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Title of article Structural implications of some radiometric ages of igneous  
rocks in southeastern New England

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## ABSTRACT

U-Th-Pb zircon, Rb-Sr whole-rock, and K-Ar hornblende isotopic ages reveal two major episodes of igneous activity in southeastern New England--one in late Proterozoic Z time (600-650 m.y. ago) and the other in Devonian to Ordovician time (375-450 m.y. ago). The dated rocks are discussed in the context of several individual structural provinces, which have evolved more or less independently of each other prior to mid- to late-Paleozoic assembly. These provinces generally are bounded by major faults and (or) abrupt changes in metamorphic grade and, from east to west, include (I) the Milford-Dedham zone, (II) the Putnam-Nashoba zone, (III) the Merrimack synclinorium, and (IV) the Bronson Hill zone. From the present and other recently published studies, reasonably accurate ages representative of the two major episodes can now be assigned to many of the igneous rocks. Other units remain less well constrained, but probably may be placed into one or the other of the general age groupings. Case by case examination of the geochronologic data make us cautious in accepting some apparent fine-structure age resolution within each grouping until factors such as inherited zircon and metamorphic overprinting can be better evaluated.

With the above-mentioned qualifications in mind, igneous rock ages summarized according to structural province are as follows:

<u>Late Proterozoic Z (600-650 m.y.)</u>	<u>Devonian to Ordovician (375-450 m.y.)</u>
<u>(I) Milford-Dedham zone</u>	
Dedham Granite and related rocks 630±15 m.y. <sup>1</sup> ; 595±15 m.y. <sup>2</sup> (1); 612-646 m.y. <sup>3</sup> .	Alkalic rocks, including Quincy, Cape Ann, and Peabody Granites, Wenham Monzonite, and Nahant Gabbro (2).
Milford Granite 630±15 m.y. <sup>1</sup> ; 591±50 m.y. <sup>2</sup> .	

Hope Valley Alaskite Gneiss and  
Scituate Granite Gneiss ages uncertain<sup>1</sup>.

Unnamed granite near Assonet 600-650  
m.y.<sup>1</sup>

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(II) Putnam-Nashoba zone

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No plutonic rocks identified, but  
may include some metavolcanic  
rocks (3).

Sharpners Pond Diorite  $430 \pm 5$  m.y.<sup>1</sup>

Andover Granite  $408 \pm 22$  m.y.<sup>2</sup>;  $450 \pm 22$   
m.y.<sup>2</sup> (4).

Muscovite granite near West Berlin  
age uncertain<sup>2</sup>.

Preston Gabbro  $424 \pm 5$  m.y.<sup>1</sup>.

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(III) Merrimack synclinorium

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Granitic orthogneiss unit of the  
Massabesic Gneiss Complex 600-620  
m.y.<sup>1</sup> (5)

Fitchburg Complex at Malden Hill  
 $402 \pm 11$  m.y.<sup>2</sup>

Metavolcanic unit of the Massabesic  
Gneiss Complex 646 m.y. or older<sup>1</sup> (6)

Fitchburg Complex at Rollstone  
Quarry  $390 \pm 15$  m.y.<sup>1</sup>.

Newburyport Complex  $450 \pm 15$  m.y.<sup>1</sup>

Ayer Granite  $433 \pm 5$  m.y.<sup>1</sup>.

Chelmsford Granite age uncertain<sup>1</sup>.

Muscovite-biotite granite at  
Millstone Hill  $372 \pm 7$  m.y.<sup>2</sup>.

Canterbury Gneisses  
 $395 \pm 10$  m.y.<sup>1</sup>;  $392 \pm 9$  m.y.<sup>2</sup>

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(IV) Bronson Hill zone

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Dry Hill Gneiss of the Pelham dome  
~600 m.y.<sup>1</sup>.

Monson Gneiss  $440 \pm 10$  m.y.<sup>1</sup>.

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<sup>1</sup>U-Pb zircon concordia intercept age. <sup>2</sup>Rb-Sr whole-rock isochron age.  
<sup>3</sup>K-Ar hornblende age.

(1) Kovach and others, 1977. (2) Zartman, 1977. (3) Olszewski, 1980.  
(4) Handford, 1965. (5) Besancon and others, 1977. (6) Aleinikoff and  
others, 1979.

