Explanation to Accompany the

PRELIMINARY BEDROCK GEOLOGIC MAPS OF THE LYNN AND MARBLEHEAD SOUTH QUADRANGLES, MASSACHUSETTS

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1977

Explanation

(Information for correlation and sequence of units)

Stratified rocks	Age or permissable time interval	Intrusive rocks
Beach tombolo, and unconsolidated deposits	Recent	
Boston Bay Group, undivided	Late Pennsylvanian to Early Devonian	
Lynn Volcanic Complex	Early Devonian or Late Silurian	Cape Ann Plutonic Series Peabody Granite Nordmarkite Reddish granite and syenite Quartz diorite at Little Nahant Olivine gabbro Nahant gabbro Salem gabbro-diorite
Weymouth Formation	Lower Cambrian	
	Ordovician?? to Late Precambrian	Dedham Granodiorite
Blackstone Series Cat Rock Volcanic Complex	Late Precambrian	

STRATIFIED ROCKS

Btu — UNCONSOLIDATED BEACH AND TOMBOLO DEPOSITS (RECENT) -- Sand beaches, sand and cobble shingle beaches, and mucky salt marsh deposits of post glacial age.

BBG

BOSTON BAY GROUP (UNDIVIDED) (DEVONIAN? to PENNSYLVANIAN?) -- Rocks from drill holes near the Sagus River consists of dark gray shale, light- to dark-gray, shaly appearing siltstone, and buff to pale green or greenish-gray tuffaceous siltstone as beds ranging from less than a millimeter to several centimeters thick. These rocks are not metamorphosed. Constituents recognizable in thin section are quartz, orthoclase, oligoclase, andesine, micas, a carbonate mineral, and opaque matter. Minute, angular grains of quartz and feldspars constitute 50 to 75 percent of these rocks. Chlorite may constitute as much as 20 percent of tuffaceous siltstone. Mica other than chlorite constitutes about 1 to 3 percent; the flakes are minute, randomly oriented, and seemingly detrital; it is mostly colorless, but occasional flakes of brown biotite occur in some sections. Calcite, or possibly dolomite or ankerite, forms tiny clots and is the interstitial cementing medium of parts of these rocks. Semi-opaque to opaque brown to green amorphous-appearing substance constitutes 20 to 50 percent and is the interstitial or cementing medium of the greater part of these rocks.

LYNN VOLCANIC COMPLEX (SILURO-DEVONIAN) --

Lv

Drab rhyolitic facies -- Predominantly porphyritic flow rock and welded tuff crudely interlayered with minor lenses of tuff, tuff breccia, and agglomerate. These rocks are dull shades of gray, greenish-gray, reddish-gray, or buff; minor lenses, streaks, and blotches of darker brownish- to purplish-red rock are enclosed in them. They mostly weather to grayish or whitish surfaces characterized by spalling of thin chips 1/2 to 1 1/2 cm. diameter. These rocks differ from those of the reddish rhyolitic facies by color, by having a slightly greater proportion of plagioclase phenocrysts, by having more abundant spherulites, and by having none or very little dust-like iron oxide dispersed in the groundmass. Parts of these rocks contain detritus derived from the subjacent Dedham Granodiorite.

Lv

Andesitic facies --Very fine-grained, dark gray or dark greenish-gray, dense, featureless rock except for scattered amygdules. It is cut by many small, irregular veins and veinlets of epidote. Thin sections show this rock to be somewhat porphyritic, tiny plagioclase phenocrysts being enclosed in a very fine-grained pilotaxitic groundmass. It is considerably altered, all feldspar being completely clouded by saussuritization; phenocrysts are partly replaced by epidote; mafic minerals have been completely altered to chlorite. It consists of about 65 percent crudely aligned plagioclase microlites, 1 percent plagioclase phenocrysts, 5 to 10 percent epidote, 5 to 10 percent chlorite, 5 percent dusty to finely granular opaque matter, and the remainder being greenish to brownish semi-opaque interstitial matter. The plagioclase is andesine or labradorite; its altered condition precludes a more exact identification. The amygdules consist of extremely fine-grained, semi-opaque gray substance cut by minute quartz veinlets.

