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Reconnaissance Bedrock Geology of the Waldoboro Pluton Complex and other Intrusive Rocks in Coastal Lincoln and Knox Counties, Maine

Part 1: Preliminary Bedrock Geology of the Waldoboro Pluton Complex

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INTRODUCTION

This preliminary report outlines granitoid macroscopic petrography, structural features in the granitoids, and mafic dikes of the herein named Waldoboro Pluton Complex. A tabled summary of the Waldoboro Pluton Complex structural development is also included. Detailed geologic mapping over a ten month period in 1987-1989 covered parts of the Union, Jefferson, Waldoboro East, Waldoboro West, Damariscotta, Friendship, Louds Island, and New Harbor 7 1/2' quadrangles (Plates 1, 2).

Previous reconnaissance mapping of Hussey (1971) in part of the Friendship quadrangle and more detailed work by Newberg (1979) in the Waldoboro East and Waldoboro West quadrangles outlined some features in the eastern and northern parts of the Waldoboro pluton.

The attached maps and legend of the Waldoboro Pluton Complex (378 km^2) detail seven major granitoid types; fractures; dominant joint sets; representative foliations and lineations; significant aplite, pegmatite, and mafic dikes; inclusions of metasedimentary rocks; and marginal structures. This work is part of a Ph.D. dissertation which also includes structural microfabric and petrographic analyses (n = 317), rock chemistry (n = 154), and mineral chemistry (n = 219) (Sidle, 1990).

GRANITOID ROCK TYPES

A digitized phase/body boundary map of the Waldoboro Pluton Complex quadrangle maps (Plates 1, 2) is reduced in Figure 1 and illustrates the major granitoid types (see map legend). The exposed margin of the Waldoboro Pluton Complex is near North Waldoboro in the north; near Warren Station in the northeast; near East Friendship in the east; at least as far as Eastern Egg Rock in the south; near Round Pond in the southwest; and near Nobleboro in the northwest.

Granite Phase (Dwg)

The granite phase (Dwg) is an equigranular, medium-grained, two-mica granite and is weakly foliated. Significant exposures of massive granite in the Waldoboro Pluton Complex belong to this phase. Muscovite-rich and schlieren-free granites are in the central area of Dwg (e.g. Demuth Hill). Low biotite/muscovite ratios highlight Dwg.

The Dwg granites range from pink gray (5 YR 8/1) to light, medium gray (N6-N7). Weathered surfaces range from gray-orange pink (10 R 8/2) to very pale orange (10 YR 8/2). Very coarse-grained to porphyritic sheets are common (e.g. southeast Benner Hill). Most of the exposures west of North Pond and towards Orffs Corner are weathered and porphyritic, blanketing more massive medium-grained granites.

The quarries north of Waldoboro occur in this phase. Rift planes are intact. These massive varieties likely extend beneath very coarse-grained to porphyritic granite sheets. These porphyritic sheets are pronounced northward into the Union quadrangle.

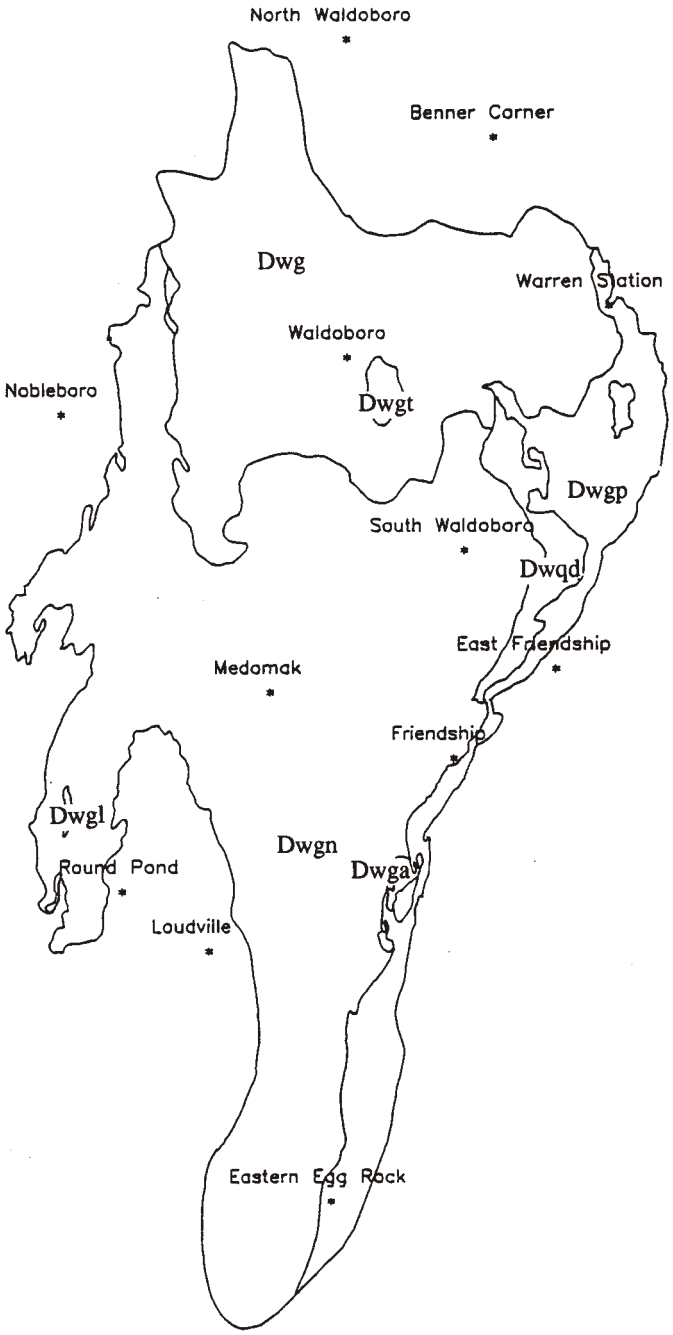

Figure 1. Geologic outline map of the Waldoboro Pluton Complex showing phases of intrusion discussed in text.

Leucogranites (Dwgl)

Leucogranites (Dwgl) in the Waldoboro Pluton Complex are fine to medium-grained, weakly foliated, with occasional garnet, and grade into granite. The weak foliation in outcrop is due to the paucity of ferromagnesian minerals. They range from very light-gray (N8) to pale pink (5 RP 8/2), and rarely, bluish white (5 B 9/1) in quartz-rich varieties with a CI less than 25.

The mapped Dwgl phases occur within Dwgn in western Waldoboro West and Louds Island quadrangles. Leucogranitic lenses of a few meters pervade Dwgn and probably extend beyond the mapped margins of the Waldoboro Pluton Complex. Their field characteristics may be indistinguishable from leucosomes amongst migmatites in and surrounding the Waldo-boro Pluton Complex

Tourmaline-Bearing Granite Phase (Dwgt)

The tourmaline-bearing granite phase (Dwgt) is a medium to coarse-grained granite, tourmaline-bearing, and non-foliated. It is principally exposed on Willet Hill, centrally located within Dwg. It is pinkish gray (5 YR 8/1) to very light gray (N8) weathering to chalky, very light gray (N8). Porphyritic lenses occur and muscovite is clearly predominant over biotite. Prismatic schorl up to 9 cm is associated with coarse-grained varieties. Segregations of black tourmaline up to 23 cm long occur in a lens near the Medomak River.

Garnet-Bearing Granite Phase (Dwgn)

The garnet-bearing granite phase (Dwgn) is the largest granitoid phase mapped within the Waldoboro Pluton Complex. It surrounds much of Dwg in the west and south. The Otter Island granites (Plate 2) are included in Dwgn. A few mappable tonalite and quartz diorite bodies are included within Dwgn (Plate 2). These are discussed with the diorite-tonalite phase (Dwqd). However, it is important to stress here that the unifying field characteristics of Dwgn are ubiquitous schlieren, boudinaged enclaves, inliers of convoluted metasedimentary lithologies, and the pervasive existence of garnet. Strong foliations prevail and ghost stratigraphies exist.

Foliated granites are medium to very coarse-grained, frequently garnet bearing, and interfinger with thick porphyritic ledge-forming varieties. Hillside ledges result from grain size differences, accentuated by weathering. Massive medium-grained varieties are less common (e.g. Round Pond; eastern Bremen Long Island). Knobby porphyritic varieties also occur (e.g. Eugley Corner Hills). Rock colors range widely.