These distinctive age patterns, together with contrasts in petrography and  
texture of the igneous rocks, in stratigraphy of the country rock, and in

## APPENDIX 1. Sample localities

Sample Number	Latitude N.	Longitude W.	Locality
Dedham Granite and related rocks			
1	42°18'50"	71°20'05"	Excavation in industrial park 120 m northwest of Rathbun Road, 350 m north of intersection with Oak Street, Natick.
2	42°16'06"	71°09'29"	Quarry of West Roxbury Crushed Stone Company 300 m east of intersection between Centre and Grove Streets, Boston.
3	42°04'18"	71°13'36"	Roadcut on west side of Interstate Route 95, 950 m north of overpass at Cocasset Street, Foxborough.
4	42°43'20"	70°53'31"	Outcrop on knoll 150 m east of Weathersfield Street, 1.0 km southeast of Dodge Corner, Rowley (hornblende diorite).
5	42°29'26"	70°50'43"	Outcrop along beach below Ocean Avenue on southwestern Marblehead Neck, 200 m east of intersection with Harbor Street, Marblehead.
6	42°28'08"	71°01'27"	Small abandoned quarry on east side of <sup>U.S.</sup> Route 1, 450 m north of intersection with Main Street, Saugus.
7	42°29'24"	71°01'06"	Roadcut inside northwestern loop of cloverleaf at intersection of <sup>U.S.</sup> Route 1 and Massachusetts Route 129, Saugus (hornblende diorite).
8	42°25'19"	71°13'47"	Roadcut on north side of Massachusetts Route 2, 160 m east of intersection with Waltham Street, Lexington (gabbroic pegmatite).
9	42°25'27"	71°14'58"	Excavation for building 140 m east of Spring Street, 200 m northeast of intersection with Massachusetts Route 2, Lexington.
Milford Granite			
10	42°11'31"	71°31'05"	Small abandoned quarry at west side of Haven Street, 300 m north of Worcester-Middlesex County line, Hopkinton.
11	42°09'46"	71°30'31"	Roadcut on east side of Cedar Street, 250 m south of underpass at Interstate Route 495, Milford.
12	42°10'52"	71°30'57"	Abandoned (Massachusetts Pink) quarry 800 m west of Cedar Street, 1.0 km south of Echo Lake, Milford.
13	42°09'49"	71°30'30"	Abandoned (West) quarry on east side of Cedar Street, 200 m north of intersection with Dilla Street, Milford.
14	42°10'38"	71°32'11"	Roadcut on north side of Camp Street, 80 m west of intersection with Purchase Street, Milford.
15	42°10'41"	71°31'48"	Roadcut on east side of Haven Street, 60 m south of underpass at Interstate Route 495, Milford.
16	42°11'16"	71°31'23"	Small abandoned quarry 100 m east of Haven Street, 140 m south of Worcester-Middlesex County line, Milford.
17	42°11'38"	71°30'17"	Roadcut on west side of Hayden Row Street opposite College Rock, 350 m south of intersection with College Street, Hopkinton.
Hope Valley Alaskite Gneiss (18), Scituate Granite Gneiss (19), and unnamed granite near Assonet (20)			
18	42°01'52"	71°48'17"	Old railroad cut 380 m northwest of Mount Daniels, 300 m east of Webster-Douglas town line, Douglas.
19	42°02'16"	71°45'40"	Old railroad cut south of Wadkin Hill, 350 m east of Wallum Lake Road, Douglas.
20	41°45'45"	71°05'23"	Abandoned quarry on west side of Rattlesnake Brook in Freetown, Fall River State Forest, 1.0 km east of Massachusetts Route 24 and 4 km south of Assonet, Freetown.