Lv

Agglomeratic-tuffaceous facies --Mainly pyroclastic rocks, agglomerate, tuff breccia, and tuff, enclosing minor lenses of welded tuff and flow rock. These rocks are predominantly brownish-red, purplish-red, or pinkish and enclose minor lenses of gray, buff, or pale green to greenish-gray rock. The surfaces of the reddish parts retain their color or become darker red when weathered; the other parts weather to grayish or whitish surfaces. These rocks range from very fine-grained equigranular tuffs to coarss agglomerates having large angular fragments. The finer-grained tuffs contain large proportions of cryptocrystalline shards, the remainder of the rock being a cryptocrystalline to semicryptocrystalline mixture of quartz and feldspars. Somewhat coarser-grained tuffs contain from 1 to 20 percent subhedral to anhedral feldspar crystals, generally having corroded and rounded edges, in a fine-grained tuffaceous matrix. The feldspars are incipient or poorly developed microperthite, albite, and oligoclase. The agglomerates consist of fragments of volcanic rock, mostly rhyolitic,

but including minor quantities of andesite and basalt, in a tuffaceous matrix. Welded tuff and flow rock are as described above. Parts of these rocks contain minor quantities of detritus derived from the subjacent Dedham Granodiorite.

Lv

Reddish rhyolitic facies -- Predominantly welded tuff and porphyritic flow rock crudely interlayered with minor lenses of tuff, tuff breccia, and agglomerate. Brownish-red to purplish-red rocks enclosing minor irregular streaks, lenses, and blotches of gray, greenish-gray, buff, or pinkish rock. The reddish parts weather to a dark red surface; the other parts mostly weather to grayish or whitish surface. All of this rock having flow banding or which is massive and nearly devoid of fragmental volcanic material is porphyritic; phenocrysts constitute from 1 to 10 percent of the rock. A third or less of the phenocrysts are quartz; a very minor proportion of them are albite or oligoclase, and the remainder are incipient or poorly developed microperthite (they have been called anorthoclase). The phenocrysts mostly are subhedral, commonly are corroded and partly rounded; many of the feldspar phenocrysts are broken. The groundmass generally is extremely fine-grained, flinty-appearing, holocrystalline, grading locally to microcryptocrystalline;

it consists of quartz and feldspars, occasional grains of hornblende, and accessory minute apatite and zircon crystals; the color of reddish and pinkish rock is caused by disseminated dust-like iron oxide in the groundmass. The welded tuff contains abundant shards and small rock fragments. Tuff also contains abundant shards. Fragmental material in tuffs, welded tuffs, and agglomerate is almost wholly porphyritic rhyolite; occasional fragments of andesite and basalt can be found, and near contacts, debris from the subjacent Dedham Granodiorite. Some of these rocks, particularly the porphyritic facies, contain minute spherulites.

WF

WEYMOUTH FORMATION (LOWER CAMBRIAN) -- Very fine-grained, dark gray, dark greenish-gray, or black hornfelsed shale and siltstone. The lower part of the exposure includes beds of white to pale green fossiliferous limestone 6 to 24 inches (about 15 to 24 cm) thick. Shale and siltstone beds range from a half inch to 24 inches (about 1.5 to 60 cm) thick. Some of the beds contain layers of flattened, ellipsoidal greenish nodules of calc-silicate minerals that range from a half inch to 2 inches (about 1.5 to 5 cm) in maximum dimension; these bodies seem to be altered calcareous concretions. The shale and siltstone weathers brownish where exposed beyond the reach of ocean waves. Minute grains of detrital quartz are a minor constituent of shale, and constitute as much as 75 percent of siltstone beds. Minute granules of epidote are abundant in all of this rock. Some of the shaly beds contain minor quantities of mica, mostly brown biotite, but some is almost colorless. These rocks contain large proportions of semi-opaque to opaque matter that cannot be identified by optical methods.

