Donald C. Alvord

Explanation for Westford and Billerica Quadrangles

Description of Map Units

Trd

Diabase Dike (basalt) - Greenish- to grayish-black non-foliate rock consisting chiefly of plagioclase and pyroxene with scattered grains or clustered aggregates of magnetite, biotite, amphibole, and pyrite. Chiefly fine- to medium-grained, slightly porphyritic with aphanitic groundmass near walls. Not exposed in quadrangle, mapped by projection from exposures in the Nashua South quadrangle with the aid of aeromagnetic data.

PTrcn

Cataclastic Rocks of the Clinton-Newbury Fault Zone - Map unit is a composite of igneous and metamorphic rocks cut from structurally adjacent units and moved into place by high angle faulting within the Clinton-Newbury zone. Within this tectonic unit the fabrics normal to the rocks of the adjacent units have been milled and sheared into a number of cataclastic fabrics, chiefly varieties of microbreccias, protomylonites, mylonites (including phyllonites), and mylonites (terminology of Higgins, 1971). Relict precataclastic

Dac

Acton Granite (quartz monzonite) - Light-gray, slightly- to moderately-foliated, fine-grained equigranular rock with a "salt and pepper" appearance owing to rather evenly scattered grains of brownish black biotite.

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mineralogies and textures locally identified within the unit include those of the Ayer and Chelmsford Granites, rocks of the Merrimack Group, rocks of the Tadmuck Brook area, and some mafic plutonic rocks of unknown association.

Dan

Andover Granite (quartz monzonite) - Light- to medium-gray, slightly- to well-foliated, mostly medium-coarse to coarse-grained equigranular rock in which quartz, plagioclase, and potassium feldspars occur in nearly equal proportions and constitute 85 to 95 percent of most specimens. Mica (biotite exceeding muscovite at most localities) ranges from about 3 to 12 percent. Simple granitic pegmatite bodies, both conformable and cross-cutting to the foliation are very common in this rock.

Dch

Chelmsford Granite (quartz monzonite) - Light- to medium-gray, slightly - to strongly-foliated, medium-grained, inequigranular to slightly porphyritic rock consisting chiefly of quartz, potassium feldspars, and plagioclase, all in nearly equal proportions. Mica makes up from 3 to 10 percent of most specimens and, in the Westford quadrangle, muscovite exceeds biotite at most places.

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Day

Ayer Granite (quartz monzonite) - Chiefly light- to medium-gray, slightly to strongly foliated prophyritic rock containing abundant euhedral to lensoidal shaped potassium feldspar phenocrysts (1/2 to 2 1/2 cm in diameter) in a medium-grained groundmass of quartz, plagioclase, biotite, and a little potassium feldspar. Biotite makes up from 15 to 30 percent of the groundmass in most specimens.

Smu

Merrimack Group (undivided) - Chiefly planar- to very low angle cross stratified, laminated to thin bedded, greenish-gray, purplish-gray, olive-gray, and medium light gray, very fine- to medium-grained actinolite-biotite-quartz schists, gneisses, and impure quartzites. Thin beds and lenses of greenish-gray calc-silicate (diopside rich) rock are erratically dispersed through the sequence. Extremely fine-grained, thinly laminated, brownish gray, lead gray, or silvery gray phyllites composed chiefly of chlorite, biotite, quartz, and muscovite (sericite) with variable amounts of pyrite and calcite are also included in the group. Xenoliths (not mapped) of Merrimack rocks are widespread in the Ayer and Chelmsford granites.

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Ot

Schist of Tadmuck Brook - Chiefly rusty weathering sillimanite-quartz-mica schists in the lower part, sericite-staurolite-andalusite phyllitic schists in the middle part, and phyllites in the upper part. Lenticular bodies of fine-grained, thin-bedded and medium-grained non-bedded or massive amphibolites and laminae to thin beds of fine-grained impure quartzite are sparsely and erratically interstratified throughout the unit. Faulting related to the Clinton-Newbury zone probably contributes to the evident discontinuity and irregular distribution of rock types within the unit.