Gneissic-banded granites, transitional to granodiorites occur especially in the southwestern areas of Dwgn. Banding in the gneisses ranges from 0.6 m to fine striping. Discontinuous streaking is common. Gradational igneous-like textures are common along with nebulitic varieties. Garnet-bearing para-gneisses and schists are often observed admixed with granitic layers. Many of these gradational to transitional granitoids overlap with more quartzo-feldspathic paragneisses and schists of the Bucksport Formation.

Locally (e.g. eastern Greenland Cove), porphyroblastic granitoids with serrated subrounded feldspars up to 15 cm occur.

These occur occasionally with small shears. Prolate, deformed, feldspathic porphyroblasts commonly transect the country rocks.

Granite-Porphyry Phase/Body (Dwgp/Dwgpp)

The granite-porphyry phase (Dwgp) is a feldspathic, megacrystic granite porphyry. It is mapped on the eastern margin of the Waldoboro Pluton Complex. More pegmatitic-rich massive varieties (Dwgpp) occur in the northeast of the Waldoboro East quadrangle (e.g. Stahls Hill). Non-aligned quartz and feldspar laths up to 7 cm within porphyritic sheets and irregular pegmatitic bodies extend westward. They intercalate with less coarse-grained varieties (e.g. Howard Hill). The pink microclines are the largest megacrysts and are usually weathered to chalky white. Rare smoky quartz and sporadic < 0.5 m poorly defined lenses of greisens are observed on southeast Stahls Hill. The greisens consist of granoblastic aggregates of quartz, muscovite, biotite, zinwaldite (?) tourmaline.

West of Wentworth Corner and southward, Dwgp is a sheared feldspathic meta-granite porphyry. It forms an arcuate exposure between Dwqd and the quartzitic units of the Benner Hill Formation. (Plates 1, 2). Megacryst deformation is well defined. In outcrop, particularly, on the outer islands (e.g. Eastern Egg Rock) protomylonite, porphyroclastic mylonites, and intrafolial blastomylonites are prolific. Strongly lineated quartz and feldspar augens up to 11 cm have serrated margins. In outcrop, pressure shadows filled with fine-grained mineral aggregates are observed. Apparent porphryoblastic feldspars persist in this southern part of Dwgp. Alternating, megacrystic Dwgp bands (10 cm to several meters) are intercalated with ubiquitous, boudinaged metasedimentary enclaves several tens of meters long (e.g. Friendship Long Island).

Dwgp exhibits a cataclastic to protomylonitic border, arcuately extending southward to the New Harbor quadrangle. Locally, the metasediments and mylonitic granitoids are difficult to distinguish except for obvious sheared, porphyroblastic, feldspathic areas (e.g. Franklin Island). The diminution of Dwgp megacrysts eastward towards the country rocks are associated with a narrow contorted migmatitic zone in Bucksport-type lithologies, (e.g. northeast Friendship Long Island).

Aplitic-Granite Phase (Dwga)

The aplitic-granite phase (Dwga) is a fine to medium-grained aplitic granite. It is weak to moderately foliated with occasional garnet. It is very light gray (N8), white (N9), to pink gray (5 YR 8/1) and contains few angular xenoliths and no metasedimentary enclaves in clear contrast to Dwgn. Exposures cover parts of Cranberry Island and Friendship Long Island (Plate 2). Rhythmic, garnet-banded massive aplites on western Hall Island may be related.

Diorite-Tonalite Phase/Body (Dwqd/Dwgb)

The diorite-tonalite phase/body (Dwqd) includes quartz diorites and tonalites ranging from dark greenish-gray (5 GY 4/1), greenish gray (5 G 6/1), to greenish black (5 GY 2/1). Massive varieties are coarse-grained and occur in the Waterman Brook area of the Waldoboro East quadrangle. Weakly foliated to strongly lineated, medium to coarse-grained varieties occur in an arcuate outcrop pattern near the east margin of the Waldoboro Pluton Complex in the Waldoboro East and Friendship quadrangles (Plates 1, 2). Locally, 1.5 cm quartz augens exist with 3 cm feldspar porphyroclasts. Abundant diffuse autolithic enclaves and rare angular metasedimentary xenoliths occur south of Waterman Brook. Rare accidental garnets occur in the quartz diorites.

Small lenses and irregular bodies are found scattered in Dwgn (e.g. Pitchers Cove). Most are gradational with metasediments. These are not considered part of Dwqd because of location, size, and association with metasediments. Their appearance in outcrop is arguably both igneous-like and metamorphic-like. Isolated green-black (5 GY 2/1) shear pods of coarse-grained uralitized gabbro (Dwgb) and dioritic lenses < 0.3 m occur in calc-silicate gneisses and amphibolite schists (e.g. northeast Hall Island).

FIELD RELATIONS

Three schematic geologic cross sections through the Waldoboro Pluton Complex are shown in Figure 2 (see map). These illustrate the incorporation of metasedimentary rocks within the granitoids. The observed gradation between many granitoids and less refractory gneisses may continue at depth.

Contacts

The margin of the Waldoboro Pluton Complex exhibits variable permeation and injection characteristics. The western margin is predominantly gradational with texturally similar paragneisses of the Bucksport Formation. Strongly foliated nebulitic granitoids are found often with a concordant envelope of gneisses. This occurrence is repeated with inliers, of Bucksport-type lithologies, which are several kilometers long within the Dwgn. Associated are ubiquitous swarms of restitic metasedimentary enclaves.

Examples of these gradational contacts between Bucksport paragneisses and Dwgn granitoids include restitic garnets bridging transitional granitoids; nebulitic migmatites; disintegration of wall country rocks into relic enclaves and swarms; arrested segregations of recrystallized metasedimentary enclaves; gradation of granites sequentially with granodiorites and bedded gneisses; and ghost stratigraphy of former paragneisses showing tight to isoclinal folding. Lit-par-lit injections have locally resulted in numerous parallel layers of intrusives.

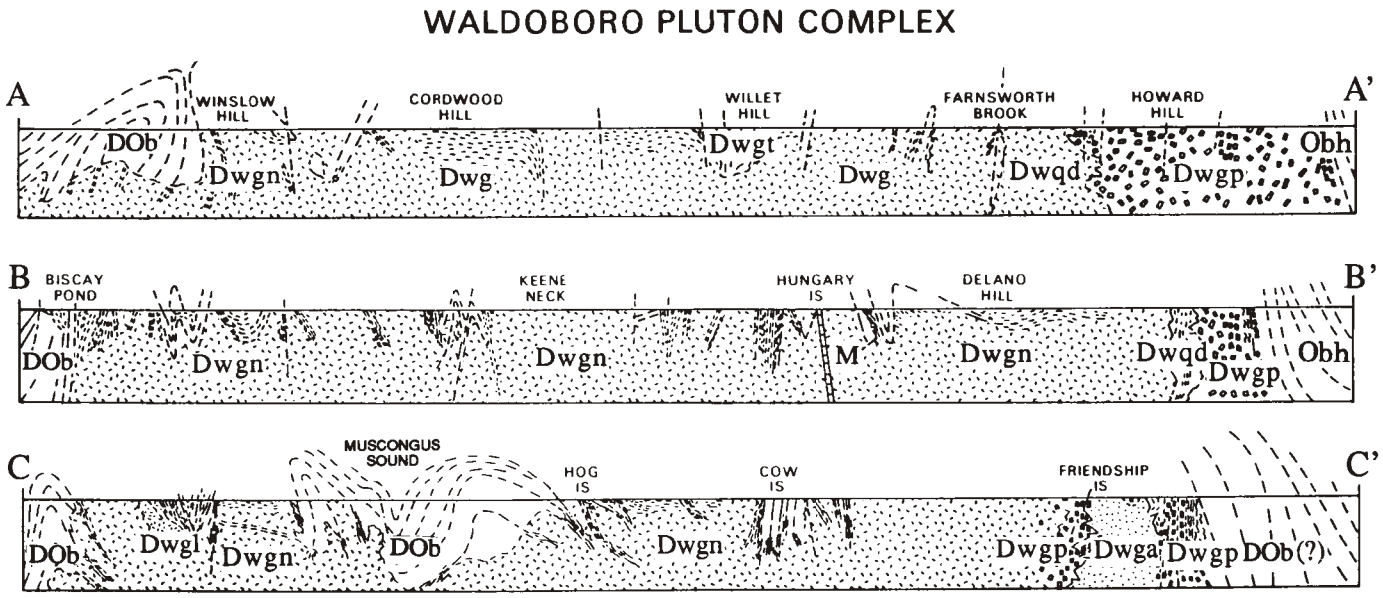

Figure 2. Geologic cross-sections through the Waldoboro Pluton Complex. Section locations shown on accompanying plates.