# Sharpners Pond Diorite

21	42°43'35"	70°56'57"	Roadcut on southeast side of Tenney Street, 350 m southwest of intersection with Jewett Street, Georgetown <sub>x</sub>
22	42°45'48"	70°54'58"	Outcrop 300 m north of Orchard Street, 1.5 km west of intersection with Middle Street, Newbury <sub>x</sub>

# Andover Granite

23	42°37'35"	71°10'47"	Roadcut on east side of Interstate Route 93, 200 m north of underpass at Dascomb Road, Andover (pegmatite) <sub>x</sub>
24	42°34'41"	71°08'35"	Roadcut in middle of Interstate Route 93, 150 m south of underpass at Salem Street, Wilmington (A, C, and D: aplite; B: pegmatite) <sub>x</sub>
25	42°37'12"	71°13'50"	Railroad cut on north side of B&M RR tracks, 60 m west of North Street, Tewksbury <sub>x</sub>
26	42°37'16"	71°13'42"	Outcrop beneath transmission lines; 100 m east of North Street at intersection with Kendall Street, Tewksbury.
27	42°26'49"	71°18'45"	Roadcut on north side of Massachusetts Route 2 at Smiths Hill, 800 m east of intersection with Concord Turnpike Cut-off, Lincoln <sub>x</sub>
28	42°40'48"	71°08'13"	Outcrop at east base of knoll in Den Rock Park, 220 m west of intersection between Massachusetts Route 114 and Railroad Avenue, Lawrence (Castle No. C-6) <sub>x</sub>
29	42°33'00"	71°17'23"	Roadcut on east side of <sup>U.S.</sup> Route 3, 200 m north of bridge over Concord River, Billerica (Castle No. C-10) <sub>x</sub>
30	42°35'42"	71°05'12"	Outcrop 20 m west of Haverhill Street, 200 m south of intersection with Marblehead Street, North Reading (Castle No. C-12) <sub>x</sub>

# Muscovite granite near West Berlin

31	42°23'14"	71°40'56"	Abandoned quarry at northeast end of Larkin Hill, 0.5 km east of Massachusetts Route 70, Boylston <sub>x</sub>
32	42°23'29"	71°40'48"	Station 36+31 of the Wachusett-Marlborough Tunnel, Clinton <sub>x</sub>
33	42°23'26"	71°40'44"	Station 39+76 of the Wachusett-Marlborough Tunnel, Clinton <sub>x</sub>
34	42°23'20"	71°40'36"	Station 48+83 of the Wachusett-Marlborough Tunnel, Berlin <sub>x</sub>
35	42°23'14"	71°40'28"	Station 58+28 of the Wachusett-Marlborough Tunnel, Boylston <sub>x</sub>
36	42°23'10"	71°40'23"	Station 63+25 of the Wachusett-Marlborough Tunnel, Boylston <sub>x</sub>
37	42°23'09"	71°40'22"	Station 64+93 of the Wachusett-Marlborough Tunnel, Boylston <sub>x</sub>
38	42°23'05"	71°40'17"	Station 69+80 of the Wachusett-Marlborough Tunnel, Berlin <sub>x</sub>

# Preston Gabbro

39	41°33'56"	71°57'03"	Outcrop on knoll 250 m south of farm buildings at eastern deadend of Crary Road, Griswold, Connecticut
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Fitchburg Complex at Malden Hill

40	42°21'37"	71°48'28"	Small abandoned quarry near south end of Malden Hill 80 m northwest of Goodale Street, 200 m northeast of intersection with Lee Street, West Boylston <sub>x</sub>
41	42°21'42"	71°48'26"	Small abandoned quarry on east side of Malden Hill, 150 m north-northeast of locality 40, West Boylston <sub>x</sub>
42	42°21'21"	71°48'33"	Outcrop from near summit of hill, 300 m south of intersection between Goodale and Lee Streets, West Boylston <sub>x</sub>
43	42°21'48"	71°48'37"	Outcrop near summit of Malden Hill, 50 m southwest of Whiting Benchmark, West Boylston <sub>x</sub>
44	42°22'19"	71°48'32"	Small abandoned quarry on east side of Malden Hill at head of small stream; 200 m southwest of Malden Street, West Boylston <sub>x</sub>

Fitchburg Complex (of Rollstone Quarry)

45	42°34'55"	71°48'51"	Abandoned (Rollstone) quarry on northwest slope of Rollstone Hill, 150 m east of Beech Street, Fitchburg <sub>x</sub>
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Newburyport Complex

46	42°51'21"	70°51'24"	Small abandoned quarry 20 m west of Seabrook Road, 0.7 km north of intersection with Gerrish Road, Salisbury <sub>x</sub>
47	42°52'06"	70°49'55"	Roadcut on south side of New Hampshire Route 286, 1.1 km west of intersection with New Hampshire Route 1A, Seabrook, N.H., New Hampshire