On

Nashoba Formation - The Nashoba Formation is a heterogeneous conformable sequence of complexly interstratified metasedimentary and metavolcanic rocks. It consists of about 50 percent lenticular-bedded, medium-grained biotite-rich gneisses, 15 percent evenly and platy-stratified, fine- to medium-grained, commonly diopsidic, amphibole- and biotite-rich gneisses and schists, 15 percent thinly bedded to massive amphibolites, 10 percent sillimanite-rich mica schists, and 10 percent weakly foliated granoblastic diopsidic calc-silicate-bearing rocks qualifying as gneiss or schist depending upon the presence or absence of appreciable biotite. Thin lenticular units of marble, laminated to thinly bedded quartzite strata, and other varieties of rock probably

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constitute 1 percent or less of the sequence. The aggregate thickness of these rocks is about 10,890 metres.

Local partial retrogressive hydrothermal alteration is widespread within the Nashoba rocks. Ferromagnesium minerals and garnet are marginally to completely altered to chlorite at many localities. Some hornblende is partly altered to actinolite. Most plagioclase is slightly to largely saussuritized. Some muscovite and sericite is pseudomorphic after kyanite and andalusite. This inequilibrated, water-activated retrogression probably accounts for the widespread occurrence of quartz-epidote-carbonate vein material, locally accompanied by albite, clinozoisite, hematite, and scapolite occurring throughout these rocks as irregular pods, fracture fillings, and thin stratiform sheets conformable to the layering and foliation of the host rocks.

In the Billerica and Westford quadrangles the Nashoba Formation is divided into 10 locally mappable lithostratigraphic units, principally by differentiating intervals of strata made up mostly of biotite-rich gneisses from intervals composed of a more heterogeneous variety of rock types. The biotite-rich gneiss intervals, which contain subordinate proportions of amphibolites and little

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or no other rocks, are herein designated, oldest to youngest, gneisses of the Tophet Swamp area, gneisses of the Nagog Pond area, and gneisses of the Long Pond area. The more complex intervals of strata, distinguished by having, in addition to biotite-bearing gneisses and amphibolites, notable proportions of calc-silicate rocks, amphibole-biotite gneisses, and less commonly sillimanitic mica schists or marble, are herein designated the Boxford Member, rocks of the Bellows Hill area, schist of the Billerica area, rocks of the Spencer Brook area, rocks of the Nashoba Brook area, rocks of the Fort Pond area, and rocks of the Beaver Brook area (Table 2).

Onb

Rocks of Beaver Brook Area - The lowermost 400 to 500 metres of the unit consist chiefly of amphibole-biotite gneisses, calc-silicate (tremolite-diopside)-bearing gneisses, amphibolites, and a few discontinuous beds of limestone. The remainder of the unit consists chiefly of medium-grained sillimanitic muscovite-biotite-oligoclase-quartz schists, both thin-bedded and massive amphibolites, amphibole-biotite gneisses, and near the top, at least one discontinuous bed of limestone with associated calc-silicate rocks.

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Onl

Gneisses of Long Pond Area - Chiefly medium-grained sillimanitic muscovite-biotite-oligoclase-quartz gneisses with a few interstratified lenticular bodies of very fine grained thinly bedded and medium-grained massive amphibolites.

Onf

Rocks of Fort Pond Area - Chiefly fine-grained amphibole-biotite gneisses, calc-silicate (diopside-tremolite)-bearing gneisses, and amphibolites. The upper part consists chiefly of the same lithologies as the lower part but includes, in addition, some sulfidic sillimanite-mica schists and discontinuous beds of marble.

Onn

Gneisses of Nagog Pond Area - Chiefly medium-grained muscovite-biotite-oligoclase-quartz gneisses with some interstratified amphibole-biotite gneisses and lenticular bodies of very fine grained thinly bedded amphibolites and medium grained massive amphibolites.

Onnb

Rocks of Nashoba Brook Area - Chiefly amphibole-biotite gneisses, diopsidic calc-silicate-bearing gneisses, and amphibolites. The middle part of the unit consists chiefly of sulfidic sillimanite-biotite-muscovite schists and gneisses with some amphibolites and biotitic gneisses.

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Ont

Gneisses of Tophet Swamp Area - Chiefly medium-grained sillimanitic muscovite-biotite-oligoclase-quartz gneisses with a few lenticular bodies of very fine-grained thinly bedded amphibolites and medium-grained massive amphibolites.