BLACKSTONE SERIES(?) (LATE PRECAMBRIAN?) --

CRv

Cat Rock Volcanic Complex -- Fine-grained, dark gray, dark greenish gray, or black mafic metavolcanic rock. It is intruded by many irregular veinlets of epidote and of Peabody Granite. Metamorphic foliation parallels bedding or layering; many local distortions of it are caused by epidote and granite veinlets. Except for introduced material and opaque matter, the rock is equigranular, consisting of: plagioclase, 30-50 percent; hornblende, 50-70 percent; opaque granules, 0.5-2 percent. The plagioclase is untwinned oligoclase. All of this rock contains clots and veinlets of introduced epidote and of quartz, occasionally accompanied by minor quantities of potassium feldspar and microperthite.

BSu?

Blackstone Series undivided? -- Fine-grained, whitish, light gray, or gray quartzite and biotite-feldspar-quartz gneisses. Thinly bedded or layered. Metamorphic foliation parallels bedding, is indicated by alignment of biotite flakes. Rock from different outcrops varies considerably in composition. The ranges are: quartz 50-80 percent; feldspars 15-40 percent; biotite 0-10 percent; other constituents 0.1-2 percent. Quartz and feldspar grains tend to be blocky and angular. Quartz has strong undulatory extinction. Feldspars generally are clouded by a very fine flaky micaceous alteration product, and species generally cannot be determined by optical methods; oligoclase or andesine can be recognized in some specimens. Biotite, where unaltered, is dark brown or dark tan; in much of this rock it is partly bleached or chloritized. Skeletal crystals of pink or reddish garnet enclosing quartz, feldspar, and biotite are very minor constituents of some of these rocks. Dust-like particles or minute granules of opaque matter are present in all of these rocks and may constitute as much as 2 percent of them.

INTRUSIVE ROCKS

ROCKS OF THE CAPE ANN PLUTONIC SERIES (SILURO-DEVONIAN)--

CApg

PEABODY GRANITE -- Medium- to coarse-grained rock having a generally even granitic texture. Unweathered rock is pale green to greenish gray and is sparsely speckled with black mafic minerals. Weathering causes the rock to become pale pinkish-brown or cream-colored. Unweathered feldspars are pale green and have a conspicuous greasy luster. The proportions of constituents vary considerably from place to place within this granite. It is composed of 50-75 percent microperthite, 15-40 percent quartz, 1-5 percent plagioclase, 5-10 percent mafic minerals, and accessory magnetite, titaniferous magnetite, sphene, allanite, zircon, and sulfide minerals. Microperthite forms the largest crystals, tending to be elongate subhedral and having maximum dimensions ranging from 5 to 15 mm; it commonly occurs as Carlsbad twins, the twinning plane being parallel to the long axis of the crystal; a minor proportion of microperthite occurs as small interstitial grains. Quartz is glassy to smoky, occurs mostly as anhedral grains slightly smaller than those of microperthite; it contains abundant dust-like microlitic particles and has moderate to strong undulatory extinction; a small proportion

of quartz occurs as tiny interstitial grains, and in some specimens there are interstitial grains or masses of micrographic quartz-feldspar intergrowths. Plagioclase occurs mostly as interstial grains but may form an occasional large grain; small segregations of plagioclase occur within some of the larger microperthite grains; most of the plagioclase is oligoclase, a minor proportion is albite. The mafic constituents occur mostly as clots or aggregates, generally less than 0.5 mm diameter; some occur partly as interstial grains. About half of the mafic material is common green hornblende forming much of the clots and occurring as scattered small grains. The clots are composed of two or more minerals, commonly displaying a reaction series; an occasional clot encloses a remnant of pale green augite; green hornblende and small proportions of secondary iron- and sodium-rich amphiboles, of which riebeckite, kataphorite, hastingsite, and glaucophane may be present, form the bulk of the clots; biotite is a very minor constituent and is not found in much of the rock. The accessory minerals occur as minute crystals and granules enclosed within and lying on the borders of mafic grains and clots. Magnetite or titaniferous