Spectacular contacts of local minor mixing within Dwgn only are evidenced by marked crenulated margins between granodiorites and granites. Unambigous intrusive-style contacts for the main granites of Dwgn with the country rock are not common.

The internal phase contact of Dwgn with Dwg is irregular and gradational. The apparent foliated margin of Dwgn to the northwest of Dwg may be related to phase separation of the melt-rich phase areas of Dwg. However no additional inferences can be documented for zonal boundaries in the field. The Dwgt phase is gradational with Dwg.

Two small plutonic bodies inferred northeast of Nobleboro by Newberg (1979) and defined by Osberg et al. (1985) are actually included in the mapped Dwgn and Dwgl (Plate 1). Injection contacts prevail in parts of the northwestern margin where observed in the Jefferson quadrangle. Also note that the Waldoboro Pluton Complex as mapped does not extend north of North Nobleboro as inferred by Osberg et al.(1985). Reconnaissance of granitoids on the west side of Damariscotta Lake (Newberg, 1979) and near Stickney Corner (Osberg et al., 1985) are texturally similar to Dwg. These very coarse-grained to porphyritic granitoids are sheetlike and probably are related to the Waldoboro Pluton Complex as mapped. Glacial deposits blanket the intervening areas. On the northeastern margin in the Union quadrangle, glacial deposits mask the contact except sporadically in western North Pond and Benner Brook Pond.

The western Dwqd contact with either Dwg or Dwgn is enigmatically gradational as mapped (Plate 1). A jointed amphibolite schist separates the Dwqd quartz diorites and Dwgn granites, not granodiorites, west of Waterman Brook. In another area east of the Goose River, contrasting foliations are observed. These may be contact areas. The remainder of the eastern contact with Dwg is obscured by wetlands. In contrast, the eastern contact with Dwgp is sharply defined. Xenoliths of quartz diorites exist in Dwgp. Lobate contacts (e.g. Howard Hill area, Plate 1) are associated with concomitant pegmatoid sheets. At the Black Ledges, these Dwgp-related pegmatoid sheets blanket Dwqd.

The eastern margin of the Waldoboro Pluton Complex is well defined. Where exposed in the northeast, Dwg discordantly intrudes the Megunticook Formation. Dwgp is coplanar along a shear zone adjacent to the quartzitic units of the Benner Hill Formation. The contact partly follows the Back River and Far Meadows area (Plates 1, 2). The sheared margin is more evident southward where a narrow migmatite zone and mylonitic textures exist. Evidence for Dwgp cutting Dwgn is suggested from the map pattern in the Friendship quadrangle. However, locally, field relations argue for a predominant gradational western contact with Dwgn. Often Dwgp is intercalated with Bucksport-Formation type rocks. Discordant contacts appear flattened and attenuated into concordant bands and streaks.

Dwga discordantly cuts Dwgp with a 5-16 cm aplite contact zone locally observed. Undigested Bucksport-Formation type rocks are disrupted (e.g. northern Cranberry Island). Angular xenoliths of Dwgp occur in Dwga about 28 m from inferred contacts. Elsewhere, Dwga intrudes Dwgn, but similar leucocratic varieties can be cryptic in the field (e.g. Cedar Island).

Otter Island and Beyer Ship Ledge have identical textural and mineralogical similarities with other melt-rich separation phases of Dwgn (Plate 2).

Mapped quartz dioritic to dioritic lenses in Dwgn and Dwgp have gradational contacts with amphibolites and amphibolite schists. Other dioritic bodies are sharply defined in localized shear zones in the southeastern margin of the Waldoboro Pluton Complex.

The extent of the southern margin of the Waldoboro Pluton Complex is not known as the granitoids project offshore. Exposed rocks of the Waldoboro Pluton Complex furthest offshore in Muscongus Bay are on Eastern Egg Rock and belong to Dwgp.

Foliations and Lineations

Foliations suggest a marked difference between the Dwg and Dwgn phases. The gentler foliations in Dwg do not however demonstrate zonal patterns within this phase. Many steeply inclined foliations are evident in Dwgn. Igneous foliations grade along strike with gneissic foliations in transitional Bucksport-Formation type lithologies. Both strike predominantly northeast. The map patterns suggest a general eastward dip to the foliations and appear locally to follow the steep limbs of close F_2 folds.

Many igneous flow foliations share a similar attitude (N20E) with S_0/S_1 surfaces in the Bucksport Formation country rock. These S_0/S_1 surfaces represent either gneissosity, schisosity, or compositional banding. Gneissic foliation essentially parallels the banding. S_1 has largely resulted from the transposition of tight to isoclinal microfolds, possibly accentuated by metamorphic differentiation. Many leucosomes are injected parallel to S_0/S_1 resulting in stromatic-type migmatites with a northeast fabric.

S_3 penetrative foliations accompanied by ML_3 lineations transect earlier igneous foliations and also ML_2 in the country rock. These strike predominantly northerly (N0-15E). Type II S surfaces in mylonites are occasionally developed, but C surfaces are visible only in thin section. Also indicative of S_3 are the ubiquitous swarms of aligned feldspar megacrysts in near-vertical foliation planes.

Folds

Polyphase deformation has generated at least two major folding episodes in the Waldoboro Pluton Complex (Table 1). Structural microfabric analyses (Sidle, l990) also support two coaxial folding events during D_2. This folding occurred synchronously with amphibolite-grade anatexis.

Synchronous folding in the granitoids is evidenced by marked S_1 and S_2 foliations in transitional granites. Ghosts of tight to isoclinal folds persist gradationally into these gneissic granitoids within Dwgn. Occasionally, an S_1 (?) surface is observed with small-scale folds in the main granitoids or rarely as contorted discoidal schlieren, not to be confused with local turbulent igneous flow patterns. This is more often observed in thin section. Arrested partial melting has left many diffuse enclaves, which were later folded resulting in very abundant swirls of schlieren. Smaller granitic injections are emplaced synchronously with F_2 folding. They occur shortened at a high angle to F_2. Other granitoids rarely exhibit broad open folds. Other apparent folds of granitoids are actually sheet-like intrusions interleaved with open folds in the Bucksport Formation.

Joints

Predominate steeply-dipping S_0/S_1 bedding or banding in the Bucksport Formation predisposed numerous bedding-plane joints to be orientated northeast. These may be continuous with faulting.

Evenly-spaced, planar, parallel joints are especially common in more melt-rich phases in Dwgn and Dwg. These reflect sub-horizontal igneous flow lines. They also separate porphyritic to very coarse-grained granitoids from medium-grained varieties.

Longitudinal joints and less often cross joints form near vertical linears. Many of the largest pegmatite dikes follow these northeast longitudinal master joint sets. They may form systematic, closely spaced 20-25 cm planar joint sets and may persist into the country rock. They form master joint sets (e.g. Back River Cove) and orthogonal joint patterns in the more massive granitoid varieties (e.g. upper Waterman Brook). Those continuous with fracturing are all oriented northeast. Rare pinnate joints in the fringe zone of master joints which have been reactivated exhibit rakes < 25 and have 8-15 cm wavelengths. Rib markings are noted.

Cross joints are commonly recognized by blue-gray to milky white quartz veining followed by aplitic and pegmatoid fillings up to 40 cm wide.

A distinctive set of closely spaced < 0.5 m hkl and cross joints(?) strike consistently northwest (e.g. eastern McCurdy Pond) cutting enclave swarms. They extend intermittently beyond the southeastern Waldoboro Pluton Complex margin at least to Maple Juice Cove. Associated with these are very fine fractures normal to Type S surfaces. They may be late magmatic or post- magmatic and appear as pervasive microveins in thin section westward at least to Dwqd. The relations between these northwest joint sets and northwest ML_4 lineations are not exposed.

Fractures

Fractures cut both the country rock and the granitoids of the Waldoboro Pluton Complex (Plates 1, 2). Of 87 fractures, the northeast set is most prominent, but is cut by northwest fractures. A summary of these mapped fractures digitized from Plates 1 and 2 is shown in Figure 3.