Ons

Rocks of Spencer Brook Area - Complexly interstratified thin-bedded amphibolite-biotite gneisses, thinly bedded amphibolites, and massive amphibolites interlayered with substantial amounts of amphibole-diopside-calc-silicate rocks, biotitic gneisses, and some thin lenses of marble.

Onbs

Schist of Billerica Area - Chiefly sulfidic sillimanite-muscovite-biotite schists with subsidiary lenticular bodies of amphibole schists and hornblende-biotite schists and gneisses.

Onbh

Rocks of Bellows Hill Area - Chiefly medium-grained sillimanitic-muscovite-biotite gneisses with subordinate fine-grained amphibole-biotite gneisses and amphibolites. Thin lenticular beds of marble and related diopside-tremolite-calc-silicate rocks occur discontinuously in the upper half of the unit.

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Onbx

Boxford Member - Chiefly varieties of thinly bedded amphibolites, massive amphibolites, and biotite-amphibole gneisses and schists interlayered with chiefly subsidary amounts of biotitic gneisses calc-silicate rock, and rare lenses of marble. In general biotite is a minor constituent of some of the gneissic and schistose beds in the lower part of the unit and increases to become a major constituent of many beds in the upper part.

Of

Fish Brook Gneiss - Chiefly very light- to light-gray, fine- to medium-grained biotite-quartz-plagioclase gneiss with some layers of amphibolite and biotite-hornblende-plagioclase schist and gneiss.

Os

Gneiss of the Shawsheen River - Chiefly medium-grained sillimanitic muscovite-biotite-oligoclase-quartz gneisses with some lenticular bodies of fine-grained thinly bedded amphibolite and medium-grained massive amphibolites. Rusty weathering sulfidic sillimanite-mica-quartz schists are the predominant rocks near the base of this unit.

NOTE: Rocks are described megascopically but minerals and textures have been verified by petrographic microscopy. Minerals are listed (from left to right) in order of increasing abundance, but only essential minerals or characterizing accessory minerals are cited. Variation from the listed relative order of mineral abundance is common.

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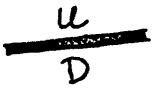
Map Symbols

Contact -- Approximately located; dashed where indefinite; dotted where concealed by water.

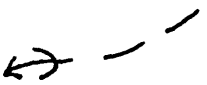
Thrust Fault -- Approximately located; dashed where indefinite or inferred; dotted where concealed by water. Sawteeth on upper plate.



High Angle Fault -- Approximately located; dashed where indefinite; dotted beneath water. U, upthrown side, D, downthrown side.

Strike Slip Fault -- Approximately located; dashed where indefinite; dotted beneath water. Arrows indicate relative horizontal movement.

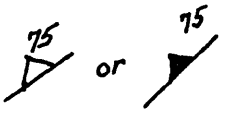
Zone of brecciated and mylonitized rock



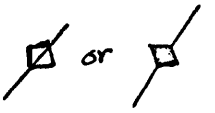
Syncline -- Showing troughline and direction of plunge.

Planar Features

Intersection of two symbols is at point of observation



inclined



vertical

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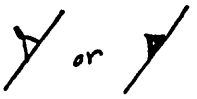
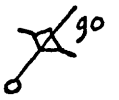
Strike and dip of foliation in igneous or other nonstratified rock



inclined

overturned

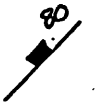
normal



vertical
facing toward numerals

(Ball indicates facing direction has been inferred from relict sedimentary structure)

Strike and dip of parallel foliation and bedding



inclined

vertical

May be combined with foliation symbol

Linear Features

Bearing and plunge of mineral lineation

May be combined with foliation symbol

Minor Folds

drag

anticline

fold class undesignated

Bearing and plunge of minor fold or crenulation axis.

May be combined with foliation symbol.