magnetite granules are most abundant. Apatite may or may not be present in a particular specimen. Minute zircons are abundant; there are two generations of zircons, one consisting of rounded, corroded, and mostly fractured and discolored crystals that probably are metamict, and the other consisting of euhedral, colorless or nearly colorless crystals. Allanite occurs as small tan or reddish brown crystals and granules. Mafic minerals in contact with zircon and allanite display dark haloes. Occasional grains of yellow, brown, and reddish brown minerals that have not been identified also are associated with the mafic clots

CAn

NORDMARKITE -- Coarse-grained rock having granitic to ophitic texture characterized by large elongate, crudely aligned feldspar crystals. The feldspar crystals commonly are Carlsbad twins, the twinning plane being parallel to the long axis of the crystal. Feldspars of freshly broken rock from below the zone of surface weathering are light greenish gray and have a conspicuous greasy luster. Weathering causes the feldspars to become brownish. Depending upon the degree of weathering the rock varies from light greenish gray to dark brown and is speckled with black mafic minerals. This rock is composed of 70-80 percent microperthite, 1/2-2 percent oligoclase, 1-5 percent quartz, 10-15 percent mafic constituents, 1-2 percent opaque minerals, and accessory apatite and zircon. Quartz occurs as scattered grains as much as 8 mm diameter and as minute grains interstitial to feldspars; it is clouded by dust-like particles, and has weak to moderate undulatory extinction. Feldspar grains are subhedral to anhedral, may have maximum dimensions as much as 15 mm, and have partly sutured boundaries. Mafic constituents display a reaction series; cores of the larger grains, about 5 mm diameter, or of aggregates of minerals,

are commonly pale green augite surrounded by an irregular, and for some aggregates discontinuous, rims of green hornblende. In some aggregates of mafic minerals there is a minor development of reddish brown biotite. Other mafic aggregates are partly or wholly altered to fibrous yellowish-brown kataphorite, commonly forming rosettes. The mafic minerals are somewhat poikilitic, enclosing small feldspar grains. Small inclusions of augite and hornblende occur within feldspar crystals. Magnetite or titaniferous magnetite occurs as small granules within and adjacent to the mafic constituents. Minute zircons are abundant; euhedral forms are uncommon, most of the grains being rounded, and many are fractured or are fragments. Minute fractures in the rock from the zone of weathering are filled with yellowish to brownish amorphous, semi-opaque matter, mainly iron oxides

CAs

REDDISH SYENITE AND GRANITE -- Medium- to coarse-grained, pinkish to salmon-red rocks generally having an even granitic texture but locally grading to semi-porphyritic and occurring as small bodies within diorite and gabbro. These rocks are mostly syenitic but are variable within a body, grading to granite. Weathering causes deep intergranular disintegration. Compositions range from syenitic facies consisting of: microperthite and microcline-microperthite, 80-95 percent; augite 0-1 percent; hornblende, may be partly chloritized, 2-15 percent; magnetite or titaniferous magnetite, 1/2-3 percent; quartz 1/2-1 percent; accessory apatite, sphene, to granite facies consisting of: quartz 15-25 percent; microperthite, 50-75 percent; plagioclase, 0-10 percent; augite, 0-1 percent; hornblende, 2-10 percent; biotite, 0-2 percent; magnetite or titaniferous magnetite 1/2-3 percent; accessory zircon, sphene, apatite. Feldspar grains in the syenitic facies tend to have sutured borders. The larger grains of the semi-porphyritic rock are microperthite, commonly as elongate Carlsbad twins having maximum dimensions of about 10 mm. Some of these rocks contain small clots of

micrographic quartz-feldspar intergrowth. Mafic constituents occasionally show a reaction series, augite to hornblende to biotite. Feldspars are mostly clouded with dusty reddish iron oxide. Some bodies of these rocks have considerable microbrecciation and cataclasis that does not exist in the enclosing diorite or gabbro; this feature indicates movement of the salic material as a crystal mush. There is minor deuteric alteration of these rocks.