Figure 3. Summary of prominent fractures within the Waldoboro Pluton Complex.

Two fracture systems are recognized in the Waldoboro Pluton Complex. These are cataclasite-fault breccia and shear-mylonite types. The cataclasite-fault breccia zones occur throughout the Waldoboro Pluton Complex and include northeast and northwest orientations. These cut all structures except late mafic dikes and cut all granitoid phases. These fractures are clearly postmagmatic. Many of the fractures are several kilometers long. Minor kink faults are observed in metapelites with tight upright F_2 folds (e.g. northeast Louds Island). These brittle faults have a low angle of normal slip and either dextral or sinistral movement. Small-scale brittle faults are observed at a wide angle to northward shears (e.g. Black Town Road and Cranberry Island).

Shear zones mylonite are more restricted to the eastern part of the Waldoboro Pluton Complex occurring in the Dwgn, Dwgp, and Dwqd phases. All major shear-mylonite type fractures observed have sinistral slip and are all oriented north to northeast. They cut T_2 pegmatite dikes, are synchronous with some T_3 pegmatite dikes, and are cut by T_4 pegmatite dikes. They do not cut basalt dikes. Some shears may have been concomitant with Dwgp emplacement.

The degree of shearing is more intense along the easternmost margin of the Waldoboro Pluton Complex. Mylonitic zones with rotated xenolith blocks lay in a chaotic matrix of secondary micaceous material and quartz. Further, within the granitoids, narrow shear is recognized by Type II S structures, narrow channels of extremely attenuated, enclave-rich granitoids, and stair-step leucocratic veining. Field evidence for continued displacement is seen in some shears. The presence of low angle structures in the shears suggests rotation rates locally exceeded recrystallization rates. Foliation is subparallel to the shears and enclaves are flattened and displaced from bookshelf-type sliding. Walls are strained and are compatible with shear in the fracture zone. Ductile shear in some granitoids with sigmoidal schistosity also suggests continuous displacement during granitoid emplacement.

Four faults deserve further mention. The longest mapped fault trace extends discontinuously from west of Muscongus Harbor to Flying Passage (Plates 1, 2). The widest fracture zone occurs along parts of a fault trace extending from Havener Cove (Newberg, 1979) to south of Johnston Hill. Almost 6 m of silicified breccia, containing up to 3 cm of vuggy quartz, is measured locally. Next, an enigmatic 8 km erosional window occurs in thinning granitoids from McCurdy Pond to northwest of Round Pond (Plates 1, 2). Scree and only one small fault with normal slip to the east along a bedding plane is recorded. Possibly this narrow zone is an erosional fault trace (?). Finally, the Biscay Pond fault mapped in part and inferred along Biscay Pond is evidenced by several meters of mullions with 16 cm amplitudes, located on the southwest shore; and numerous sympathetic bedding-plane fractures. Probably, an intrusive contact along this bedding-plane fault forms the axis of the narrow 6.5 km pond and marsh.

Basalt and Diabase Dikes (M)

Twenty-eight unmetamorphosed mafic dikes (M) are observed intruding the Waldoboro Pluton Complex. They range from 5 cm to 2.5 m. Only mafic dikes greater than 1 m are mapped. The best exposures are on Wreck Island in the Louds Island quadrangle. The aphanitic basalt dikes (e.g. Wreck Island) are grayish black (N2) while the diabasic dikes appear

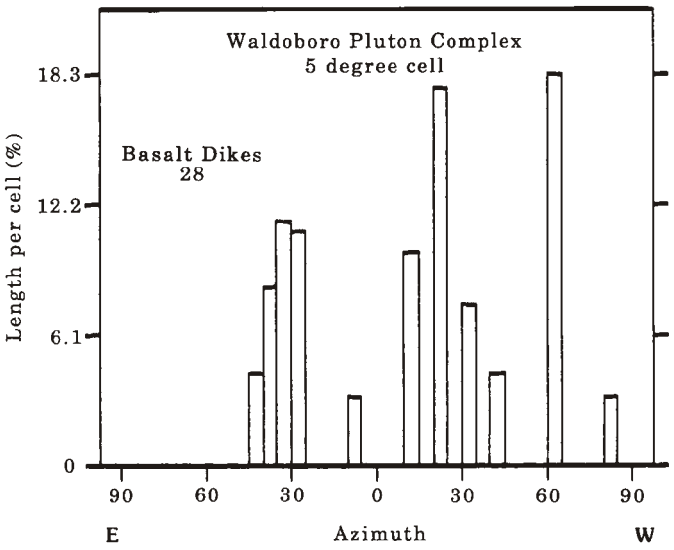

Figure 4. Histogram of azimuths of basalt dikes intruding the Waldoboro Pluton Complex.

TABLE 1: SUMMARY OF DEFORMATION AND RELATIVE EMPLACEMENT HISTORY OF THE WALDOBORO PLUTON COMPLEX

D_1:	F_1: Tight isoclinal; gently inclined; recumbent; intrafolial. S_0: Bedding. S_0/S_1: Compositional banding. S_1: Schistosity; gneissosity. ML_1: Boudinaged enclave; mineral lineation; pegmatoid boudin. M_2: Amphibolite
D_2:	F_2: Close; steeply inclined; $F_1 + F_2$ non-coaxial sheaths; $F_{2A} + F_{2B}$ coaxial interference. S_2: (S_{2A}/S_{2B}) Schistosity. L_2: Rodding; bedding/cleavage intersection; crenulations. ML_2: Mineral lineation; boudinaged enclave; pegmatoid boudin. M_2: Amphibolite. Fracture: Shear.
D_1-D_2:	Migmatization-anatexis Dwqd (?) emplacement. Dwgn, Dwgl, Dwg, Dwgt, emplacement. T_1, T_2 pegmatite/aplite dike emplacement
D_3:	S_3: Mylonite; Type II S; schistosity. ML_3: Mineral lineation; boudinated enclave; banding. Fracture: Shear; NE (?) brittle. Dwgp emplacement. Dwga emplacement. T_{3A}, T_{3B} pegmatite/aplite dike emplacement.
D_4:	ML_4(?): Mineral lineation. Fracture: NE + NW brittle. Joint: Pronounced NW sets M_3: Retrograde. T_4(?) pegmatite/aplite dike emplacement
D_5:	Basalt dike (M) emplacement.

weathered, olive black (5 Y 2/1) and rarely, spheroidal weathered (e.g. northwest Hockomock Channel).

These mafic dikes have not been folded and with one tentative exception are not faulted. On southwest Crane Island, an apparent offset is noted, but the gap between this dike is weathered. At least two episodes of dike injections are observed. Eight of nine aphanitic basalt dikes strike northwest (Figure 4). Eleven of 18 non-aphanitic basalt dikes strike parallel to the regional northeast structural fabric.

SUMMARY OF STRUCTURAL DEVELOPMENT

Detailed field mapping plus microfabric analyses and geochemistry (Sidle, 1990) suggest five marked deformation periods accompanied and postdated the Waldoboro Pluton Complex syntectonic granitoids. A preliminary assessment is summarized in Table 1.

Anatectic melting of Bucksport-type protoliths probably climaxed during late Acadian D_1 and D_2 compressional folding. The field relations and geothermobarometric calculations strongly suggest limited transport of the granitic melts. Pronounced D_3 shearing with late dynamic crystallization culminated along the eastern Waldoboro Pluton Complex margin. Some massive granitoid areas, particularly, within the Dwg were not significantly overprinted by these tectonic events.

Many migmatitic granitoids within Dwgn were perforated by abundant rest melts or pegmatite bodies during final differentiation. Late D_4 fracturing and attendant metasomatism are documented prior to decompression.

Final magmatism is represented by D_5 rift-margin basalts.

Part 2: Reconnaissance Bedrock Geology and Chemical Analyses of Meduncook-South Cushing Area Granitoids

INTRODUCTION

Previous field investigations by Newberg (1979), Hussey (1971), and Guidotti (1979) partly outlined a gabbroic or dioritic intrusion in the Cushing-St. George area. It was apparently not recognized by Chapman (1962). It represents the southwesternmost mafic suite named herein the Raccoon pluton and suggested here to belong to the coastal Maine magmatic province of Hogan and Sinha (1989).

