite syenite and older alkalic mafic rocks.

Carboniferous

Rocks of the Sebago pluton

Cg — **Two-mica granite.** Medium-grained equigranular, biotite-muscovite granite, white to pale pink, generally lacking metasedimentary inclusions. Locally pegmatitic. Demonstrably younger than biotite granite.

Cgm — **Cgm -** Migmatitic aspect around Raymond Hill.

Cbrg — **Cbrg -** biotite-riebeckite marginal facies at contact with Rattlesnake Mountain igneous complex.

Cbg — **Biotite granite.** Medium-grained biotite granite with or without accessory muscovite, locally subporphyritic. Frequently associated with or gradational into pegmatitic stringers, segregations, and dikes. Associated with metasedimentary xenoliths and septa. Fine-grained variant interpreted as marginal facies. (Inferred at western edge of quadrangle from mapping in Naples quadrangle to the west.)

Cpg — **Pegmatite.** Biotite-muscovite granite pegmatite generally free of metasedimentary inclusions and occurring as irregularly shaped bodies.

Cmgg — **Muscovite-garnet granite and migmatite.** Coarse to pegmatitic muscovite-garnet granite. Muscovite abundant; garnet inhomogeneously distributed. Tourmaline and biotite in pegmatitic zones. Leucocratic muscovite-granite aplite included within coarse-grained granite or pegmatite. Migmatite (not shown separately) - muscovite-garnet with inclusions of biotite granofels and/or pelitic schist.

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Bedrock Geology of the Raymond Quadrangle, Maine

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