CAqd

QUARTZ DIORITE AT LITTLE NAHANT -- Fine- to medium-grained rock having sub-ophitic, porphyritic texture. Evenly distributed, randomly oriented, tabular, greenish plagioclase phenocrysts having a greasy luster, and maximum lengths of 5 mm constitute 5 to 10 percent of the rock. Clots of dark green mafic constituents, 1 to 5 mm diameter, constitute another 5 to 10 percent of the rock. The matrix is fine-grained, varies locally from light reddish-purple to light green. Weathered surfaces have many pits, 1 to 2 mm diameter caused by leaching of calcite. In thin section this rock shows considerable alteration that has produced epidote, chlorite, and calcite; phenocrysts are corroded and embayed. This rock is composed of: quartz 5-15 percent; tabular or lath-shaped plagioclase 15-25 percent; blocky plagioclase 10-15 percent; incipient microperthite 25-40 percent; hornblende and chlorite 5-10 percent; biotite 3-7 percent; magnetite 2-5 percent; apatite 0.2-0.7 percent; epidote 3-5 percent; calcite 0.5-1 percent; accessory sphene. Quartz grains are small and interstitial. There are occasional clots, 1-2 mm diameter of micrographic quartz-feldspar intergrowth. The tabular or

lath-shaped plagioclase forms the phenocrysts and part of the matrix; it has undergone severe saussurization causing the grains to be clouded; most of it seems to be labradorite; some grains are too much altered to permit identification. The more blocky, plagioclase is less altered, grains are commonly zoned, andesine cores, oligoclase rims. Incipient microperthite, showing partial exsolution of albite, mostly forms anhedral grains; an occasional grain is an elongate Carlsbad twin. Hornblende grains and aggregates are partly altered to chlorite; grains have ragged borders, are poikilitic. Biotite has an unusual reddish-tan color, is slightly altered to chlorite. Epidote occurs as minute granules and grains, seemingly entirely as a saussurization product, concentrated within or adjacent to plagioclase. Calcite is mostly in clots 1-2 mm diameter.

CAog

OLIVINE GABBRO -- Coarse-grained and crudely compositionally banded rock. It has an even granitic texture, is black sparsely mottled with white or pale gray. Its composition is: plagioclase 5-20 percent; olivine 20-50 percent; pigeonite 25-40 percent; hornblende 5-15 percent; biotite 2-5 percent; an asbestiform mineral (antigorite?) 2-5 percent; accessory sulfide minerals. The plagioclase is labradorite or andesine depending upon the layer from which the specimen was taken; it is entirely interstitial to pigeonite and olivine. Olivine grains are 5 to 10 mm diameter, are considerably fractured, the fractures being filled with finely granular magnetite and antigorite(?); this magnetite within the olivine causes it to appear black by macroscopic observation. Pigeonite grains are 5 to 10 mm diameter, are titaniferous, pinkish, and commonly clouded with swarms of parallel-oriented needles or dust-like particles of opaque substance. Hornblende occurs mostly as fine interstitial grains and forms a few clots 5 to 10 mm diameter. Biotite occurs as small flakes having an unusual bright reddish-tan color. Magnetite ranges from dust-like particles to

grains 5 mm in maximum dimension; the larger grains commonly have corroded and embayed borders. Minute grains of pyrite and pyrrhotite are recognizable in hand specimens.