Reconnaissance geologic mapping during 1988-1989 (Plates 1, 2) was part of a Ph.D. dissertation to determine the origin of quartz diorites occurring in the Waldoboro Pluton Complex (Sidle, 1990). This work involves a reconnaissance effort only in the Meduncook-South Cushing area bordering the St. George River fault (Hussey, 1971; Osberg et al., 1985) in Waldoboro East and Friendship 7 1/2' quadrangles. Note that this fault is not to be confused with the St. George (thrust) fault (Osberg et al., 1985).

PRELIMINARY PETROGRAPHY

Raccoon Gabbro (Drgb)

The type area is the Raccoon Ledges in southeast Waldoboro East quadrangle. Pyroxene cumulate layers occur among the fine-grained noritic gabbros. The topography in the Waldoboro East quadrangle around Fresh Pond is distinctly knobby and reflects the cumulate gabbro phase of the Raccoon gabbro intrusion. Normal gray-green (5 GY 2/1) gabbros and noritic gabbros (Drgb) with CI > 60 occur in the Raccoon mafic intrusion. Weathered surfaces are olive drab to brownish green (5 GY 2/2), knobby, and occasionally pockmarked with box workings.

Massive Drgb gabbros occur also in a less defined area west of South Cushing in the northern Friendship quadrangle.

Noritic, fine-grained, massive gabbros contain less than 38% anhedral, very low birefringent, non-pleochroic, green to colorless orthopyroxene (Table 2). These occur within the Raccoon gabbro as well as cumulate gabbros. The cumulate sequences observed and seen in thin section are Pl + Opx; Pl + Opx + Cpx; Pl. No olivine is observed in the cumulates in outcrop or in thin section.

Igneous lamination is weak to moderate in Drgb. Coalescence of grain growth suggests textural equilibrium. Distinct poikilitic textures are not evident, but are clearly evident in the cumulate gabbros on Monhegan and Manana Islands in the Monhegan quadrangle (Sidle, l990).

Normal gabbros appear to be more common with CI < 60, are medium to coarse-grained, equigranular, and show evidence of weak recrystallization. Clinopyroxenes include augites and ferroaugites, show weak exsolution lamellae on {100} and some dusty magnetite on diallage. Subordinate prismatic hypersthene is weakly pleochroic. Marked uralitized kelyphitic rims on orthopyroxene occur. Plagioclases have An_{58-66}, exhibit occasional deformation lamellae and seritization. Late anhedral magnetite is 4%. Rare pyrite, arsenopyrite, and chalcopyrite crystals appear in veinlets in the Raccoon gabbro. Locally, deuteric alteration is intense.

Raccoon Hornblende Gabbros (Drgbh)/Diorites (Drd)

Amphibole gabbros predominate with diorites (Drgbh/Drd) in the Raccoon gabbro intrusion mapped west of the St. George River fault. Weak secondary foliation is exhibited by decussate hornblendes which show alteration to biotite. Textures range from seriate to equigranular. Amphibole

TABLE 2: REPRESENTATIVE MODAL ANALYSES OF THE RACCOON INTRUSION.

(CIPW)	Drgb	Drgb	Dmgd	Dshg
Q	3.6	2.0	8.7	29.0
C	-	-	-	1.7
Or	1.0	0.7	21.2	27.9
Ab	10.5	18.9	51.5	26.1
An	35.1	33.9	4.9	6.6
Di	14.0	9.9	3.4	-
Hy	28.5	28.1	8.0	6.6
Ol	-	-	-	-
Mt	2.4	2.9	1.4	0.7
Il	4.3	2.9	0.8	1.0
Ap	0.6	0.7	0.1	0.4

(MODAL)	Drgb/Drd					Dcid
	WE589	F122	F491	F492	F503	F113
Qtz	-	-	2.9	tr	-	8.2
Ksp	-	-	4.3	tr	-	9.1
Plg	54.2	39.8	41.7	46.1	55.5	43.6
Olv	-	-	-	-	-	-
Opx	33.1	13.1	-	1.2	38.0	-
Cpx	8.9	33.7	27.3	23.1	2.4	-
Hbl	-	8.7	21.1	26.5	-	39.1
Bio	-	tr	4.2	3.1	-	-
Sph	-	tr	1.2	tr	-	tr
Mnt	3.8	1.9	1.6	tr	4.1	-
Ilm	-	2.8	tr	-	-	tr
Apt	tr	tr	tr	tr	tr	tr
Zir	-	tr	tr	tr	-	tr

segregations are common. Many amphiboles are strongly zoned. Some amphiboles are admixed with blue-green chlorite-type minerals. Seritization is moderate in strongly albite-twinned plagioclase cores. Quartz is present and subgrain polygonization is rare.

Diorites (Drd) have a wide variety of green hues, generally are the most weathered rocks, and are more coarse-grained in the Raccoon gabbro intrusion. They are principally are exposed from eastern Maple Juice Cove to Hornbarn Cove. Many of the diorites grade into quartz diorites and feldspathic monzodiorites. Rare masses of black tourmaline on small fractures with or without isolated pyrite or chalcopyrite are present. Seritization is moderate to intense. Sporadic polygonal quartz and rare microboundinage of amphiboles with shredded biotites occur. Euhedral sphene is abundant. The diorites may or may not share a sharp contact with gabbros. Tonalitic varieties occur proximal to Dshg. Local assimilation of the amphibolites and amphibolite schists are observed. The complex nature of the contacts between gabbros and diorites was not resolved.

Crotch Island Diorites/Amphibolites (Dcid)

An elongated northeastward-striking exposure of medium to coarse-grained diorites and quartz diorites (Dcid) occurs from northwest of Bradford Point south beyond Crotch Island. These foliated diorites intrude and are gradational with northeastward striking amphibolites and amphibolite schists. A wide variety of green hues and sporadic feldspathization(?) occur. The alkali feldspars are perthitic and microcline is exceptional. Reddish brown biotites are ragged and sphene is common.

Many of the Dcid diorites and quartz diorites appear to represent recrystallized amphibolite-rich metasedimatary rocks. The distinction is difficult except where shear pods or rotated and flattened garnet porphyroblasts are present. Fusiform enclaves are exceptional and further suggest the recrystallization origin of many of these dioritic-like lenses. The mapped Dcid includes most of the small-igneous-like dioritic rocks. The amphibolites and amphibolite schist probably continue on strike north of Hornbarn Cove where Drd diorites are mapped. Small-scale northwest structures served to discriminate texturally similar diorites of the Drd and Dcid bodies.

Meduncook Granodiorites/Granites (Dmgd)

The Meduncook granitoids (Dmgd), named herein, include medium-grained, light olive-gray (5 Y 6/1) to yellowish gray (5 Y 8/1), foliated to massive granodiorites and granites. These are distinctively enclave poor and are not associated with anatectic metasedimentary enclaves in contrast to Waldoboro Pluton Complex granitoids (Sidle, 1990). This appears to be a small body and lacks the pervasive porphyritic sheets so commonly associated with granitoids in the Waldoboro Pluton Complex.

Dmgd is moderately recrystallized. Subhedral green-brown biotite is greater than green slightly pleochroic amphibole. Plagioclases range from An_{22-31}.

They forcibly intrude parallel to Drgb along a narrow gneissic border that is observed in Kimble Cove and northwest of Fresh Pond. The Mgd intrusion bifurcates in predominantly granofels-textured quartzites and amphibolites between which the Meduncook River flows.

Spruce Head Granite (Dshg)

The Spruce Head granite (Dshg) cuts Drgbh/Drd. It is fine to medium-grained, ranges from very light gray (N8) to pinkish gray (5 YR 8/1). Dshg is moderately foliated to massive. Abundant tonalitic enclaves occur toward more autointrusive tonalite varieties. The distinctive attentuated and mingled-type enclaves are noted. The hybrid nature of the rocks is evident along northeastern Maple Juice Cove.

PRELIMINARY FIELD RELATIONS

Alternating cumulate layers, 3-11 cm thick, pyroxenes and plagioclase, where exposed, dip centripetally in the small Raccoon Ledge phase of the Raccoon gabbro intrusion. The few exposures suggest steeper east-facing intrusion walls towards the Meduncook River. A narrow gneissic border with Dmgd is partly exposed.

No chill margin of Drgb is exposed. Much of this phase has weathered into hummocky terrain masking the precise contacts with the country rocks. Elsewhere, poorly defined cumulate layers are sporadic near Kimble Cove and may be autobrecciated. The contacts with Drgbh/Drd are gradational. Chilled contacts between Drgbh/Drd and the metasediments are documented north of Hornbarn Cove. No contact aureole is evident. If present, it is strongly overprinted by subsequent deformations, plus is more difficult to recognize in the predominant quartzite and amphibolite country rocks.