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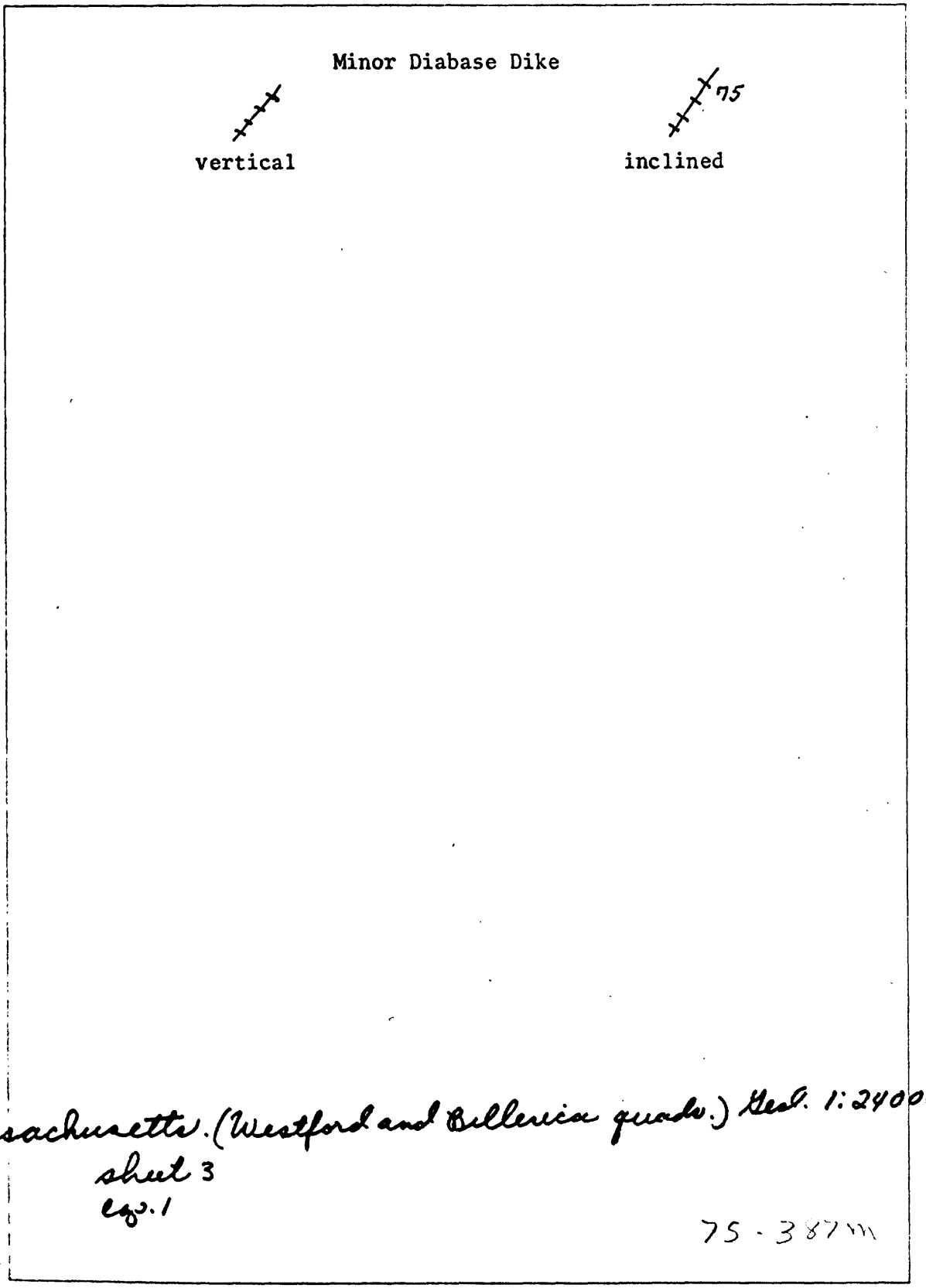
9.1267