CAng

NAHANT GABBRO -- Medium- to coarse-grained, greenish-gray, dark greenish-gray, or black rock, compositionally layered at Nahant and Egg Rock, massive elsewhere. It has a generally equigranular granitic texture but locally grades to sub-ophitic. The more mafic layers are gabbroic, the coarser-grained, and darker colored. The lighter-colored layers are the finer-grained and trend toward dioritic composition. This rock is characterized by greenish feldspars having a greasy luster. It is composed of quartz, 0-5 percent; orthoclase 0-6 percent; plagioclase 55-65 percent; olivine, 0-2 percent; pyroxenes 30-45 percent; amphiboles, 0-10 percent; biotite 0-2 percent; magnetite or titaniferous magnetite, 3-10 percent, apatite 0-1 percent; accessory zircon, and minor quantities of erratically distributed epidote, chlorite, and calcite, seemingly formed by deuteric alteration. Quartz, if present, occurs as small interstitial grains. Orthoclase occurs as small interstitial grains and is a major constituent of occasional tiny feldspathic veinlets. Plagioclase is in the form of subhedral tabular to somewhat blocky crystals commonly having corroded borders; it is labradorite

except in some of the lighter-colored rock of dioritic composition where it may be andesine; it is partly clouded by products of saussurization and a micaceous (sericitic?) alteration. A pinkish titaniferous pigeonite occurring as large anhedral grains having corroded borders and commonly filled with swarms of parallel-oriented minute needles or dust-like particles of opaque substances is the most abundant pyroxene; pale green augite occurs sparsely in some specimens. Amphiboles are mostly altered to chlorite; hornblende was the most abundant, perhaps the only original amphibole; among the altered parts there are minute quantities of fibrous mineral(s) that may be secondary amphiboles. The biotite has an unusual bright reddish-tan color. Occasional scattered clots of mafic minerals display a reaction series, pyroxene-amphibole-biotite. Olivine is a sporadic minor constituent of the gabbroic part of the rock. Magnetite or titaniferous magnetite occurs as minute granules and grains having maximum dimensions ranging to about 3 mm; grains are commonly corroded and embayed. Magnetite is concentrated in the more mafic facies.

CAsg

SALEM GABBRO-DIORITE -- Fine- to medium-grained, greenish-gray, dark greenish-gray, or black rock of several textural and compositional facies. It is characterized by greenish feldspars having a greasy luster. Weathered surfaces are brownish, and joint surfaces in the zone of weathering are coated with tan-brown scale. Textures vary from equigranular granitic to ophitic or porphyritic facies having granitic groundmass. Microscopic textures are extremely variable. In thin section, much of this rock has a very ragged heterogeneous appearance caused by an unusual abundance of mineral species, shredded mafic constituents, abraded feldspars, and abundance of microlites. Compositions range from olivine gabbro through diorite to quartz diorite. Several textural and compositional facies may occur in a single outcrop. The ranges of mineral compositions are, quartz, 0-5 percent; microperthite, 0-5 percent; orthoclase or microcline, 0-5 percent; plagioclase, 30-70 percent; olivine 0-10 percent; pyroxenes, 0-30 percent; amphiboles 5-40 percent; biotite, 0-15 percent; magnetite or titaniferous magnetite 1-5 percent; apatite 0.1-2 percent; sphene 0.1-0.5 percent; accessory minerals are zircon and allanite. Quartz,

if present, occurs as small interstitial grains. Plagioclase ranges from labradorite to oligoclase, being mainly labradorite in gabbroic facies and andesine or oligoclase in quartz diorite facies. Plagioclase phenocrysts of porphyritic rock are commonly zoned, having labradorite or andesine cores and oligoclase shells. Microperthite is an occasional constituent of the gabbroic and dioritic facies and is a common minor constituent of the quartz diorite facies. The mafic rock adjacent to and near pinkish syenitic bodies intrusive into it commonly contains pinkish feldspar grains and phenocrysts that may be either plagioclase or microcline, or both. In some parts of the rock the larger feldspar grains and phenocrysts have corroded and embayed borders; in other parts of the rock the larger feldspar grains have abraded borders, and there is considerable interstitial pulverized feldspar and shredded mafic constituents resulting from milling of a crystal mush prior to complete crystallization of the rock. Mafic constituents commonly occur as clots of two or more minerals of a reaction series. In the more mafic facies such clots may have a core of pinkish