Few northwestward foliations and lineations within the Raccoon gabbro intrusion, particularly the Drgb phase, contrast with the regional northeasterly fabric. They may be due to crystal sorting, flow differentiation, or local stress regimes. However, the igneous textures are intact in Drgb and subsolidus deformation is very weak.

Northwestward bedding strikes and steep dips are mapped. These are interpreted to be near the projection of the nose of a plunging anticline mapped by Guidotti (1979) immediately east of the St. George River in the Tenants Harbor quadrangle. A few lineations in Drgbh/Drd strike northwest, but the remainder are more northerly.

Two northwestward fractures associated with changes in bedding attitudes are mapped. One is related to marked northwesterly jointing that has been mapped from Maple Juice Cove into the Waldoboro Pluton Complex and may be due to a D_4 de-

formation episode (Sidle, 1990). These clearly postdate the Raccoon gabbro intrusions. The other is a bedding-plane fracture on the northwest limb of a large regional anticlinal fold (Guidotti, 1979) whose continuation is documented by this reconnaissance work and named the Maple Juice anticline.

Evidently, the Raccoon gabbros/diorites intruded the northern flank of the Maple Juice anticline following F_1/F_2 folding and in this reconnaissance area straddles its nose. Much of the intrusion here is made up of Drgbh, and contacts with Drd are uncertain. Hybrid tonalitic granioids occur, and at least one part of the lensoidal sheet-like intrusions is eroded, exposing rocks of the Benner Hill Formation(?). Its west limb must fade and/or abruptly swing northeastward near Hornbarn Cove. Regional fabric strikes northeasterly from west of Hornbarn Cove.

One brown 0.9 m orthopyroxene-rich auto-intruded dike is mapped in the Waldoboro East quadrangle. Three other dikes include black aphanitic basalts(?) and amphibolite in the Friendship quadrangle. Aplitic net-veining (e.g. Harthorne Point) helps distinguish gabbros from transitional dioritic varieties. The most extensive net-veining in the reconnaissance area occurs adjacent to the inferred St. George River Fault (Hussey, 1971).

Local shearing, gneissic foliation, and xenoliths of granodiorite and Benner Hill (?) quartzite in Drgbh occur along part of the eastern contact between Dmgd and Drgb/Drgbh. Reaction zones around the granitic xenoliths are clearly evident. These observations suggest that the gabbros are younger than Dmgd or possibly mixed with similar granitic magmas during emplacement.

Hybrid granitoids eastward toward Dshg are evidenced by microgranitoid swarms and attenuated and mingled-type tonalitic enclaves (Vernon et al., 1988). These occur in the undefined Drd of the Raccoon gabbro intrusion and proximal to granites and tonalites near and within Dshg. The mingling of similar viscous granitoid magmas associated with the Spruce Head pluton may account for the wisps and lobate embayed margins of these attentuated enclaves.

Gradations among the microgranitoid enclave swarms occur exclusively within the quartz diorites and diorites. Mapped enclaves occur largely in Drd and less commonly on Crotch Island. They are always fusiform and have either sharp or diffuse boundaries. They are strikingly similar to the Dwqd phase of the Waldoboro Pluton Complex (Sidle, 1990). It could not be determined if the microgranitoid boundaries exhibited a preferred direction of gradation. This may indicate that mixing was heterogenous in this area.

PRELIMINARY CHEMICAL ANALYSES

Rock chemistry data for five samples are reported in Table 3. The Drgb analyses support its gabbroic mineralogic composition. Sample WE589 represents a noritic gabbro with mesocumulate orthopyroxenes. Samples WE584 and WE602 are more massive fine-grained normal gabbros.

TABLE 3: GEOCHEMICAL ANALYSES OF SELECTED SAMPLES FROM THE RACCOON GABBRO (Drgb), THE SPRUCE HEAD GRANITE (Dshg), AND THE MEDUNCOOK GRANITOIDS (Dmgd).

	F-13-1 (Dshg)	WE-60-2 (Drgb)	WE-58-9 (Drgb)	WE-58-4 (Drgb)	WE-59-1 (Dmgd)
SiO_2	68.9	49.6	48.7	50.0	65.0
Al_2O_3	14.2	15.1	14.9	16.2	15.5
CaO	1.55	10.9	11.90	9.64	1.72
MgO	0.96	8.87	10.24	6.43	0.17
Na_2O	3.08	1.24	1.24	2.23	6.09
K_2O	4.73	0.17	0.17	0.12	3.59
Fe_2O_3	3.04	11.4	10.40	13.40	6.63
MnO	0.05	0.25	0.32	0.25	0.26
TiO_2	0.50	1.61	2.33	1.61	0.43
P_2O_5	0.16	0.31	0.29	0.31	0.06
LOI	1.08	0.1	0.49	0.23	0.54
Total	98.25	99.52	100.98	100.42	99.99
Rb	212	38	11	22	138
Sr	147	623	242	531	94
Y	45	23	23	19	88
Zr	156	<10	<10	<10	816
Nb	19	19	18	18	61
Ba	528	88	94	113	482
Be	4	nd	5	nd	10
Cs	3	nd	<0.5	nd	63.8
Li	nd	nd	nd	nd	nd
B	10	nd	<10	nd	10
F	nd	nd	nd	nd	nd
Pb	18	nd	<2	nd	8
Th	9.6	nd	<0.5	nd	6.7
U	2.3	nd	<0.5	nd	2.8
Hf	5	nd	1	nd	19
Ta	1	nd	1	nd	4
Sc	8.7	nd	39.4	nd	3.1
Zn	49	nd	160	nd	210
V	58	nd	480	nd	14
Cr	120	nd	100	nd	75
Co	8	nd	36	nd	2
Ni	9	nd	419	nd	1
Cu	2	nd	19	nd	3.5
La	21.7	nd	8.5	nd	21.9
Ce	53	nd	27	nd	58
Nd	24	nd	15	nd	36
Sm	5.1	nd	3.4	nd	7.2
Eu	1.3	nd	2	nd	3.1
Tb	1.1	nd	0.8	nd	1.3
Yb	3.3	nd	2	nd	3.8
Lu	0.49	nd	0.32	nd	0.54

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APPENDIX A
PRELIMINARY FIELD SUMMARY OF THE WALDOBORO PLUTON COMPLEX

Dwg: Biotite muscovite, weekly foliated, medium-grained, equigranular granite; locally massive; occasionally muscovite predominant; pink gray (5 YR 8/1) to light medium-gray (N6-N7); weathers to gray orange-pink (10 R 8/2) to very pale-orange YR 8/2); CI < 30; schlieren common; locally porphyritic sheets and irregular bodies.

Dwgt: Tourmaline-bearing, non-foliated, medium to coarse-grained, granite; locally porphyritic lenses; muscovite predominant over biotite; pinkish gray (5 YR 8/1) to very light-gray (N8); weathers to chalky, very light gray (N8); CI < 30.

Dwgn: Garnet-bearing, foliated, medium to coarse-grained granite, locally gneissic and gradational to granodiorite where femic mineral segregations and clots common; biotite predominant over muscovite; rare amphibole; CI < 50; grayish orange-pink (5 YR 7/2), yellow gray (5 Y 8/1), pink gray (5 YR 8/1) to greenish gray (5 GY 6/1) in gneissic varieties; ubiquitous schlieren and abundant boudinaged metasedimentary enclaves including large inliers of Bgs; neosomes common with nebulitic structures and gradational with Bgs; locally porphyroblastic; abundant porphyritic sheets and lenses; abundant pegmatoid dikes, sheets, and irregular bodies; stromatic and folded-type migmatites common and continue beyond mapped Dwgn.

Dwgl: Leucocratic fine to medium-grained, weakly to non-foliated equigranular granite; occasional garnet; CI<25; very light-gray (N8) to pale pink (5 RP 8/2); rarely bluish white (5 B 9/1) in quartz rich varieties; includes numerous pods and lenses; rare enclaves.

Dwqd: Weakly foliated to strongly lineated medium to very coarse-grained quartz diorite; CI < 70; dark greenish-gray (5 GY 4/1), greenish gray (5 G 6/1), to green black (5 GY 2/1); biotite and amphibole proportions variable; rare quartz augens; abundant metasedimentary and autolithic (?) enclaves; locally gradational with Bgs amphibole schists with feldspar porphryoblasts; rare garnet; includes smaller mapped bodies within Dwgn.