Massachusetts. (Westford and Billerica quads.) Geol. 1:24000.
sheet 3
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Westford
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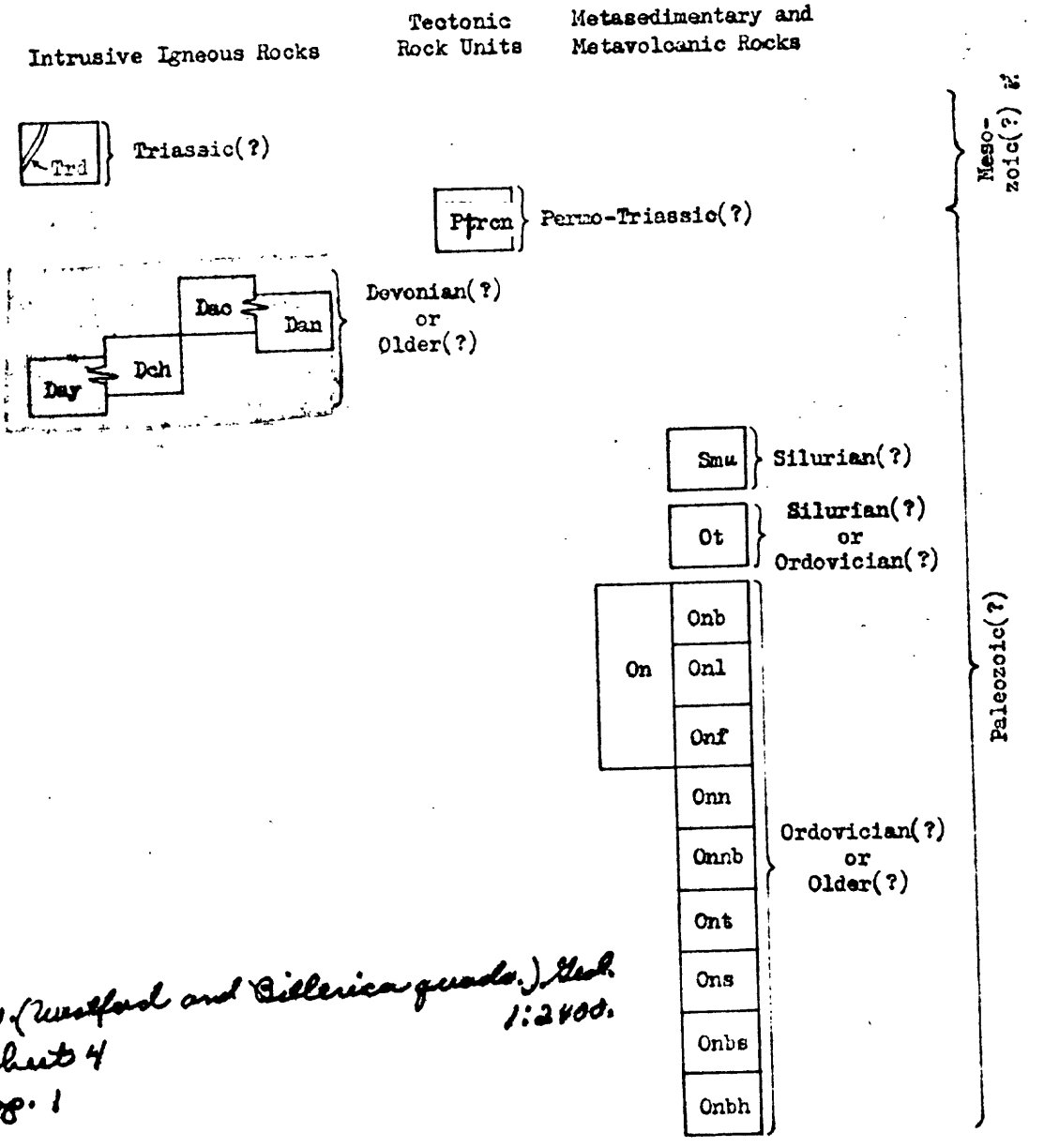
Preliminary Bedrock Geology

CORRELATION OF MAP UNITS



nassa Bedrock Seattle (Westford and Billerica quads.) Sheet 4 of 4 sheets 1:2400.

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Billerica
D. C. Alvord
Preliminary Bedrock Geology

CORRELATION OF MAP UNITS

Intrusive Igneous Rocks	Tectonic Rock Units	Metasedimentary and Metavolcanic Rocks	
Trd		Triassic(?)	Meso-zoic(?)
	Pptrcn	Permo-Triassic(?)	
Dac, Dan, Day		Devonian(?) or Older(?)	
		Smu — Silurian(?)	
		Ot — Silurian(?) or Ordovician(?)	
		On: Onl, Onf, Onn, Onnb, Ont, Ons, Onbs, Onbh, Onbx — Ordovician(?) or Older(?)	Paleozoic(?)
		Of	
		Os	

Massa