titaniferous pigeonite, commonly filled with swarms of parallel-oriented opaque needles; this core is surrounded by generally discontinuous shells of pale green augite, common green hornblende, and occasionally biotite. Pigeonite does not occur in the quartz diorite facies. Some of the more salic parts of the rock contain only hornblende and biotite, or either of these minerals alone. Secondary sodium- and iron-rich amphiboles, including riebeckite, kataphorite, hastingsite, and glaucophane, may be very minor constituents of the dioritic and quartz dioritic facies. Magnetite or titaniferous magnetite occurs mostly as small granules associated with the mafic minerals. Apatite occurs as tiny prisms and as minute granules, sphene as small granules. Zircon and allanite are most abundant in the more salic facies. There are two generations of zircons, one consisting of rounded, corroded, commonly fractured and discolored grains that are probably metamict, and the other consisting of euhedral, generally colorless grains

CAsgb

SALEM GABBRO-DIORITE INCLUDING SALIC DIKES, VEINS, AND INTRUSION BRECCIA -- The dikes, veins, and intrusion breccia consist of fine- to coarse-grained pinkish to salmon-red rock, generally having an even granitic texture. An occasional vein or dike is semi-porphyritic. The compositions are predominantly granite, but there are many variations ranging to granodiorite and syenite. Feldspars are clouded with dusty iron oxide causing the pinkish to reddish color. Typical compositions of the common granitic facies are: quartz 10-20 percent; microperthite and microcline-microperthite 60-80 percent; orthoclase or microcline 0-5 percent; oligoclase 0.5-2 percent; hornblende 2-10 percent; biotite 0.5-5 percent; magnetite 1-2 percent; accessory sphene, apatite, zircon. The rock becomes syenitic by decrease of quartz, granodiorite by increase of plagioclase, decrease of other feldspars. Crystal boundaries in quartz-poor facies are commonly sutured. The larger grains in semiporphyritic facies are microperthite. Zircons are abundant; some are euhedral, colorless or pale green; others are metamict, rounded, and are various shades of yellow, gray, or brown. The zircons have

developed weak pleochroic haloes in biotite. The rock of some of these dikes and veins has minute irregular bands and streaks of finely granular material interstitial to the larger grains; this feature suggests emplacement as crystal mush.

Dgd

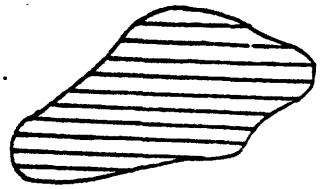
DEDHAM GRANODIORITE (LATE PRECAMBRIAN(?)) -- Medium- to coarse-grained rock generally having an even granitic texture; minor parts are somewhat porphyritic, having microcline phenocrysts. Unaltered, or slightly altered rock is pale gray to white sparsely speckled with black mafic minerals. Rock that is hydrothermally altered has pinkish to salmon-red feldspars, and mafic constituents are chloritized and greenish. Quartz has colorless to smoky glassy appearance. This rock is composed of: quartz 25-40 percent; potassium feldspars 25-40 percent; plagioclase 25-40 percent; mafic minerals, generally chloritized 2-5 percent; accessory opaque minerals, apatite, and zircon. Most of the quartz grains are fractured and have strong undulatory extinction; they contain abundant dust-like inclusions, some in trains, some randomly distributed. Much of the potassium feldspar is devoid of twinning, some has microcline twinning; some grains show minor perthitic exsolution of albite. Plagioclase ranges from $Ab_{75}An_{25}$ to $Ab_{65}An_{35}$. Most of the feldspar grains are minutely fractured. The original mafic constituents seem to have been mostly biotite; some parts of the rock contain remnants of hornblende. Apatite occurs as minute prisms associated with the mafic constituents.