Dwgr: Isolated shear pods and irregular lenses of medium to coarse-grained uralitized gabbro in Dwqd/Bgs amphibole schist; green black (5 GY 2/1).

Dwgp: Feldspathic, sheared porphyroblastic meta-granite porphyry; locally augens 11 cm with visible grain pressure shadows in protomylonite; ubiquitous enclaves of Bgs (?), locally several tens of meters; associated non-aligned quartz and feldspar laths in porphyry sheets and irregular bodies.

Dwga: Leucocratic, fine sugary to medium-grained, weak to nonfoliated aplitic muscovite-granite; occasional garnet-bearing; very light-gray (N8), white (N9), to pink gray (5 YR 8/l); rare xenoliths; rare lit-par-lit.

P/A: Pegmatite bodies mapped include dikes greater to or equal than 1 m and an irregular body in Dwgp; simple zoned types predominate in, T_1, T_2, T_{3A}, and T_4; rare beryl complex type in T_2, rare spodumene-lepidolite complex zoned in T_{3B}; locally well-developed garnet-bearing rhythmically layered sheets and dikes in T_3; Aplites are less common.

M: Porphyritic diabase dikes; rare aphanitic basalt; black (N1)to dark gray (N3); rare spheroidal weathering to Feox ochres.

DOb (undiff.): Bucksport Formation (in mapped area): predominantly, alternating biotite gneiss and biotite-amphibolite gneiss; occasional amphibolite; locally meta-graywacke and meta-pelite with pronounced slaty cleavage; locally garnet-sillmanite schist and tourmaline schist; generally fine-grained and fine banding <3 cm common in gneissic calc-silicate varieties; commonly gradational to Dwgn; locally well-developed gross banding with paleosomes; alternating greenish-gray (5 G 4/1) with yellowish gray (5 GY 8/1) to very light-gray (N8) with medium light-gray (N6); weathering to very dusky red (10 R 2/2) and dusky brown (5 YR 2/2) largely in meta-pelite members.

DObsh: Garnet-sillmanite schist and tourmaline schist; two continuous mapped units shown; numerous smaller beds, enclaves convoluted with neosomes of Dwgn.

Obh (undiff.): Benner Hill Formation (in mapped area): biotite quartzite; finely laminated: stromatic migmatites adjacent to Dwgp; occasional banded amphibolite with meta-graywacke and meta-pelite; medium gray (N5), medium bluish-gray (5 B 5/1), to dark greenish-gray (5 G 4/1); distinctive ribbed weathered surface and to very dusky-red (10 R 2/2) and dusky brown (5 YR 2/2); occasional protomylonitic to mylonitic streaks and limited stromatic migmatites bordering Dwgp.

Plate 1

Reconnaissance Bedrock Geology of the Waldoboro Pluton Complex and other Intrusive Rocks in Coastal Lincoln and Knox Counties, Maine

by
William C. Sidle

Maine Geological Survey
DEPARTMENT OF CONSERVATION
Walter A. Anderson, State Geologist

OPEN-FILE NO. 91-3

1991

- Strike and dip of S_0 bedding; S_0/S_1 compositional banding; S_1 schistosity; (vertical)
- Igneous flow layer; S_1 gneissic foliation; S_2 axial cleavage; S_3 mylonitic foliation; (open triangle = dip < 20°)
- Horizontal igneous flow layer
- Vertical igneous flow layer; S_1 gneissic foliation; S_2 axial cleavage; S_3 mylonitic foliation
- Strike and dip of joint (predominant set i.e. parallel, cross, or longitudinal); (open rectangle = dip < 20°)
- Horizontal joint
- Vertical joint
- Bearing of L_2 bedding/cleavage intersection and crenulation; or ML_1 boudinaged enclave and mineral lineation; or ML_2 mineral lineation and pegmatoid augen
- Bearing of ML_3 boudinaged enclave and mineral lineation
- Quartz vein
- T_2, T_3, and T_4 pegmatite and aplite dikes ≥ 1m
- Diabase and basalt dikes
- Shear fracture with slickensides, breccia, or mullions
- Inferred thrust or reverse fault(?)
- Mineral lineation on fracture
- Inferred fracture from aerial photo with field-evident jointing or dikes
- Approximate contact
- Inferred contact
- Migimatitic limit
- NM — Not mapped (within Waldoboro Pluton Complex)

IGNEOUS ROCKS

Waldoboro Pluton Complex Granitoids

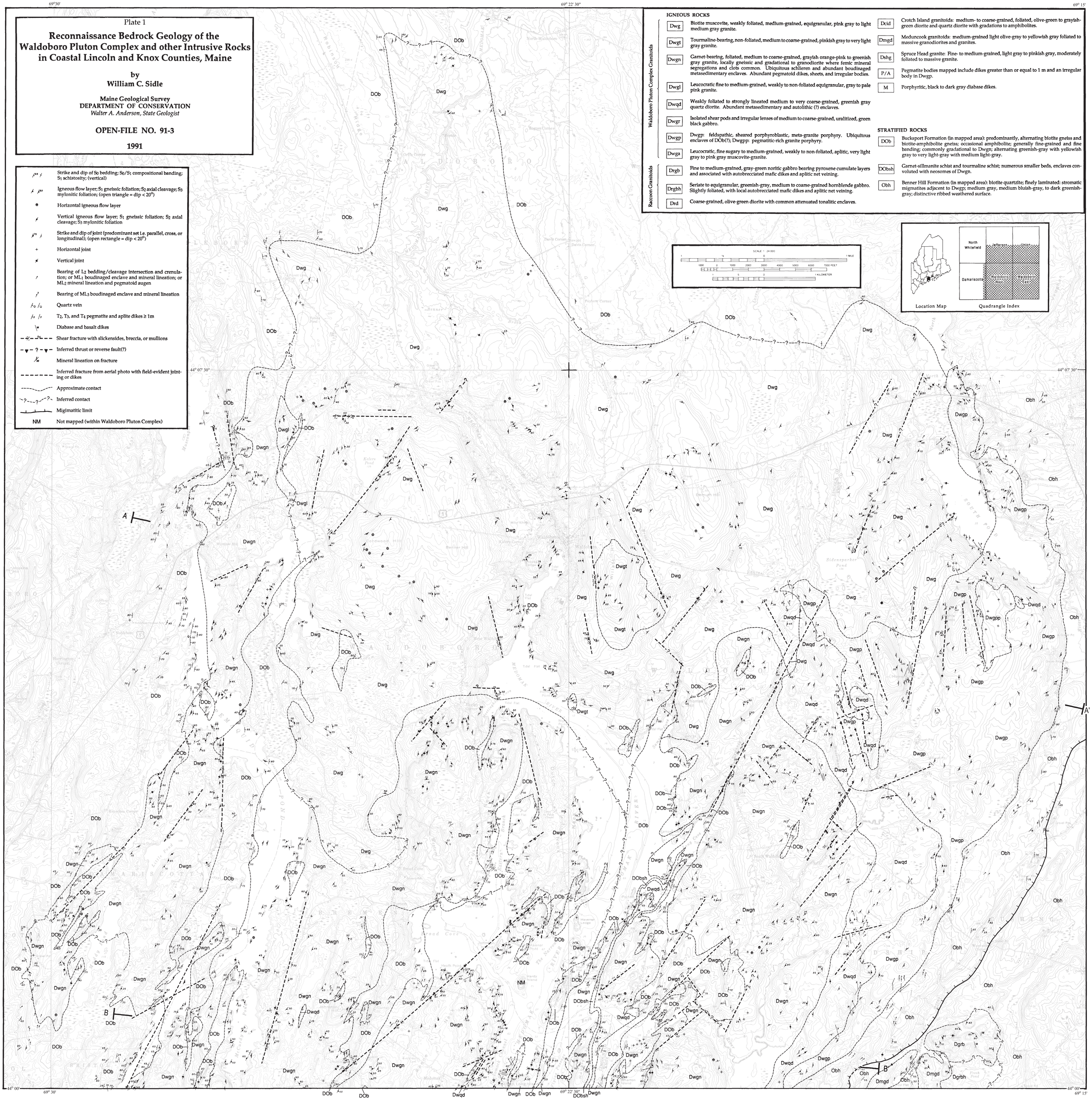
- **Dwg** — Biotite muscovite, weakly foliated, medium-grained, equigranular, pink gray to light medium gray granite.
- **Dwgt** — Tourmaline-bearing, non-foliated, medium to coarse-grained, pinkish gray to very light gray granite.
- **Dwgn** — Garnet-bearing, foliated, medium to coarse-grained, grayish orange-pink to greenish gray granite, locally gneissic and gradational to granodiorite where femic mineral segregations and clots common. Ubiquitous schlieren and abundant boudinaged metasedimentary enclaves. Abundant pegmatoid dikes, sheets, and irregular bodies.
- **Dwgl** — Leucocratic fine to medium-grained, weakly to non-foliated equigranular, gray to pale pink granite.
- **Dwqd** — Weakly foliated to strongly lineated medium to very coarse-grained, greenish gray quartz diorite. Abundant metasedimentary and autolithic (?) enclaves.
- **Dwgr** — Isolated shear pods and irregular lenses of medium to coarse-grained, uralitized, green black gabbro.
- **Dwgp** — Dwgp: feldspathic, sheared porphyroblastic, meta-granite porphyry. Ubiquitous enclaves of DOb(?); Dwgpp: pegmatitic-rich granite porphyry.
- **Dwga** — Leucocratic, fine sugary to medium-grained, weakly to non-foliated, aplitic, very light gray to pink gray muscovite-granite.