Ayer Granite

48	42°25'04"	71°39'23"	Roadcut at intersection of Lancaster and Wataquodock Roads, Bolton <sub>x</sub>
49	42°21'12"	71°43'18"	Outcrop 20 m west of Central Street, 300 m southeast of intersection with Linden Street, Boylston <sub>x</sub>
50	42°33'48"	71°34'30"	Roadcut on west side of Old Ayer Road, 0.7 km north of intersection with Central Avenue, Ayer <sub>x</sub>

Chelmsford Granite

51	42°35'58"	71°28'22"	Large abandoned quarry on northeast side of Snake Meadow Hill, 1.0 km northwest of Graniteville, Westford <sub>x</sub>
52	42°34'29"	71°33'48"	Excavation for telephone cable 40 m east of Snake Hill Road, 0.9 km southeast of intersection with Old Ayer Road, Ayer <sub>x</sub>

Muscovite-biotite granite at Millstone Hill

53	42°16'24"	71°46'58"	Roadcut on north side of Belmont Street, 50 m west of intersection with Skyline Drive, Worcester <sub>x</sub>
54	42°16'17"	71°46'56"	Abandoned quarry on southeast side of Belmont Hill, 300 m west of Adams Street School, Worcester <sub>x</sub>
55	42°16'46"	71°46'51"	Large abandoned quarry 100 m southwest of Armory atop Millstone Hill, Worcester <sub>x</sub>
56	42°16'44"	71°46'51"	Large abandoned quarry 20 m south of locality 55, Worcester <sub>x</sub>

# Canterbury Gneiss

57	41°49'30"	72°01'50"	Small abandoned quarry 300 m south of Carter Road, 0.8 km west of intersection with Brooklyn Road, Pomfret, Conn.
58	41°46'51"	72°01'33"	Roadcut on north side of <sup>U.S.</sup> Route 6 at intersection with secondary road to Hampton Center, 1.6 km west of Stetson Corner, Hampton, Conn.
59	41°45'03"	72°01'52"	Roadcut on north side of Windham Turnpike, 0.8 km east of Sand Hill Road, Hampton, Conn.
60	41°43'13"	72°01'21"	Outcrop on knoll 60 m east of Brooklyn Road, 1.5 km north of Westminster, Canterbury, Conn.
61	41°41'15"	72°03'44"	Small abandoned quarry 60 m north of Khourie Road, 300 m east of intersection with Hanover Road, Scotland, Conn.
62	41°34'05"	72°07'55"	Roadcut at intersection of Connecticut Routes 32 and 87, 1.2 km north of Yantic, Franklin, Conn.

## Eastford Gneiss (now assigned to Canterbury Gneiss)



63	41°50'26"	72°03'48"	Excavation for pipeline 400 m south of Pilshire Road, 0.7 km west of intersection with Fayette Road, Eastford, Conn.
64	41°51'56"	72°02'57"	Roadcut on south side of <sup>U.S.</sup> Route 44, 100 m west of intersection with Fayette Road, Eastford, Conn.
65	41°55'10"	72°00'39"	Small abandoned quarry 40 m south of Quarry Road, 150 m west of intersection with New Sweden Road, Woodstock, Conn.
66	41°54'50"	72°00'46"	Small abandoned quarry 450 m southeast of Quarry Road, 0.8 km west of intersection with New Sweden Road, Pomfret, Conn.
67	41°55'05"	72°00'38"	Outcrop on knoll 250 m south of Quarry Road, 150 m west of intersection with New Sweden Road, Woodstock, Conn.
68	41°50'49"	72°03'23"	Small abandoned quarry 40 m west of Fayette Road, 2.4 km south of intersection with <sup>U.S.</sup> Route 44, Eastford, Conn.

## Dry Hill Gneiss at Northfield Mountain

69	42°37'03"	72°25'58"	Small abandoned quarry approximately 2 km inside Northeast gate of Northfield Mountain Pumping Storage Project off Mountain Road, Erving, Conn.
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## Monson Gneiss

70	42°33'30"	72°18'16"	Roadcut on southwest side of interchange between Massachusetts 2 and South Main Street, Orange, Conn.
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 Samples provided by R. O. Castle (see Castle, 1965).
  Samples provided by J. W. Skehan (see Skehan, 1968).