Zircons are mostly minute, colorless, and euhedral. The opaque matter, mostly associated with the mafic constituents probably was magnetite, but granules of it are now partly or completely altered to reddish iron oxide.

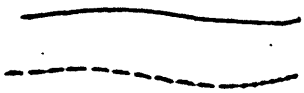
Dgdb

DEDHAM GRANODIORITE, BORDER FACIES -- Fine- to medium-grained rock having an even granitic texture. The unweathered rock is mostly greenish-gray to green; parts of it are speckled with pinkish or salmon-red feldspar grains. This rock contains abundant fine-grained mafic metavolcanic xenoliths; also small dark gray to black schlieren that seem to represent partly assimilated xenoliths. It differes from the normal granodiorite by being finer-grained, has less quartz and more mafic constituents, and is more altered. The alteration seems to be mostly deuteric, the products being epidote and chlorite; placioglase is partly saussuritized. Parts of the rock have been subjected to the later hydrothermal alteration that caused a fine, flaky micaceous alteration of feldspars and also a reddening of them by introduction of dusty iron oxide. This rock is composed of: quartz 15-30 percent; potassium feldspars 20-35 percent; plagioclase 30-45 percent; mafic minerals, generally chloritized 5-15 percent; epidote 5-10 percent; accessory apatite, sphene, and opaque minerals. Quartz and feldspar grains are fractured. Quartz has strong undulatory extinction, contains abundant dust-like inclusions. Potassium feldspar is

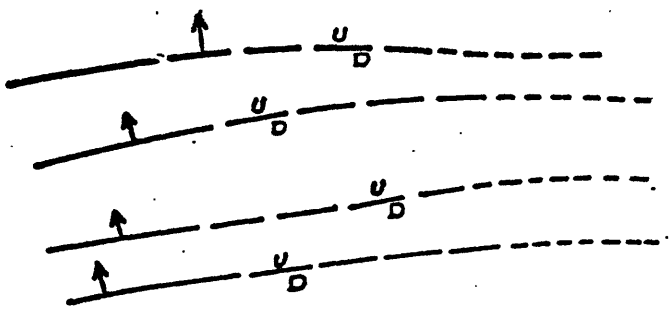
devoid of twinning; some grains show minor perthitic exsolution of albite. Plagioclase is more altered than potassium feldspar, many grains being completely clouded; the least altered grains are andesine. In most of the rock the mafic constituents are almost completely altered to chlorite; there are remnants of hornblende and biotite; biotite is more altered than hornblende. Epidote occurs as minute grains and small clots formed by saussurization of plagioclase.



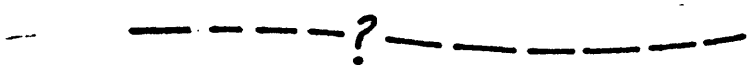
Outcrop. Patterned where too abundant to map separately



Contact. Solid line where accurately located, dashed line where approximately located, dotted line where under water

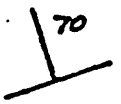


Fault. Solid line where accurately located, long dashed line where approximately located, short dashed line where under water. Weight of line indicates relative magnitude of faults. Arrow indicates direction of dip. U, upthrown side. D, downthrown side

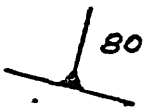


Possible fault

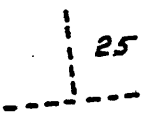
Approximate transport direction on fault



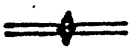
Strike and dip of bedding



Strike and dip, metamorphic foliation parallel to bedding



General strike and dip of layering of Lynn Volcanic Complex



Strike of flow foliation, vertical dip

Breccia zone associated with faults

Drill hole