Raccoon Granitoids

- **Drgb** — Fine to medium-grained, gray-green noritic gabbro bearing pyroxene cumulate layers and associated with autobrecciated mafic dikes and aplitic net veining.
- **Drgbh** — Seriate to equigranular, greenish-gray, medium to coarse-grained hornblende gabbro. Slightly foliated, with local autobrecciated mafic dikes and aplitic net veining.
- **Drd** — Coarse-grained, olive-green diorite with common attenuated tonalitic enclaves.
- **Dcid** — Crotch Island granitoids: medium- to coarse-grained, foliated, olive-green to grayish-green diorite and quartz diorite with gradations to amphibolites.
- **Dmgd** — Meduncook granitoids: medium-grained light olive-gray to yellowish gray foliated to massive granodiorites and granites.
- **Dshg** — Spruce Head granite: Fine- to medium-grained, light gray to pinkish gray, moderately foliated to massive granite.
- **P/A** — Pegmatite bodies mapped include dikes greater than or equal to 1 m and an irregular body in Dwgp.
- **M** — Porphyritic, black to dark gray diabase dikes.

STRATIFIED ROCKS

- **DOb** — Bucksport Formation (in mapped area): predominantly, alternating biotite gneiss and biotite-amphibolite gneiss; occasional amphibolite; generally fine-grained and fine banding; commonly gradational to Dwgn; alternating greenish-gray with yellowish gray to very light-gray with medium light-gray.
- **DObsh** — Garnet-sillmanite schist and tourmaline schist; numerous smaller beds, enclaves convoluted with neosomes of Dwgn.
- **Obh** — Benner Hill Formation (in mapped area): biotite quartzite; finely laminated: stromatic migmatites adjacent to Dwgp; medium gray, medium bluish-gray, to dark greenish-gray; distinctive ribbed weathered surface.



69° 30'
44° 00'
69° 22' 30"
69° 15'
43° 52' 30"

Plate 2

Reconnaissance Bedrock Geology of the Waldoboro Pluton Complex and other Intrusive Rocks in Coastal Lincoln and Knox Counties, Maine

by
William C. Sidle

Maine Geological Survey
DEPARTMENT OF CONSERVATION
Walter A. Anderson, State Geologist

OPEN-FILE NO. 91-3

1991

SCALE 1 : 24 000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETER

IGNEOUS ROCKS

Waldoboro Pluton Complex Granitoids

- **Dwg** — Biotite muscovite, weakly foliated, medium-grained, equigranular, pink gray to light medium gray granite.
- **Dwgt** — Tourmaline-bearing, non-foliated, medium to coarse-grained, pinkish gray to very light gray granite.
- **Dwgn** — Garnet-bearing, foliated, medium to coarse-grained, grayish orange-pink to greenish gray granite, locally gneissic and gradational to granodiorite where femic mineral segregations and clots common. Ubiquitous schlieren and abundant boudinaged metasedimentary enclaves. Abundant pegmatoid dikes, sheets, and irregular bodies.
- **Dwgl** — Leucocratic fine to medium-grained, weakly to non-foliated equigranular, gray to pale pink granite.
- **Dwqd** — Weakly foliated to strongly lineated medium to very coarse-grained, greenish gray quartz diorite. Abundant metasedimentary and autolithic (?) enclaves.
- **Dwgb** — Isolated shear pods and irregular lenses of medium to coarse-grained, uralitized, green black gabbro.
- **Dwgp / Dwgpp** — Dwgp: feldspathic, sheared porphyroblastic, meta-granite porphyry. Ubiquitous enclaves of DOb(?); Dwgpp: pegmatitic-rich granite porphyry.
- **Dwga** — Leucocratic, fine sugary to medium-grained, weakly to non-foliated, aplitic, very light gray to pink gray muscovite-granite.

Raccoon Granitoids

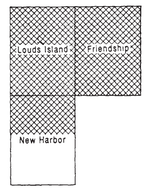
- **Drgb** — Fine to medium-grained, gray-green noritic gabbro bearing pyroxene cumulate layers and associated with autobrecciated mafic dikes and aplitic net veining.
- **Drgbh** — Seriate to equigranular, greenish-gray, medium to coarse-grained hornblende gabbro. Slightly foliated, with local autobrecciated mafic dikes and aplitic net veining.
- **Drd** — Coarse-grained, olive-green diorite with common attenuated tonalitic enclaves.
- **Dcid** — Crotch Island granitoids: medium- to coarse-grained, foliated, olive-green to grayish-green diorite and quartz diorite with gradations to amphibolites.
- **Dmgd** — Meduncook granitoids: medium-grained light olive-gray to yellowish gray foliated to massive granodiorites and granites.
- **Dshg** — Spruce Head granite: Fine- to medium-grained, light gray to pinkish gray, moderately foliated to massive granite.
- **P/A** — Pegmatite bodies mapped include dikes greater than or equal to 1 m and an irregular body in Dwgpp.
- **M** — Porphyritic, black to dark gray diabase with rare aphanitic black basalt dikes.

STRATIFIED ROCKS

- **DOb** — Bucksport Formation (in mapped area): predominantly, alternating biotite gneiss and biotite-amphibolite gneiss; occasional amphibolite; generally fine-grained and fine banding; commonly gradational to Dwgn; alternating greenish-gray with yellowish gray to very light-gray with medium light-gray meta-pelitic members.
- **DObsh** — Garnet-sillmanite schist and tourmaline schist; numerous smaller beds, enclaves convoluted with neosomes of Dwgn.
- **Obh** — Benner Hill Formation (in mapped area): biotite quartzite; finely laminated: stromatic migmatites adjacent to Dwgp; medium gray, medium bluish-gray, to dark greenish-gray; distinctive ribbed weathered surface.

- Strike and dip of S_0 bedding; S_0/S_1 compositional banding; S_1 schistosity; (vertical)
- Igneous flow layer; S_1 gneissic foliation; S_2 axial cleavage; S_3 mylonitic foliation; (open triangle = dip < 20°)
- Horizontal igneous flow layer
- Vertical igneous flow layer; S_1 gneissic foliation; S_2 axial cleavage; S_3 mylonitic foliation
- Strike and dip of joint (predominant set i.e. parallel, cross, or longitudinal); (open rectangle = dip < 20°)
- Horizontal joint
- Vertical joint
- Bearing of L_2 bedding/cleavage intersection and cremulation; or ML_1 boudinaged enclave and mineral lineation; or ML_2 mineral lineation and pegmatoid augen
- Bearing of ML_3 boudinaged enclave and mineral lineation
- Quartz vein
- T_2, T_3, and T_4 pegmatite and aplite dikes ≥ 1m
- Diabase and basalt dikes
- Shear fracture with slickensides, breccia, or mullions
- Inferred thrust or reverse fault(?)
- Mineral lineation on fracture
- Inferred fracture from aerial photo with field-evident jointing or dikes
- Approximate contact
- Inferred contact
- Migimatitic limit
- NM — Not mapped (within Waldoboro Pluton Complex)

Quadrangle Index



Location Map